Geosciences Teaching and History

Proceedings of GeoSciEd 2018: 8th Quadrennial Conference of the International GeoScience Education Organisation (IGEO)

– Geoscience for Everyone –

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July, 22nd – 27th, 2018
Campinas, SP, Brazil

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Proceedings of GeoSciEd 2018: 8th Quadrennial Conference of the International GeoScience Education Organisation (IGEO) – Geoscience for Everyone –

International GeoScience Education Organisation

"promoting GeoScience education worldwide"

Simultaneous Meeting:

EnsinoGEO 2018: VIII Simpósio Nacional de Ensino e História de Ciências da Terra (Geociências para Todos)

– Geoscience for Everyone –

**Campinas, Campus "Zeferino Vaz",
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July, 22nd – 27th, 2018**

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Promotion

Realization

International GeoScience Education Organisation

University of Campinas

Institute of Geosciences

Graduate Program on Teaching and History of Earth Sciences

Preface

VIII GeoSciEd Conference

The Brazilian Geology Society, a scientific association with more than 70 years of history and almost 5,000 members, is pleased to host the VIII International Conference on Geoscience Education Conference.

"Promoting GeoScience Education Worldwide" is a must for all of us, scientists, professors, professionals, and we do this with dedication, respect and responsibility. The success of the conference was shown by the large number of participants of all education levels.

In addition, the conference has directed a focus onto a variety of sessions, courses, fieldwork and several meetings on new projects. It has proved to be a great opportunity for scientists to come together from different countries.

For the Brazilian Geology Society, being the depositary of the "Proceedings" is something honorable.

Brazilian Society of Geology
Gilmar Vital Bueno
Director President

Editorial

The Brazilian community of Geosciences Education is pleased to publish the annals of two conferences held in Campinas in July 2018, promoted by the Brazilian Society of Geology. This document (Proceedings GeoSciEd-2018 / complete papers) synthesizes relevant contributions along with several thematic lines, gathered in the broad general theme "Geosciences for all" – in the framework of the 8th GeoSciEd 2018 – **8th Quadrennial Conference of the International Geoscience Education Organization (IGEO)**. The conference was held in parallel to the VIII National Symposium on Teaching and History of Earth Sciences / EnsinoGEO-2018.

A few years ago, when we began the arduous journey, we perceived the magnitude of the challenge, especially in view of the situation experienced by Brazil; this required concentrated effort to overcome obstacles, but the final result has been acknowledged by the participants. New members were joined the organizing associations. The next EnsinoGEO-2019 symposium will take place in Campinas, in parallel to another event in the series of the Southeast Geology symposia, promoted by SBGeo-Núcleo SP. The upcoming GeoSciEd conferences will be in Japan-2022 and US-2026. In 2018, we celebrated 110 years of the first Japanese immigration to Brazil. Thus, we, Brazilians, took the opportunity to consolidate the excellent relationship with the Japanese people and with the American people.

This volume consecrates the extensive contribution of specialists, researchers, professors, students and other interested in these fields, who submitted a total of 290 scientific papers, distributed in three auditoriums. Two-thirds of the works presented correspond to EnsinoGEO-2018, a fact that indicates the enormous willingness of the national community to show Brazilian and foreign colleagues the progress and scope of their research. With the decisive support of the Association of Teachers of Unicamp (ADunicamp), a Round Table was held on the Guarani Aquifer System. This is an interdisciplinary theme, as well as a critical one, of interest to Brazil, Argentina, Paraguay and Uruguay. Twelve teaching workshops were offered for teachers and students of basic education, both in the official language of the event (English) and in Portuguese. Five field trips were held by the end of the conference, which extended the exchange among the participants. Numerous groups of high school students attended the "Geoscientists of the Future" session, when they were able to share results of experiments and practical activities in Earth Sciences.

Participants from Argentina, Australia, Canada, Chile, France, India, England, Germany, Ireland, Italy, Japan, Morocco, Paraguay, Peru, Republic of Korea, South Africa, United Kingdom, and USA who traveled here experienced warm welcome. The national community had a decisive presence in all activities and meetings. We would like to record some goals, partially or fully achieved:

1. Although some previous editions of EnsinoGEO have published annals with full papers, the annals with complete papers from the GeoSciEd conference are published for the first time. A part of the articles was selected to compose a special edition of *Terræ Didatica*, the IG-Unicamp electronic magazine. It is hoped to increase the penetration and diffusion of the proposals contained in these studies.
2. The ties of the national community with researchers from the three Americas were strengthened during the event.
3. Also during the event, members of the Education Commission for High School level (COGEM) of the Brazilian Society of Geology started their work, aimed to increase the presence of Earth Sciences in Brazilian basic education.

The central theme of the two conferences (*Geosciences for all*) assumes, in this singular moment, the broader meaning of education as “a process of constant liberation of man”, in the exact sense formulated by Paulo Freire, the great Brazilian educator[1]. The team that focused intensively on the construction of the events shares the idea that the knowledge on Geosciences promotes autonomy of thinking, critical vision and construction of socio-cultural values and practices that help to chase the path of sustainability. We hope that the exchange provided by the debate in Campinas will disseminate this strategic vision and help to definitively abolish the culture of narcissistic individualism and unbridled competition that causes ruptures in the social tissue, instead of promoting cooperation and understanding among people.

The Editors,
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Summary

Opening Conference

Comunication and Divulgation of Geosciences

Education, Teaching of Geosciences and Teacher Training

Environmental Education, Sustainability Education and Geoethics

Geosciences and Science, Technology, Society and Environment

Geoconservation, Geotourism and Geopatrimony

Geosciences and Natural Sciences for Basic School

Geosciences in Higher Education

History of Natural Sciences

Technology and Educational Innovation

Opening Conference

A PERSPECTIVE FOR GEOSCIENCE EDUCATION FOR IMPROVING THE FUTURE OF HUMANITY

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Abstract— This is the complete version of the opening lecture of the conferences: 8th Quadrennial Conference of the International Geoscience Education Organisation (IGEO) – Geoscience for all –VIII GeoSciEd 2018, and VIII Simpósio Nacional de Ensino e História de Ciências da Terra / EnsinoGEO-2018 – Geociências para todos –.

Introduction

Good evening, ladies and gentlemen.

First of all, let me say I am not fluent in English – you will certainly notice – and I present my apologies for that.

I am deeply honored in being invited by professor Dal Ré Carneiro to address this speech in the opening of the VIII Geoscience Education meeting.

I would like to salute the distinguish board in the person of Pedro Wagner Gonçalves, Chairman of the Conferences.

About me, I can say I am neither an academic nor a teacher. I was an industrial petroleum geologist for about 50 years.

But geologists, as we know, are very curious people, always interested in what happens around.

Specifically, O&G is an industrial sector deeply involved with C&T and worldwide social, political and economical dimensions; petroleum geologists, to understand the entire extension of their profession have to be also concerned on these matters.

What I will modestly present to you now is a reflection of what I have tried to build about this theme, Geology Education, which has been interesting to me along my professional life.

I would like to tell you beforehand I am sure that what I will say here is not absolutely unknown for each one of you who is giving me the honour to be listened to.

I have divided my message in three parts:

1. The world we live in.
2. The importance of scientific dissemination to the general public, to the ordinary global citizen.
3. The benefit that the teaching of geological science basic knowledge can bring to the ordinary citizen, mainly young people and children.

Said this, let's see now the world in which we live nowadays.

1. The world we live in

World population = we are 7.6 – seven six billion of human beings. We will be 10 billion around 2050.

800,000,000 (eight hundred million) starve – from 2015 to 2016 it increased 40 million (forty million).

155,000,000 (one hundred fifty million) of children under 5 (five) starve or are submitted to severe undernourishment.

4,500,000,000 (four point five billion) people lack basic sanitation.

21,000,000,000 (two one billion) do not get hold of drinking water.

1.4 (one point four billion) do not have acceptable housing.

According to UN 2017 (twenty seventeen): 260,000,000 (two hundred sixty million) children and teenagers are out of school.

1,300,000,000 (one point three billion) of people have no access to electricity.

According to UN 900,000,000 (nine hundred million) or 12% (twelve percent of world population) defecate into the open air.

1 million of nurslings and children die before five, per year: 99% (ninety-nine percent) in poor and developing countries. 49/1,000 (forty-nine to each one thousand) live births.

800 mm (eight hundred million) of people are illiterate adults (over fifteen years old). Among the youngs, 1 (one) billion worldwide have no access to education.

There are more than 40 (forty) millions of slaves worldwide; more than 70% (seventy percents) are women.

According to UN, in every 10 women, worldwide, have been sexually raped or will be, in some moment of their lives.

Child prostitution reaches 1 million children. In some countries, 50% (fifty) percent of prostitutes are children.

2 (two) millions of teenagers are HIV (EITCH AI VI) carriers.

There were 66 (sixty-six) millions of refugees in 2017. 50 (fifty) percent are children.

Just only 1/3 of the countries – 28% (twenty – eight) percent of the world population – assure social protection from the state – health, education, housing – to their citizens.

In the other side of this coin, literally, 1% (one) percent richer = owns wealthy of 99% (ninety-nine) percent remaining.

The richest person in this world owns wealth bigger than the GDP of 140 countries.

About environment and nature

Species extinction in 2014 (twenty fourteen): 784 (seven hundred eight-four animal species were extinguished during the past 40 (forty) years.
Deforestation: 3.4 million km^2 deforested during the past 16 (sixteen) years.
Russia + Brazil: Taiga and the Amazon forest suffer a fast pace devastating process. 100 m (a hundred) thousand km^2 in 2017 (twenty seventeen), Canada + the USA = 50 m (fifty) thousand km^2 in 2017 (twenty seventeen).
The world consumption of natural resources and energy can triplicate until 2050 and result a catastrophic impact on the environment. The present consumption standards, mainly in the occident, are not sustainable.

This is an unacceptable reality.

One first conclusion: from these data, we can´t deny either try to hide that the political regime models of humanity governance and the current instruments and global multilateral institutions – UN, IMF, WB, WTO, FAO, ILO… – are shown to be totally outdated. They are not ready to recognize cultural diversities, to fight against racism, colonialism, sexism, discrimination, the prejudices and the huge social inequalities that are in the central heart of their own origin.

Also, regarding environment protection, they failed to present and adopt effective solutions of any type.

We all, humankind, are facing a totally unsustainable situation.

We have built a time bomb whose short fuse was already lighted.

And we all are seated on it.

It will socially, economically, environmentally explode, my friends!

Like a much bigger Krakatoa, to use a term we all know perfectly. But it can even be worst, as the forecasts about industrial activities indicate.

Industrial revolution 4.0 = (1) automation. (2) integrated and interconnected systems. (3) artificial intelligence, self-aware robots. (4) telecommunications.

It is estimated that on the next decade 5 (five) million workstation will be extinguished in OEDC countries and 15 (fifteen) million in developing countries.

Impact scholars of this revolution state that mankind should be reinvented to face this reality.

But there is a light in the end of this ghostly tunnel.

About telecommunications

Internet (2018): more than 4bb (four billion) of people (53% fifty three) percent, doubled in 8 (eight) years.
social networks = 3,2 (three two) billion (42% – forty-two percent).
mobile phones = 5,1 (five one billion – (68% sixty-eight percent).
mobile internet: 3bb (three billion) (40% forty percent).

Internet can certainly be – as we already are experiencing – a decisive tool to face the challenges we have in front of us.

2. The importance of scientific dissemination to the general public, to the ordinary global citizen

The second part of this message is based in a 2011 publication of Bahia State Federal University (1) with the title "*Diálogos entre Ciência e a Divulgação Científica – Leitura Contemporânea*" (Dialogues between Science ant the Scientific dissemination – contemporary readings), listed in the references below of this text that I have handled to the organizers of this event.

People and citizens interacting with the C&T themes, at present times, called "scientific culture" – play an important role to the contemporary societies political, social and economic life.

The final address of the scientific dissemination are widely the youths and the organized society in its different institutions.

The ordinary citizen, at last, becomes the scientific culture dissemination main addressee.

The knowledge and the scientific culture are the promoters of the critical citizen formation and decisive participants so that scientific work have as a result the global population social well- being involving principles and civilizing ethical values, besides attitudes, habits and information.

The consolidated concept that the access to the scientific information is, before being vital, indispensable to the total and participatory citizen formation, embodies ethic, social, politic, economic, and corporative worries and imposes that the disclosure of C&T transcends its academic circle and reaches effectively the whole society.

Social behavior is greatly influenced by knowledge, which enables the individual to understand and criticize the society and claim and strive for changings.

In other words, searching the continuous improvement of life quality with the aid of science is a guide to a commitment with the formation of true citizens and their participation into the positive transformation of the social and cultural relationships of all humanity.

The austro-english phylosopher Karl Popper [1902-1994] stated that:

> "Civilized citizens aren't the product by chance, but actually an education process."

Another reference is made to the French philosopher Michel Foucault:

> "There is no neutral knowledge, all knowledge is political".

Science and technology are closely related to citizenship and democracy.

The mobilization of people begins at knowledge acquisition.

So, science education and the formation of a science culture are, first of all, a transforming step, favorable to the individual, necessary cognitive and critical resources essential to his participation in the society.

The reverse of this is the “scientific illiteracy”, which consequences are much more dangerous today than in the past.

It is threatening the ordinary citizen to ignore the true causes of issues humanity faces today produced either by ourselves, human beings, our action (ethic, social, politic) or by natural unavoidable phenomena resulting from the permanent 5 billion year old transformation process of the planet Earth, like global warming.

We all should be ready to solve and to avoid the first ones and to attenuate the impact of the second on humankind. This depends upon the scientific/humanistic information common citizen knows. Instead of this, the called “scientific literacy” has been facing difficulty of performing itself, since this issue of taking the science to the ordinary citizen was mentioned in the XIX (nineteenth) century.

Scientists did not succeed in achieving the goal of building a widespread scientific culture in mankind, we must admit.

Why?

A lot of difficulties are faced in the building of a scientific culture in society.

Common citizens think that scientific and humanities knowledge are related to subjects, concepts and visions only related to the scientific and humanities communities.

So, they did not learn to link science-humanities to their lives and, as result, they are not comfortable to practice reflections about the world, the societies where they live in.

On the contrary, common people are easy targets to the big media, representing, in general, great political, financial and ideological interests.

So, common citizen is convinced since childhood, of non-civilizing anti-values and absurd anomalies as, for instance, the division of human beings in winners and losers.

It is necessary to promote people’s interest and enable the airtight scientific language into an accessible, light and pleasant message to the ordinary citizen.

Transform the science into something as cultural and social as art.

We have to consider scientific field under the vision of inserting it in the social, politic and economic context.

It is an issue that has persisted for a long time, and it has to be discussed: the division between natural sciences and that one called the humanities, in order to identify, between both, conciliation areas.

It has been common to accept a kind of bipolarity between natural sciences and the humanities.

There would be an insuperable abysm, sometimes with hostility and aversion between these two areas of human knowledge.

The pure scientific culture is intrinsic to the western culture and reveals itself as outdated, with a single base of human rationality.

Along the last decades, however, interdisciplinary and multidisciplinary fields stand out in many scientific areas, which have in their set and in their origins, elements that eliminate the barriers between the two cultures, the natural sciences and the humanities.

This way, the scientific fields most suitable to serve as a basis of attractiveness of the individual curiosity, are the suitable and effective tools to overcoming scientific illiteracy and to the building of a scientific/humanistic culture.

This is extremely important now, when we have got at a very special and decisive moment in mankind history: not only because the long list of ethic and social problems humankind is facing, as we already saw, but concerning to the already running on fourth industrial revolution.

It is not acceptable anymore that humankind goes on with such human tragedy, criminal extinction of other species and environmental havoc of large proportion.

The full and responsible global citizenship, worldwide, must perform a decisive role so that its implementation shall be pro people not impairing them.

There is no place nor time for wishful thinking.

The fourth industrial revolution must, compulsorily, contribute to the general well-being increase of all human beings, and it will not be this way, if the aware citizen does not mobilize himself and fight against or it will deepen even more the humane tragedy context that we see nowadays worldwide.

In an article – published in 2006 – by the magazine *The Futurist*, of WFS (2), Ray Kurzweil foresees, with great optimism, the future of humankind as result of the extra-ordinary scientific & technological development, at that time already on the road.

Other authors, however, following Kurzwiel’s predictions, do not agree. They affirm historically science and technology not always promoted social and economic advancements for the majority of the mankind.

They defend human life comprises a lot of experiences and fillings much more important than the simple material fruition promoted by scientific and technological development.

Some weeks ago, in an interview (3) to a Portuguese newspaper, the Italian philosopher Franco Berardi warns about the threats humankind will face in the future.

He focusses on the very negative aspects the financial ultracapitalism is bringing to the humankind, mainly in the western world, associated with the fourth industrial revolution.

But the 4.0 revolution has brought the worldwide dissemination of internet also.

The fantastic proficiency in providing, in real time, worldwide, to connected people in order to discuss problems and to find solutions, has created the basic conditions to raise the global citizenship. Internet and electronics are the perfect tools to be used to take the scientific-humanistic culture to the global common citizen, wherever he lives in this planet.

3 Benefits of teaching basic knowledge on Geological Science to ordinary citizen

It is easy to accept basic scientific/humanistic knowledge spreading foccused on the children – of course according with specific didactic tools – will be an effective, enriching contribution for the formation of future responsible citizenship, in spite of children may have contact with anti-civilized visions and attitudes throughout their lives until adulthood.

Thinking on the near future, it can seem an utopy, but it is possible to build a new scientific culture through the scientific literacy, which should begin at school, since the early life stage, in childhood.

The school role at elementary school at the formation of this “scientific culture” is decisive.

The extraordinary communication electronic tools available in the modern education systems are splendid to teach children.

The challenge is to create an educational system that explores the children and teenager’s curiosity and keeps their motivation to learn through lifetime and become a civilized citizen in every sense.

That said, let us try to imagine why and how Geology can contribute in dissemination of scientific-humanistic culture among humankind, and, very important, focusing our children.

In advance, I have to recognize the personal work, here in Brazil, in this university, of professor Dal Ré Carneiro, always concerned with Geology Education and direct responsible for the magazine *Terræ Didatica*, where this matter is permanently discussed.

Again: all what I will say here, you know perfectly.

As far as I’m concerned it is not difficult to us, geologists, in realizing the importance of our contribution.

First of all, because Geology is – maybe a rare exception among all scientific spectrum – a science markedly interdisciplinary and multidisciplinary, to represent a concrete “bridge” between the scientific and humanistic cultures.

This statement, nowadays accepted with relative ease in scientific circles, is largely because of Robert Frodeman’s extraordinary work “Geological reasoning: geology as an interpretative and historical science”, published by GSA in 1995 (4), translated to Portuguese in *Terræ Didatica*, 2010.

Frodeman confirms this brand of Geology when defends – ex-cathedra – that geology is not a science that comes from logic techniques, such as Physics. He says:

> “the geological thinking developed its own set distinct of logic procedures – what actually embodies a different methodology in the sciences context and offers a global model – better than physics – to understand the reasoning logic into sciences and daily life.”

In subsequent work (4), equally a benchmark, titled “the significance of geological time: cultural, educational, and economic frameworks”, 2012, also published by GSA (5), Cervato & Frodeman take up the agreement impact of the element “geological time” prints in the mankind history analyses with cultural, educational and economic consequences in the society.

Geology is not only the science that deals with the past of our planet and attempts to predict natural events envolving potential danger to human beings, until now with very few success, as the present astonishing lava flows in Hawaii.

Geology is a scientific-humanistic base for the humankind knowledge and reflection – ethical, ideological, political, social, economical, technological – about not only ourselves’ future, but also our responsibility on the preservation of environment and other living beings on this planet.

This is Geology.

To the effect of the elimination of the scientific illiteracy – it’s worth remember – some messages of Geology that can influence civilizing formation of the new global citizens, mainly when this information comes to them in childhood.

The most important and leading message is that planet Earth is integrated in a unique space, everywhere, in spite of being far from each other.

Besides this, Earth is a “living organism”, inasmuch as it has its proper ways and processes to change, to transform and to evolve by itself. It has been this way since its inception about 5 billion years.

Plate tectonics promotes a scientific understanding of our planet upon an unified, consolidated view of the Earth history as an integrated system of dynamic forces that shapes the planet’s surface.

An earthquake in New Zealand is greeted for new fumaroles in Stromboli.

All inhabitantes of this planet live in a whole and unique one place.

So, we are all together.

The New Zealander who feels the earthquake is not different from the Italian who recorded the fumaroles in stromboli, neither from the Brazilian in Copacabana Beach, that is drifting apart from Africa by 5 cm per year.

Simultaneously.

Regarding life itself, plate tectonics has brought us an extraordinary meaningful contribution.

It links every living beings, the entire land biota, in the origin of our own life, which coming up in this planet, happened around of fumaroles from the deep ocean trenchs, over 3 billions of years.

Geology teaches us we live not only in the same home, we have the same origin.

Our planet does not distinguish us, neither isolate us.

On the contrary, it belongs to us, it joins us.

Specifically concerning about our species, *Homo sapiens sapiens*, the same occurs.

We born along the East African Rift System, that begun 30 (thirty) millions years ago and, in the next 10 millions years will separate its eastern part from the African continent.

In the regions affected by that long crustal crack arised about 200 (two hundred) thousand years ago, our most ancient ancestral, whose descendants we are.

Geology, and just Geology, can bring us this scientific truth: we, all human beings, have the same origin, live in the same home, are all siblings.

This fact imposes us – as hegemonic species and infinitely the most intelligent of the entire earth’s biota – therefore, the ethical obligation to respect, defend and keep the survival of all living beings remaining on our planet.

Under the environmental viewpoint it is the same situation: the criminal firing of South American Amazon forest and the incredible devastation of taiga – Russia, impact the climate of all the planet which will affect everybody, from Artic Greenland Eskimo to the Brazilian Yanomani living inside the dense equatorial forest.

The central, most important message is: the planet Earth is the common home, of all of us, human beings and all the other beings living on int.

And, regarding humankind, we human beings, are all brothers.

We share the same destiny.

This is not a naïve statement.

This is Science.

These are some essentially geological information from scientific-humanistic culture that has to reach everybody worldwide, mainly our children.

So, Geology can, effectively, contribute to the humanistic-scientific illiteracy eradication of all citizens from this planet and to the formation of a true global citizenship, with principles and civilizing values and conscious of their ethical, political and social responsibilities with all mankind, with all the other living beings.

Global citizens have to know the meaning and to be acquainted with the term "Anthropocene".

That consciousness of our full responsibility to the planet Earth, as a whole, is revolutionary.

It is the basement, the bedrock, literally, to promote the building of a new, civilized humankind.

Everyone, all human beings, without exception, have the right of freedom, full democracy increasingly participatory, decent life, with equal opportunities for all, to live in a planetary society without hate, prejudices and exclusion.

It will be our today's children, who – as adults in close future, the true and effective global citizens – will fully understand and make to hold to, by all the humankind, the *Declaration of Human Rights* (6) (UN 1948, 70 years old and never went out from the paper) and the *State of the Planet Declaration – Planet Under Pressure*, 2011 (7).

As science, Geology will have finally fulfilled its mission – as all other Sciences – just for the benefit of mankind.

Thank you all.

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Thematic Line

Comunication and Divulgation of Geosciences

'COLECIONADORES DE OSSOS': A CASE STUDY OF GEOSCIENCE COMMUNICATION ON SOCIAL MEDIA

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Abstract----'Colecionadores de Ossos' is the largest Brazilian web of social media on paleontology and geosciences independently created and maintained by actual professionals in the field. The data here released is the result of several years of integrative work between the 'Colecionadores de Ossos' blog, Facebook Page, and YouTube channel. On the contrary of what is affirmed by the media on the juvenile interest on dinosaurs and paleontology, most of our visitors are aged between 18 and 44. There is a greater presence of males, females being more engaged in Facebook. Blog impact is very short nowadays, and there is also a decreasing interest in Facebook, with most of the public looking for our audiovisual alternatives. Dinosaurs are more than ever the gateway of public interest for the geosciences. The most effective communication to date comprises informal videos that provide a direct interaction between the audience and geoscientists.

KeywordsScience----Communication, Science Perception, Post-truth Era, Internet, Web, Education.

Thematic line----Communication and Dissemination of Geosciences.

1 Introduction

Social media are currently having a significant impact on science communication, both on the way scientists communicate with peers and on the dissemination of science to the general public. Social media provide an open space, where a diverse audience with different information needs can access scientific information and also interact with it. Through this kind of platform, scientists can talk to the public directly, informally, and sometimes in depth about several important, controversial or just curious scientific topics.

'Colecionadores de Ossos' (or 'Bone Collectors') is a collaborative initiative formed by Brazilian paleontologists, whose objective is to disseminate the science of paleontology and paleontological knowledge produced in Brazil to a diverse audience. It was first conceived as a blog, in 2010, where several colleagues cooperated writing posts in portuguese. Nonetheless, nowadays, the 'Bone Collectors' (BC) comprehends an integrate multilingual network of outreach media, including a blog (www.scienceblogs.com.br/colecionadores), a Web Site (www.colecionadoresdeossos.com), a YouTube channel (www.youtube.com/colecionadoresdeossos), and a Facebook page (www.facebook.com/colecionadoresdeossos). All content is produced, edited and published by a group of academics active in the Field (including the authors of this paper). All of them divide their time between research and scientific communication.

Herein we present information collected from BC's work on social media.

2 Material and Method

Any Web site that allows social interaction can be considered a social media, including social networking sites such as Facebook; video sites such as YouTube; and blogging platforms.

We used 'Google Analytics' (GA) and Facebook's own analytical tool to obtain data about BC's blog, YouTube channel, and Facebook page.

The YouTube data analysis considered the last four years (2014-2018), and the entire period since the channel was created (which was in early 2014). Data was obtained on February 25th, 2018.

The Facebook Page analysis considered all the available time interval, which was until June 2016, despite the page was created in 2013. Three time intervals were used for comparisons: June 2016 (the earliest data available for some metrics); April 2017 (arbitrarily chosen); and February 2018 (the most recent data available). Data was obtained on February 25th, 2018.

Precise metric data was not available for the blog. Since BC's blog is integrated to a larger platform ('Science Blogs Brazil') on Wordpress. 'Google Analytics' data could not be accessed for the individual blog, only the whole platform.

The information provided by analytical tools in the case of YouTube and Facebook is much richer. Both require user login to subscribe, so visitors information such as gender and age are available.

3 Results

3.1 The YouTube channel

BC's YouTube channel has 544,829 accumulated views, nearly 18,000 subscribers, and 2,657,573 minutes of exhibition time (Table 1). The average viewing time of the public for all period is 4:52 minutes. The last 365 days, however, showed a decrease in the average attention span, but this can be justified by the latest changes in YouTube's metrics.

Male presence in the channel is markedly greater (84%) and most of the subscribers are from Brazil (Tab. 2). The majority of followers are between 18 to 34 years old (Tab. 2), followed by users aged between 35 to 44.

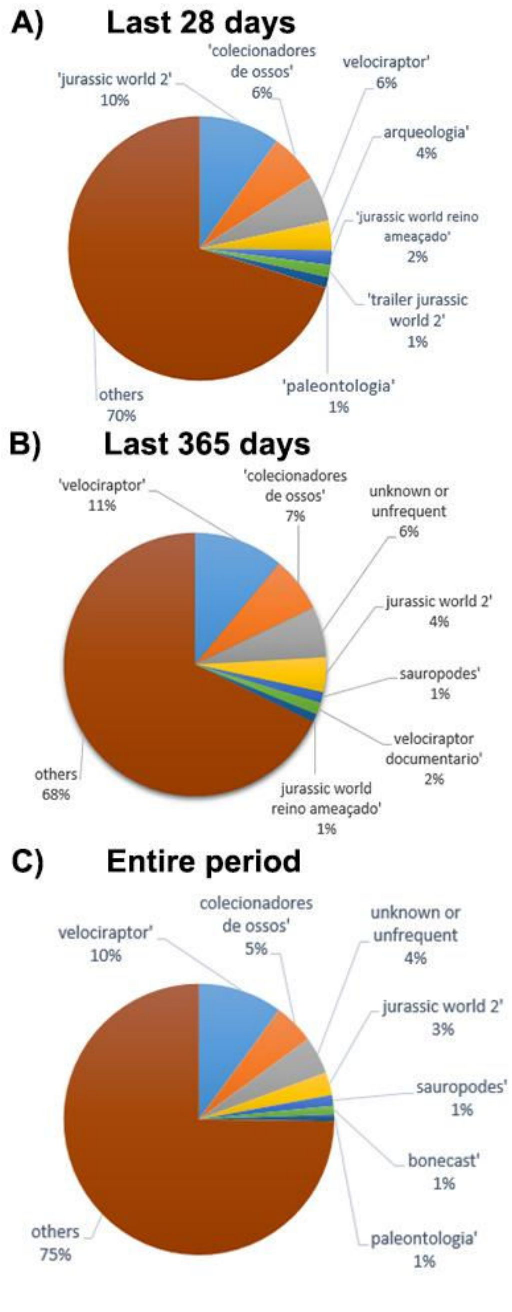

Figure 1. Most searched terms YouTube visitors use to reach BC's channel

The most sought terms of the entire period, which eventually lead to the channel, are 'Velociraptor', 'Colecionadores de Ossos' and 'Jurassic World', respectively. 'Archeology' and 'Jurassic World 2' were also popular browse words (see Fig. 1).

The most visualized playlists of all time were the 'Most Popular Videos' (48%) and 'BoneCasts' (40%), in contrast with the last 28 and 356 days, in which the 'BoneCasts' playlist was by far preferably visualized

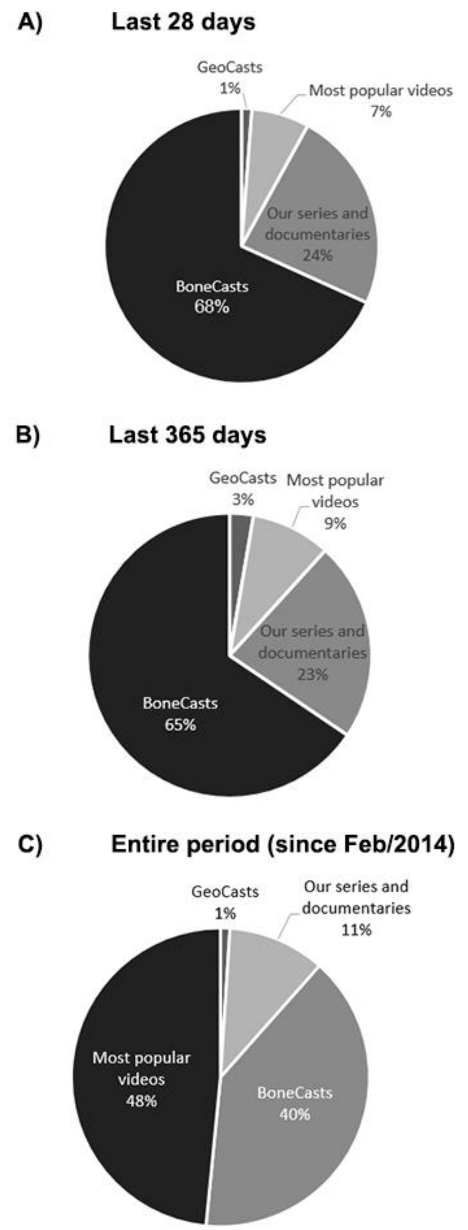

Figure 2. Most visualized playlists (subjects) in 'Colecionadores de Ossos/Bone Collectors' YouTube channel

Table 1. General view of the 'Colecionadores de Ossos/Bone Collectors' YouTube channel in numbers

	Jan/14 to Jan/15	Jan/015 to Jan/16	Jan/16 to Jan/17	Jan/17 to Jan/18	All Period
Total views	3,579	81,105	164,952	244,548	544,829
Average viewing time (minutes)	1:44	4:04	6:58	3:57	4:52
Subscribers	61	2,177	9,519	5,177	17,931
'Likes' / 'Dislikes'	100%	98.8%	99,6%	97.9%	98.1%
Comments	18	146	498	1,209	2,135

Table 2. Public profile of the 'Colecionadores de Ossos/ Bone Collectors' *YouTube* subscribers

	Last 28 days	Last 365 days	All Period
Female/Male presence	18.4%/81.6%	17.8%/82.2%	16%/84%
Brazilian subscribers	97.9%	74.1%	46.6%
Users aged up to 17	8.9%	7.6%	6.4%
Users aged from 18 to 24	29.4%	31.1%	32%
Users aged from 25 to 34	36%	38.4%	40.9%
Users aged from 35 to 44	19%	16.4%	14.8%
Users aged 45 and up	6.6%	6.4%	6%

3.2 Facebook Page

BC's Facebook page has 12,277 'Likes' and 12,189 followers. The average organic post reach between February 25th, 2016, and February 25th, 2018, was 3,915 users. The maximum organic post reach in the same period was 27,582 users. Post reach in BC's Facebook page apparently decreased over time, and particularly in the last six months (Fig. 3).

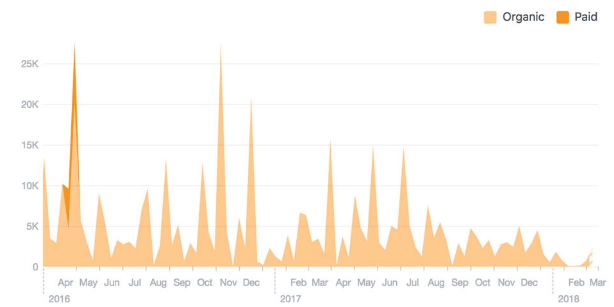

Figure 3. Post Reach of the 'Colecionadores de Ossos' Facebook page between February 2016 and February 2018

Since 2016, user interactions also considerably decreased over time (Table 4, see 'Follow/Unfollow' and 'Like/Dislike' rates; and Fig.4).

Table 4. General view of the 'Colecionadores de Ossos' *Facebook* page over intervals of 10 months since June 2016

	Jun 2016	Apr 2017	Feb 2018
Total followers	8,311	11,170	12,183
'Follow' / 'Unfollow'	93.8%	50%	60%
'Like' / 'Dislike'	94.7%	50%	25%
Average organic post reach	2,746	3,281	1,369

Regarding the BC's Facebook page public, most of the followers are male (61%), but females are proportionally more engaged (Table 5). People between 18 and 34 years makes up the majority of followers and the age range between 25 and 34 is the more proportionally committed.

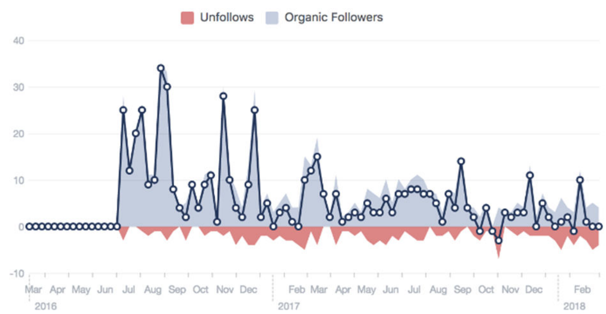

Figure 4. 'Organic follows' versus 'unfollows' of the 'Colecionadores de Ossos' Facebook page between June 2016 and February 2018

The great majority of the followers are Brazilians (91.9%). After them there are Mexicans (1.66%), U.S.A. citizens (1.3%), Portuguese (1.25%), and Argentinians (0.94%). People from Spanish-speaking countries comprehend 5.23% of the total followers.

Table 5. Public profile of the 'Colecionadores de Ossos' *Facebook* followers

	Followers	People reached	People engaged
Female presence	39%	47%	42%
Male presence	61%	52%	57%
Users up to 17	1 to 2%	1%	0.75 to 1%
Users from 18 to 24	14 to 20%	16%	12 to 19%
Users from 25 to 34	13 to 21%	18 to 21%	17 to 22%
Users from 35 to 44	5%	7 to 9%	6 to 8%
Users from 45 and up	4.78 to 7%	4.8 to 4.9%	5.75 to 7%

3.3 The blog

BC's blog started in April 2010 in the Blogger platform. Soon, it started gaining attention and at the end of 2011, the blog was elected to integrate an invitation-only network of Brazilian Science Blogs called 'Science Blogs Brazil' (SBBr). SBBr platform is housed in Wordpress and has at least 40 blogs covering different scientific areas, divided between 'Universe', 'Life', 'Earth' and 'Humanity' (see http://www.scienceblogs.com.br). From this cooperation, BC's blog gained much more popularity, since the 'Science Blogs' platform (operated by Seed Media Group) is worldwide recognized by the quality and trust of the science blogs that integrate it.

It was possible to observe an increase of the public and also of the interactions with the blog posts from 2011 until 2013 when there was a significant decrease in the interest for blogs in general.

The actual metrics for SBBr (Table 6) indicate there was an average of 2,200 visitors per blogs in February 2018, a little above the metric of the entire last year period (1,825). The BC's blog has been fed less frequently since 2015, on an average of one post per month. But there are still a considerable amount of people who interact with the blog posts. The last five blog posts received more than 200 'likes'. And one of them, related to 'Pleistocene Megafauna', received more than 450 'likes'.

Table 6. Metrics from the whole ScienceBlogs Brazil web (~40 blogs) which includes 'Colecionadores de Ossos'

	Last 28 days	Last 365 days
Monthly visitors	88,000	73,000
Monthly visitors per number of blogs	2,200	1,825
Weekly visitors	13,000	15,000
Daily visitors	3,600	1,700
Portuguese speakers	88%	88%

4 Discussion

4.1 YouTube channel

Currently, BC is one of the worldwide largest, if not the largest, YouTube channel focused in paleontology and conducted independently by a group of active researchers in the field. Its outreach could be higher if the channel had consistency in posting. Having a schedule, and sticking to it, is one of the ways recommended by YouTube consultants to grow subscriber base and keep the existing subscribers engaged. Also, establishing a specific day and time to post the videos is highly advocated. However, it is very difficult to maintain periodicity and constancy in a journey divided between research, formal teaching and science communication. The engaged parts need to write the video scripts, film, edit the media and upload the final product to YouTube. This is time and also money consuming since quality videos demand the acquisition of special equipment and editing software.

This whole endeavor is an overload little rewarded for the scientist willing to communicate. There is no specific funding support for it and the activity is not recognized or repaid in opportunities for promotion or career development. Actually, this incursion is sometimes negatively seen by managers and research peers, which is extremely discouraging (Stewart & Nield 2013).

It is important to remember that if a scientist does not accept the responsibility for communicating its own work, someone who understands less or does not understand at all, about science will be communicating it. Or even worse, it will not be communicated at all (see discussion in Stewart & Nield 2013). This is extremely worrying in the post-truth era in which we are living, for there is again the rise of pseudosciences and the spreading of fake-news (Lilienfield 2018).

Analyzing BC's YouTube channel audience, on the contrary of what is generally affirmed by the media regarding the higher infant interest on dinosaurs and paleontology, most of our visitors are aged between 18 and 44 years old (around 85%). This is probably explained by the way the channel is presented, including its visual language and the depth of discussions, even if dinosaur videos are recurring. There is, however, a subtle growing engagement of people aged 17 and younger (from 6.4 to 8.9%), after the releasing of videos about the *Jurassic Park* (JP) franchise.

The female presence in the channel is worryingly very low (16%). This probably reflects a serious problem involving a broader situation, beyond the scope of this article, which is the representation of women in science. Geosciences still broadly stereotyped as a masculine interest. And even with one of the channel hosts being a successful female scientist, the sense of recognition of the female audience remains very low. After attempts in some videos to reinforce the role of women in sciences and warnings for prejudices, female subscribers slightly increased (from 16% to 18.4%), but hate speeches and anti-feminist comments have emerged. The Internet provides a shield of anonymity for individuals who propagate hate speech and the herd dilution effect causes negative comments to increase more and more over time.

The ever-growing number of subscribers and comments in the channel, and the very high involvement ('like/dislike') ratio (never below 95%) is an indicator that there is a considerable interest in the themes being discussed.

The channel's average viewing time can be considered good or reasonable inasmuch as the channel videos are between five and six minutes in duration on average.

The terms YouTube visitors search (and end up finding BC's channel) show the high repercussion entertainment media has on the general public, especially the JP franchise. In the last year, there was a noticeable growing influence of '*Jurassic World*' (JW) movies into the public's interest. This is reinforced by the most popular video (nearly 95,000 views) is this a reaction to the JW sequel trailer, under the eye of science.

Another indirect influence of the JP franchise is the major interest in the dinosaur taxon *Velociraptor*, which was largely popularized by these movies. 'Velociraptor' is a term constantly searched.

It is also interesting to highlight that a considerable amount of people reach BC's YouTube content looking for the word 'archeology'. In fact, people end up in BC's channel four times more often using the term 'archeology' than 'paleontology'. This can be partly a reflection of people not understanding the difference between these two sciences (see Clark 2008 for example) and/or really a greater interest in archeology, which have long been popular within the general public.

A very small number of visitors end up to our channel looking for the term 'geology'. This may be a consequence of a long-term lack of geological information available to the general public (Stewart & Nield 2013). This fact highlights the urge to produce more content about further geological themes other than paleontology.

The content in BC's channel is subdivided into four playlists:

- Series and short documentaries produced by the channel's own authors. They present formal narratives focusing in paleontology.
- 'BoneCasts'. Videos informally presenting many concepts, new discoveries and studies in paleontology. These include interviews with paleontologists from distinct areas and from different parts of the world.
- 'GeoCasts'. The same concept of the 'BoneCasts', but more related to other geological themes. Most material is filmed during fieldworks and presented as a live-action.

- The most popular videos on the channel.

Considering the entire period of time, the preferred BC's playlist was the 'Most popular videos', which can be partially explained by how YouTube suggests videos to its users. One of the YouTube's criteria is based on the number of views, so people are guided/invited to watch this content. 'BoneCasts' was the second most viewed playlist of the entire time, which may reflect the number of videos it contains (47), followed by the 'Series and short documentaries' content (14 videos). 'GeoCasts' was the least viewed playlist, what can be explained by the fact it is still a very new enterprise in the channel (it started in 2017) and it has only seven uploaded videos until now. 'GeoCasts', however, stands out for the number of mean views per video and the nice community engagement.

Over time it seems audience changed its behavior and preference since, in the last year, users are more often actively seeking the 'BoneCasts' playlist, followed by the 'Series and documentaries'. 'Most popular videos' strongly fell among public's choice, which seems the audience is being more selective about what it wants to watch.

Observing carefully user comments there is a significative preference for videos with outdoor filming, *in-situ* explanations and adventurous situations with a 'real exploration' narrative. It is also noticeable a more mature audience in the 'GeoCasts' when compared with the 'BoneCasts' videos. Especially regarding the dinosaur-related content.

Also considering user interactions, there was an increase in the volume of negative reactions and 'haters' following the publication of videos talking about the 'scientific mistakes of *Jurassic Park/World* franchise', feathered dinosaurs, and prejudice against women in science. This is probably a reflection of the post-truth society, which significantly appreciates beliefs above reason (Pavić & Šundalić 2017). Besides that, as Gross (2006) and Stewart & Nield (2013) observed, "science happens ahead of the rate at which people can adjust their cognitive framework to make sense of it". And if an information is not consistent with their beliefs and values, they are most likely to misconceive, ignore or even go against it (e.g. Colbert & Durfee 2004).

Finally, after a critical look at all the preferred videos in terms of views and interactions, it seems that content in Portuguese is significantly more popular than content in other languages, even with subtitles in Portuguese always available. This is possibly explained by the majority of channel followers being Brazilian. This audience probably as soon as recognizes a language barrier, promptly rejects the content.

Despite the larger amount of published content and greater community involvement, there was an attenuation on the fast-growing curve of subscribers in 2017 (+5,177 subscribers) compared to that of 2016 (+9,519 subscribers) (see Table 1). This was a negative effect of the latest changes in YouTube's metrics.

4.2 Facebook page

BC's Facebook is one of the largest Latin American paleontology-focused pages moderated and fed by active paleontologists. The page was created in 2013 and since then, fed daily with paleontological news, research articles links, curiosities, and fun posts in many languages, mostly English, Portuguese and Spanish. The English and Spanish posts most of the time are not translated to Portuguese for lack of time of the authors.

The BC's Facebook page demonstrated a slow increase in followers since 2016. A much lower rate than the way the BC's Youtube channel grew. The interaction with the Facebook page, however, decreased over time, suggesting a decline in public interest.

In 2017, Facebook has changed the way things are shown in people's feeds. The likelihood a post from any page followed by the user being shown on the user's feed has decreased. This may partially explain the drop in engagement. Also, in the last six months, there was a noticeable decrease in page feeding by the authors because they were more dedicated to field and research activities.

The age curve of the BC's Facebook page is more inclined to a younger audience than in the BC's YouTube channel. Most BC's Facebook page followers are between 18 and 34 years old. The type of content posted on the page may be attracting more young people, especially posts with jokes and fun fact about paleontology.

Despite females representing only 39% of followers, BC's page posts reach both genders nearly equally (47%/52%) (See Table 5). This highlights that women are proportionally more open to engaging with content.

The notable greater participation of females on BC's Facebook (39%) than on YouTube (18.9%) should be analysed carefully. Among internet users, it is known a greater percentage of women use Facebook, but the difference is not so great (Duggan & Brenner 2013). Maybe women feel more inclined to participate in Facebook because they receive less hate and harassment comments from anonymous users, when engaging with contents. On Facebook it is harder to hide behind a shield of anonymity, so hate speeches are less common.

4.3 Blog

The blogging trend started to decline worldwide around 2010, mostly because of the rise of Tumblr, Twitter and finally YouTube (Kopytoff 2011). The decline among the Brazilian public apparently began a little later, but this fact still needs to be studied and confirmed.

Despite the observed world 'blog crisis', the interaction with the BC's blog continues, demonstrating that a portion of the public still seeks such elaborated content, which is very useful for school and college work, for example. Also, it is possible to observe that the comments in BC's blog posts are more usually made by more literate people, sometimes engaging in extensive discussions about the exposed content.

5 Conclusions

It was clear from our perspective, that since 2014 there was an increase in preference for audiovisual content instead of written media. Also, that there is a growing predilection for shorter content, that does not take much time from the viewer/reader. This tendency suggests that we should invest more broadly in audiovisual, with the production of short videos (between 3 and 5 minutes). Also, that live-action content showing scientists in the field is preferred by the audience and may conquer a larger public. Furthermore, there is a need for more geology-driven material, outside the paleontology scope. There is a lack of this type of content available in Portuguese on the internet.

It is important to remember that despite the clear influence of broadcast media tendencies, each analyzed social media consist of a different form of communication, which impacts distinct audiences. Therefore, using different media makes communication more inclusive.

Each analyzed space can be exploited for different disclosure reasons. Blogs allow a wide space for discussion and content presentation. YouTube allows the content producer to give more emotion to the subject, with a high visual and sounding appeal. And finally, through Facebook, you can work with "information pills" and redirect the audience to other interesting material. The "platform character" of BC, acting on different fronts of communication, has proven to be a very successful formula. One media feeds the other and the public has only increased over the years.

Regarding the effectiveness of public outreach through the experimented social media, we conclude blogs may be really losing relevance, while Facebook is still important, and YouTube remains the "fashion" of the moment until something new and revolutionary appear.

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DIDACTIC TRANSPOSITION OF THE SCIENTIFIC LANGUAGE IN GEOSCIENCES PUBLICIZED BY THE PRESS MEDIA FOR NON-SPECIALISTS

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Abstract— This work integrates a research project in development that has as its theme the didactic transposition of the scientific language in Geosciences to the non-specialized public. The topic addresses the difficulty that the non-specialized public has in understanding the symbols, codes and signs used in content of scientific articles and the need to transform them into a language suitable for this audience so that information can be disseminated. Specifically in this work, the objective was to present a didactic transposition proposal for the scientific language in Geosciences published through the print media and to discuss the role of the mediatization of this type of language. As a methodological procedure, a theoretical review was carried out and a path of analytical reading and scientific article in Geosciences was proposed to reflect on the mediatization of scientific language. The results demonstrate that the mediation of scientific language in Geosciences is a theme still under construction that does not necessarily follow the traditional journalistic media, but can be reinvented in the perspective of another journalistic logic.

Keywords— Journalist, transposition through media, Geosciences, non-specialized public.

Thematic Line — Comunication and Divulgation of Geosciences.

1 Introduction

We know that stories are useful in the transmission of values, giving reason to human behavior, dealing with abstract issues, difficult to understand by the unspecialized public when isolated from the context. The stories develop critical sense, build an active personality and work reasoning and opinion formation.

However, it is not enough to tell stories as in journalistic texts or educational texts to instigate the non-specialized public to read them, to become interested in them and to understand the importance of reading and writing in their daily development. It is necessary to direct and bring this audience closer to the development of oral and written language skills, to the understanding and appreciation of knowledge, including scientific knowledge. In this sense, scientific literacy and the didactic transposition of scientific language to the non-specialized public becomes a central issue, which is addressed in this work.

2 Dewey: Progressive School and its philosophy and José Reis with the Scientific Divulgation

The logical theory or the essence of the hypothesis broadly presented by Dewey (1953) is defined as a scientific method. This method not only summarizes the study of men's daily life but also customs and behaviors, this method covers all areas of human knowledge. The process of acquiring human knowledge, Dewey (1953), defines as a logic or theory: "Logic - theory of inquiry".

If we think: How do we acquire knowledge? The answer would be that man does not come from knowledge as a product that has an end; ends; has a validity; or exhausts the possibilities, man starts from the existing facts, what he sees and perceives in his experience, in his day-to-day life. Another question we can ask is what does man do or how does man do to gain knowledge? Describing here the human experience of knowledge, we will find the necessary elements for a theory of this unique experience, that is, the theory of research seeking knowledge in the very logic of its objective. Knowledge, as Dewey (1955) says,

> "is the result of an activity that originates in a situation of perplexity and that ends with the resolution of this situation".

Knowledge is the controlling element of a given situation, and perplexity is an indeterminate situation. If in the daily life of our existence, everything happens and occurs in a situation of perfect balance, there is, therefore, no need to seek knowledge or knowing, only act automatically and recognize what is known.

When there is no balance between what to do and what to do in the face of a strange situation with no meaning, or when something unexpected happens, a disturbance out of control or in the zone of comfort, it seems that the world is falling in the head. To seek to understand and to perceive what happens through observation or / and asking questions for a possible solution through verification or investigation is less complicated and painful, that is, it reestablishes the balance through acquired knowledge and proceeds daily activity.

Anísio Teixeira warns us through his words on the basis of Dewey's logic theory, written in the Brazilian Journal of Pedagogical Studies (1955. p.3-27) says that "Knowing, knowing is thus an operation, an action that transforms the world and restores the balance". The person with knowledge tends to have more security and tranquility in himself and in solving problems in daily life. Having peace of mind and giving free passage to life through knowledge is one of the proposals. Staying in an indeterminate situation becomes determined because one has control because of the knowledge that has been acquired.

> "To know, therefore, not to learn notions already known, is not to familiarize oneself with the previous baggage of information and knowledge; but to discover them again, operating as if we were their original discoverers. Taking the knowledge already formulated or pointing to this knowledge is not, says Dewey expressly, a case of knowledge, much as taking a chisel from a toolbox is not making this chisel". (Teixeira 1955, p.3-27).

Dewey's logic and its corresponding theory of knowledge, on the other hand, make experimental operation essential to the process of knowledge. Logic is not the theory of "acquired knowledge" nor that of its "demonstration"; but rather the theory of the "process of acquiring knowledge," in which "acquired knowledge" is the limiting term, the final term.

It is not enough to have the knowledge acquired if we cannot value the importance of research and science, in order to become aware of this knowledge that Dewey refers to and to bring knowledge closer to society, only then will scientists and scientific institutions have the support deserved and necessary of this population and of the governments and, in this way, would obtain more finances and investments in the area. José Reis, a prominent figure both in the construction of Brazilian science and in the scientific dissemination of our country, acted as a scientific disseminator, legitimizing and supporting the development of science and scientific research in Brazil.

Reis was present at a time of mobilization of the scientific community, marked by the creation of SBPC (1948), in which Reis was one of the founders, and in support of the creation of CNPq (1951) and Fapesp (1960). Reis used the term "scientific incomprehension" to explain this lack of awareness on the part of society in general and governments of the role and importance of science as a foundation in the development of a "civilized" and prosperous country. Reis claimed in the 1940s that scientific activity was still not seen with good eyes by many, as in the following passage:

> "The incomprehension of science is still very great in our country. At all times we find "practical men" twisting their noses at research and research. When these men are in government, they are against appropriations for laboratories and librarians who direct the red pencil of budget cuts. And if they want to save on staff costs, then they think of mutilating the salaries of those in the public administration who dedicate themselves to the work of science". (Folha da Manhã, 31 de julho de 1947, p.4).

According to Reis, these "practical men" still viewed scientific activity as a waste of money. And this worried him, for many of these men, when they were in government, would be against or would cut off the money for laboratories and scientific activities when necessary. Therefore, scientific dissemination would be so important as it would create a mentality of support for scientists and scientific practice.

3 Confrontation between the traditional journalistic media versus new possibilities of medialization

For the scientific divulgation it is used the television news that is the main information that the majority of Brazilians has of the world that surrounds them. In this sense, the news media occupies a significant dimension in the construction of the scientific reality, and many journalists, communists and other professionals, question whether journalism is science. In an interview with the portal, "Communicate," Chaparro (1999) says that journalism is not science, much less scientific journalism, and argues that the journalist's job is not to produce knowledge but to socialize it, and concludes that: "it is not up to journalism to venerate science".

For Pena (2005), there is scientific journalism and explains that this is an instrument that aims to popularize science and even can be used as a tool to educate people. Scientific journalism is the most effective instrument of popularization of scientific knowledge, enabling its appropriation by society and serving as a tool of education for science. Also defined as the specialization of journalistic activity directed to cover science and technology (C & t) (Pena 2005 apud Ritton, p.109).

We understand that media with its technologies become responsible for disseminating information and knowledge to the society that has "authorized" it to represent it in events occurring in the world, for example, scientific. Educators use these materials in classrooms as a way of interpreting language, and in approaching citizenship issues with their students, as they know of the ethical and moral responsibility communicators have when publishing a fact.

Another issue to be discussed with the elimination and / or reduction of scientific illiteracy is the close relationship between scientists and journalists, which can be built for the process of developing and disseminating the news. According to Oliveira (2005), there are journalists who only copy in full what they have heard from the interviewer or try to interpret in their own way what they did not understand, which makes the communication vehicles inform texts that are not understandable, incomplete or wrong for the public. This conflict relationship is a two-way street, because on the one hand scientists complain about the lack of preparation and basic knowledge about the subject addressed and the lack of attention.

On the other hand, journalists complain about cybercriminals, claiming that they are intransigent and reluctant to pass on information, as well as communicating with technical terms of the area, which makes it difficult to understand the topic, providing erroneous interpretations and simplifications. Scientists as well as journalists should first and foremost have the same purpose, to think about the good of society that depend directly or not on their work to make personal and professional decisions in their lives. We believe it's up to them to communicate more and be tolerant of each other.

Attentive to this problem of reducing scientific illiteracy is the close relationship between scientists and journalists, this work proposes an approximation of these two professionals – journalist and scientist as a possibility of mediation between the scientific article and a different methodology, used in traditional journalism and known as lead; by most authors, lead is the opening, the most important part of journalism, the synthetic paragraph that must seek to answer the traditional questions: what ?, who

?, when ?, where ?, how ?, it's because? (AMARAL, 1978, p.66-68).

The word lead originates in the English language and its literal translation into Portuguese is linked to al-guns meanings such as: lead, guide and lead. In journalism, the lead "expresses exactly the function of the first lines of the newspaper text: to guide the reader, to attract him, in a process very close to seduction" (Garcia 1996, p.31).

Our proposal is to develop a methodology that makes possible the joint work between the scientist and the journalist for the purpose of diffusion to non-specialized public of information in Geosciences. The proposal also foresees using the lead tool so important and used in traditional journalism.

4 Objective

To present a didactic transposition proposal for the scientific language in Geosciences published through the print media and to discuss the role of mediation in this type of language.

5 Methodology

All the work of the scientist requires an effort, a dedication. Every scientific experiment needs the financial resources and available time of the scientist, because in addition to the experiments the scientist needs to register in the form of a scientific article that is the result of the constant work of the researcher who observed, investigated, analyzed, experimented, interpreted and reconstituted knowledge both in their respective areas of activity and in other correlates and this knowledge recorded in the form of written content.

The data generated in the surveys are generally analyzed and recorded in the scientific article, which are restricted to the academic class, preventing access to the non-specialized public, for example, cultural associations, religious authorities, banks, libraries, candidates for entrance exams, clubs, consultants, consumers prospective, charitable and charitable organizations, future employees, non-governmental organizations, political parties and isolated individuals.

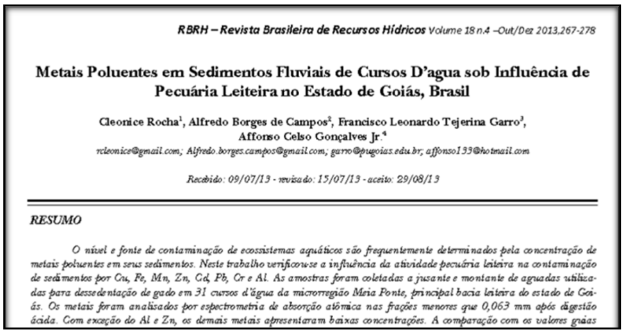
The scientific paper is often forgotten or lost for lack of access or has not been disclosed; did not arouse interest in society; thinking about this possibility some questions were asked: the non-specialized public does not have access to the content and data of the research because there was not enough disclosure to meet this demand ?; the symbols, codes and signs in written and scientific language make it difficult to understand the content and data for this audience ?; and one last question that aroused the interest of our research: if the contents and data of the scientific article were in another language would be more appropriate for the understanding of this public?.

With these inquiries we seek support in tools such as the analytical reading and the file to make the mediatic transposition of knowledge presented in the scientific article "Pollutant metals in fluvial sediments of water courses under the influence of dairy cattle in the state of Goiás, Brazil" codes, symbols and signs of the area of Geosciences. To this end, we propose a methodology to convert the text of this article into another language.

This section is subdivided into two blocks to report on the methodological procedures used in the research development: article choice, tools used to convert the scientific article. The following are detailed procedures.

5.1 The choice of article

We chose the scientific paper "Pollutants in river sediments of watercourses under the influence of dairy cattle in the state of Goiás, Brazil" by the authors Cleonice Rocha, Alfredo Borges De-Campos, Francisco Leonardo Tejerina Garro and Affonso Celso Gonçalves Jr., for be an article with empirical data obtained in a case study in the area of Geosciences (Fig. 1). Trusted by journalists and analyzed by the authors of the article, these were Analytical Reading and Registration, as shown in (Fig. 2).


RBRH – Revista Brasileira de Recursos Hídricos Volume 18 n.4 –Out/Dez 2013,267-278

Metais Poluentes em Sedimentos Fluviais de Cursos D'agua sob Influência de Pecuária Leiteira no Estado de Goiás, Brasil

Cleonice Rocha[1], Alfredo Borges de Campos[2], Francisco Leonardo Tejerina Garro[3], Affonso Celso Gonçalves Jr.[4]

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RESUMO

O nível e fonte de contaminação de ecossistemas aquáticos são frequentemente determinados pela concentração de metais poluentes em seus sedimentos. Neste trabalho verificou-se a influência da atividade pecuária leiteira na contaminação de sedimentos por Cu, Fe, Mn, Zn, Cd, Pb, Cr e Al. As amostras foram coletadas a jusante e montante de aguadas utilizadas para dessedentação de gado em 31 cursos d'água da microrregião Meia Ponte, principal bacia leiteira do estado de Goiás. Os metais foram analisados por espectrometria de absorção atômica nas frações menores que 0,063 mm após digestão ácida. Com exceção do Al e Zn, os demais metais apresentaram baixas concentrações. A comparação com os valores guias

Figure 1. Part of the initial page of the scientific article containing the data of the publication in print and the style of scientific writing.

The choice of the article considered the fact that one of the authors, with interest and involvement in the process of converting the knowledge generated in the research to printed material, could be an easily accessible interlocutor.

5.2 Tools used for didactic transposition of the scientific article.

The tools used for the didactic transposition proposed in this research were chosen considering the reading process to make possible and feasible to be constructed by journalists and analyzed by the authors of the article, these were Analytical Reading and Registration, as shown in (Fig. 2).

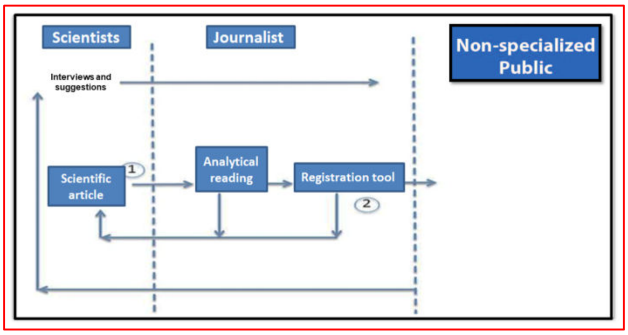

Figure 2. Image of the Experimental Flowchart

6 - Results and Discussion

6.1 Moment one: Analytical Reading

The selection and collection of information was carried out through the analytical reading of the scientific article. There were four readings of the article, three for the comprehension of the text and one for the selection and collection of the technical information pointed out in the article, according to Figure 3.

Analytical Reading of the Scientific Article

Text:
"Metais poluentes em sedimentos fluviais de cursos d'agua sob influência de pecuária leiteira no estado de Goiás, Brasil"

Abstract:
O nível e fonte de contaminação de ecossistemas aquáticos são frequentemente determinados pela concentração de metais poluentes em seus sedimentos. Neste trabalho verificou-se a influência da atividade pecuária leiteira na contaminação de sedimentos por Cu, Fe, Mn, Zn, Cd, Pb, Cr e Al. As amostras foram coletadas a jusante e montante de aguadas utilizadas para dessedentação de gado em 31 cursos d'água da microrregião Meia Ponte, principal bacia leiteira do estado de Goiás.
Os metais foram analisados por espectrometria de absorção atômica nas frações menores que 0,063 mm após digestão ácida. Com exceção do Al e Zn, os demais metais apresentaram baixas concentrações. A comparação com os valores guias canadense de qualidade de sedimentos (VGQS) mostrou que o Zn apresenta risco potencial de contaminação da biota, enquanto o Cu, Cd, Pb e Cr apresentam baixo risco. O Zn apresentou maior concentração a

Figure 3. Part of the initial page of the scientific article

6.2 Moment two: Registration

At that moment we collect information from the use of the Registration tool. This tool was elaborated and made available for the research project by Professor Jorge Megid Neto of the Faculty of Education of Unicamp, 2016.

The tool has 15 items to select, organize and record pertinent information of the scientific article. The tools are:

1- Article references (author, title, magazine, city, vol./num., Month/year, p.);
2- Topic of the Study;
3- Problematic;
4- Problem / Issues;
5- Objective;
6- Methodological procedures (brief description);
7- Subjects Researchers (researcher);
8- Object investigated or Investigated subject (population or educational situation or documents etc.);
9- Instruments and Tools of data collection;
10- Data source (live and / or documentary);
11- Data analysis technique;
12- Categories of analysis;
13- Theoretical referential;
14- Research paradigm (positivism, social constructivism, post-positivism, critic, etc.);
15- Personal comments about the article / survey.

It is observed that in developing the methodology of the printed medium, it was necessary in the first moment of two tests until the approval of the scientist responsible for the scientific article and interlocutor of the research process. (Fig. 4).

Registration Tool

Text:
"Metais poluentes em sedimentos fluviais de cursos d'agua sob influência de pecuária leiteira no estado de Goiás, Brasil"

1- Article references (author, title, magazine, city, vol./num., Month / year, p.)

Metais Poluentes em Sedimentos Fluviais de Cursos D'agua sob influência de Pecuária Leiteira no Estado de Goiás, Brasil – Cleonice Rocha, Alfredo Borges de Campos, Francisco Leonardo Tejerina Garro, Affonso Celso Gonçalves Jr.

2- Topic of the Study
Contaminação de ecossistema aquáticos pela concentração de metais poluentes.

3. Problematic
Influência da atividade pecuária leiteira na contaminação de sedimentos por Cu, Fe, Mn, Zn, Cd, Pb, Cr, e Al.

Figure 4. Registration tool - data capture of the scientific article

6.3 Lead of the 50s versus New possibility of constructing information in Geosciences

The explanations for the rise of the lead in journalism are the most varied. One of the comments, according to Fontcuberta (1993), arose with the War of the Secession in the United States. After the struggles, the author explains, the journalists wanted to send their stories to the newsroom and depended on the telegraph. Due to the "short time", Fontcuberta says that journalists avoided giving opinions and were only concerned with the "essential" of events.

Telegraph operators have developed a lead method to give preference to journalists. This is the origin of the lead in journalism, according to Fontcuerta, a method that is still in force today. Pompeu de Souza, in 1950, in the Diário Carioca introduced the lead in Brazil.

Our methodological proposal for the didactic transposition of the Scientific Language in Geosciences through print media for the non-specialized public advances in comparison with traditional journalism in the sense that it provides a new way for didactic transposition for the journalist, who does not always have knowledge and specific training in the area of Geosciences. The journalist uses the lead as a structure for building and understanding texts. We propose a new possibility where the journalist and the scientist are allies, and through the analytical reading and the recording the journalist retains the information.

In traditional journalism the journalist has his / her culture and knowledge to understand the theme and the lead is the instrumental for the construction of the text.

In the present proposal the journalist starts from an analytical reading of the scientific article to understand the terms and technical data used in the research, besides the participation of the scientist as a source of consultation. The "instrumental" filing fragments relevant data and with the approval of the scientist are made available to serve the unskilled public through print media.

We understand that journalism is not a mirror image of reality, but a form of social knowledge that we construct daily in the world around us.

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DROUGH IN THE SEMIARIDO BAIANO: CLIMATE INFORMATION FROM MEDIA

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Abstract— The present study aimed to analyze qualitatively and quantitatively the climate news disseminated by two important newspapers with wide circulation in Bahia state during the dry season of 2012, relating to meteorological data of the region. The result showed that there is a relationship between rainfall data and the amount of the news about drought in this period. Although the media has spread information about drought, it did not act in the perspective of allowing the society to have available contextualized and enlightening information on drought in the Bahia semi-arid.

Keywords— Semi-arid, drought, media, climate information.

Thematic Line— Geosciences communication and outreach.

1 Introduction

The semi-arid region of northeastern Brazil lies between the geographic coordinates 2.5 ° S and 16.1 ° S and 34.8 ° W and 46 ° W, with an area of about 1,542,000 km2, this is the18,26% of the Brazilian area (Magalhães et al. 1988, Marengo et al. 2017). This region is vulnerable to extremes of climatic variability (Marengo et al. 2013) and among the most recorded meteorological phenomena in the region, drought is the most noteworthy.

Drought may be caused by reduced precipitation, increased evaporation, reduced groundwater or changes in soil cover (Marengo & Bernasconi 2015). Long-term droughts or recurrent extreme drought events in arid and semi-arid areas have devastating consequences from social, environmental and economic point of view. Examples of the impacts are desertification, limited availability of water for domestic purposes consumptions (Mishra & Singh 2010), loss of agricultural crops, famine, migration to large urban centers (Freitas 1996, p.12), among others.

Due to its impacts the drought gains attention in scientific research and in the mass media. Severals national and international studies analyse and discuss the drought, its effects and causes (examples: Moira & Shukla 1981, Araujo 1982, Magalhaes et al. 1988, Aceituno et al. 2012, Marengo & Bernasconi 2015).

Recent research has shown that the media play an important role as source of information on climate topics for the wide population (Stein et al. 2004). By the way in most of the cases the information provided are wrong, with conceptuais errors and propagated in a sensationalist way. In the Bahia State the mass media take care of transmitting news about the drought, especially in the dry season. This allow the population to have access to some kind of information related to this phenomena.

Brazilian media as well as governmental agencies, present the drought of 2012 and 2013 as the most serious in recent decades. In several states of the northeastern part of Brazil many districts have declared a state of public calamity, especially in the semi-arid region in these years (Marengo & Bernasconi 2015).

In this context, the present research had the objective of analysing qualitatively and quantitatively the climatic notices propagated by two important newspapers of wide circulation in the state of Bahia at the time of the drought of 2012, and make relation between these news and the rainfall data collected in the semi-arid region.

2 Metodology

The research was divided into three steps: (i) rainfall data from the semi-arid region collection for 2012, (ii) mass media news collection of 2012, (iii) joint analysis and comparison of the rainfall and media data.

Step 1 - Rainfall data collected by the precipitation data from the National Water Agency (ANA) and the National Institute of Meteorology (INMET), for the year 2012, were used for thirty-six municipalities in the drought polygon of the semi-arid region of Bahia. The series available since 1961 were used in annual and monthly scales and then was calculated the climatological normal of the region.

Step 2 - Collection of the news published by the media in 2012: The selection of the newspapers was guided by the criteria of diffusion and influence (newspapers that form public opinion on a regional scale). The newspapers “Correio da Bahia” and “Jornal da Tarde” were selected because they met the criteria. A total of 86 news items were collected and analysed for the period selected.

Step 3: Joint analysis of rainfall and media data: the total news of each newspaper was compared with the precipitation on the monthly scale of the year 2012. This analysis was divided in dry season (May to September) and rainy season (October to April), according to Figure 1. Additionally, the news were analysed qualitatively and quantitatively.

3 Results and discussions

Figure 1 shows, on a monthly scale, the precipitation of the Bahian semi-arid region and the number of news published by the newspapers analysed in 2012. It is observed that the news about the drought was propagated in a balanced way in the dry and rainy seasons. 53% of the total drought news was published in the naturally rainy months (January to April and October to December), and 48% of the total news was broadcast in the dry months (May to September). The months of March, April, May and June presented the highest number of news items in the year, with a total of 8, 28, 22 and 10 news stories respectively. The month of April presented the largest amount of news on the drought (32% of the total news). This gradual increase in news from the beginning of the year, culminating in the peak in April and May, may be associated with the cumulative effect of low amount of precipitation recorded in the months of January, February, March and April. Together, these months recorded 211 millimeters of rainfall below expected. This region presents annual rainfall averages ranging from 300 to 800 mm (Conti 2005, 8). These results suggest that there has been an approximately 2-month delay in reporting the drought.

In the dry season, the number of news declined. In August, even if it had rained above the average for that month the number of news rose. This fact may be associated with the low rainfall recorded in the previous months, in June and July. Figure 2 shows the anomaly of rainfall and the percentage of news about drought. It is possible to note that the greater the negative anomaly of the rain, the greater the number of news reported.

In contrast, the month of December presented negative rainfall anomalies and a low amount of news. It can be inferred that this occurred because November presented positive anomalies of precipitation, registering 71.4 mm above the expected average. We verified that as high as the negative anomaly of rainfall registered, higher is the number of media news published.

Analysing the news it was possible to noticed that the great majority of them present conceptual errors, superficial description of the concept and information gap. Similar results were described in the works of Maia et al. (2012) and Steink et al. (2006). The100% of the articles analysed presented the classic conceptual error of misusing of the word “climate” and "weather", an example is the news of the May 11, 2012, entitled: "Bad climate makes Conab reduce crop forecast" (Correio da Bahia, 27), another example is the news published on March 11, 2012, named: "Climate: the drought reach the population of north, northeast, center-west and southeast of Bahia" (A Tarde, pages A4 and A5) . In addition, important issues such as "El Niño and La niña", "Climate Change" and "Desertification" were addressed with little explanations, presenting superficial and out of context informations.

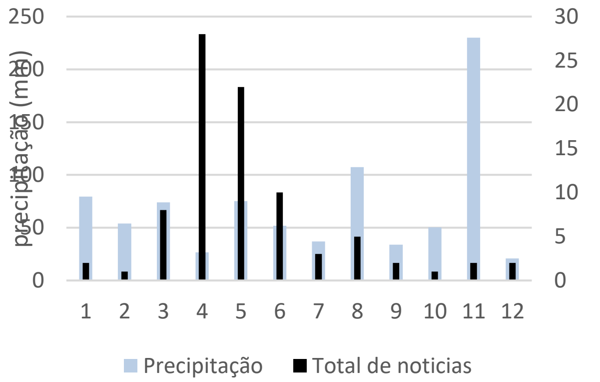

Figure 1. Monthly precipitations in the semi-arid region and number of news published in the newspapers in 2012

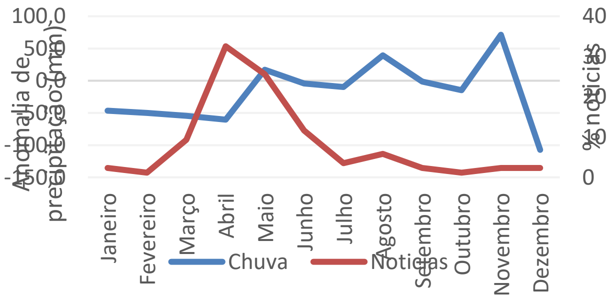

Figure 2. Anomaly of precipitations and porcentages of news about the drought in the year 2012

4 Conclusions

It was find a relation between the precipitations and the number of news related to the drought in the studied period. Relates to negative precipitation anomalies was observed a significant increase in the news with a two months delay. In conclusion we could state that although the media had disseminated climate informations relates to the drought, by the way they lose the possibility of informing the population with scientifically correct informations.

Acknowledgmentos

We thank the Public Library Team of the State of Bahia for allow the access to newspapers archives and to Kennedy Xavier for scanning the news.

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THE EARTH SCIENCE OLYMPIAD AND ITS INFLUENCE IN PROMOTING GEOSCIENCE EDUCATION IN SRI LANKA

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Abstract— The Sri Lankan National Earth Science Olympiad was initiated in 2009. As Geoscience / Earth Science is not included as a main subject in school curriculum, when this competition was organized in 2009, students did not respond well; only 38 students representing twenty one schools took part in the competition. The test had only simple multiple-choice questions related to Geography, basic Geology, Environmental Science and Astronomy. This was the first experience for students in an Earth Science Olympiad; besides, they did not have much exposure to Geology. Therefore, they did not perform well in the competition. However, based on the results, the top four students were selected to represent Sri Lanka at the 3rd International Earth Science Olympiad (IESO), Taipei, Taiwan, September 2009. It was a useful experience for both students and organizers of the Sri Lankan Earth Science Olympiad. The 3rd IESO can be considered as the turning point in promoting Earth Science Olympiad in Sri Lanka. With the experience gained by participating in the 3rd IESO, the Sri Lankan National Earth Science Olympiad Organizing Committee was able to introduce a syllabus and structure for the national competition. The Geological Society of Sri Lanka contributed to publicising the Earth Science Olympiad among school teachers and students. After 2009, the Sri Lankan National Earth Science Olympiad has been organised as an annual event of the Geological Society of Sri Lanka. The number of candidates participating in the competition increased year after year. At present, the national competition is organized in nine examination centers covering the nine provinces and 24 districts of Sri Lanka. Students who perform well at the provincial level competition are interviewed and the best four students are chosen to represent Sri Lankan at IESO. With the introduction of the Sri Lankan National Earth Science Olympiad, students evince more interest to participate in this competition. Also, when they prepare for the competition, they read Geoscinece-related books and learn the basics of Geoscince. Thus, students’ interest in learning Geocience has increased.

Keywords— Curriculum, Geoscience, Earth Science, Olympiad.

Thematic line— Geosciences and Natural Sciences for Basic Education.

1 Introduction

There are nine Olympiad competitions are organize in Sri Lanka at national level by various universities, institutes and societies. These Olympiad competitions include: Biology, Physics, Astronomy, Information Technology, Mathematics (junior and senior), Statistics, Junior Olympiad and Earth Science. Earth Science Olympiad competition which was initiated in 2009 is the youngest Olympiad competition organize in Sri Lanka. Some of these Olympiads like Biology, Physics, Mathematics and Statistics are very popular among school students. These subjects are included in the secondary school curriculum in Sri Lanka and is the main reason for these Olympiad competitions are popular among secondary school students. The syllabuses of these competitions are very similar to school curriculum of these subjects. However, in Earth Science Olympiad competition, students have to study new concepts which they do not study at their school curriculum. The initial syllabus of the Earth Science Olympiad competition included basic concepts of Geography, basic Geology, Environmental Science and Astronomy.

2 Education system in Sri Lanka

Education system in Sri Lanka can be divided into four main stages i.e. pre-school, primary, secondary and tertiary level (Fig. 1).

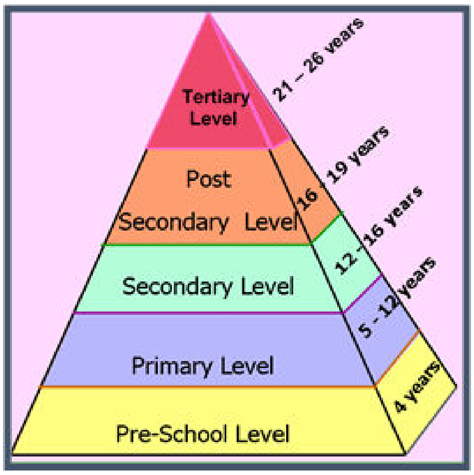

Figure 1. Educational levels in Sri Lanka

Curriculum at pre-school level mainly focuses to develop students’ basic writing, reading, listening and speaking skills. At primary level, students have the opportunity to master the skills they have developed at pre-school level and also few other subjects like Mathematics, Languages, Social Studies, Religion, Esthetic subjects are introduced at this level. After completing six years of primary education at about twelve years of age students are promoted to secondary education level. Secondary level education in Sri Lankan education system separated into two. At the first stage of secondary education level students are exposed to learn subjects like Biology, Physics, Chemistry, Geography, Commerce and Accounts, Agriculture etc. Also at this stage few Geology concepts are integrated with few subjects mentioned in the above. Second stage of the secondary school curriculum is very important for students as they have to select one of five disciplines i.e. Biology, Mathematics, Commerce and Accounts, Agriculture, Arts and Languages. Students' tertiary or university level education depend on the discipline that they select. After two years students sit for a competitive examination and qualified students enter to university (Fig. 2). According to the education system in Sri Lanka as explained in the above, students do not have a chance to follow Geoscience as a main subject. This is one of the main reasons that students do not follow Geology as a subject at undergraduate course. Therefore, it is necessary to introduce many geological concepts at secondary education level and make students more interest to follow Geology at university. This will help to produce more geologists in future in Sri Lanka. However, compared to other professions like doctors, engineers etc. there is no much demand for geologists in Sri Lanka. This is another reason that students do not pay more interest to become geologists and they tend to become doctors, engineers etc.

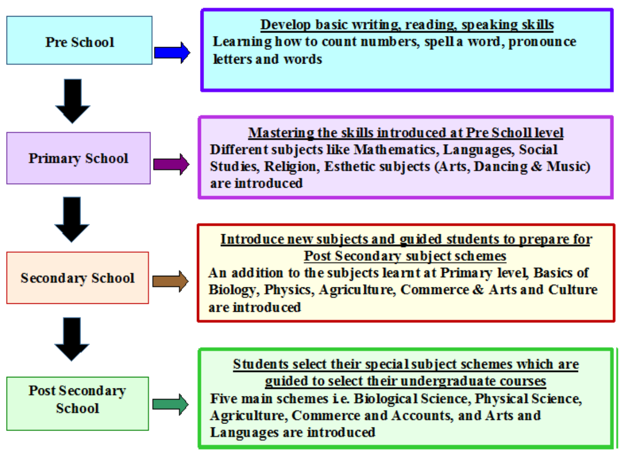

Figure 2. Learning objectives of different levels of education system in Sri Lanka

3 Geoscience education at secondary school level in Sri Lanka

As explain in the above Geoscience or Geology is not introduced at primary, secondary or post-secondary level school curriculum in Sri Lanka. Therefore, students do not have an opportunity to learn several important concepts which are very useful and inter-related with few other disciplines. For example, the knowledge of chemical compositions of minerals and rocks can be useful when students study similar topics in Chemistry similarly, they can use the knowledge about physical properties of minerals can be related when they study similar topics in Physics. Also school; students do not have a chance to learn some important basic concepts in Geoscience and are useful for their day to day life. For example awareness about landslides is very useful for students those who live in landslide risk areas. However, most of the students do not aware about how a landslide occur, what are the evidences of occurring a landslide etc. After the tsunami 2004, the Sri Lankan government has paid more attention to natural disasters and also to promote geoscience education at schools. Sri Lankan school curriculum has revised recently. In this revision, few topics related to geoscience include from grade 7 to grade 10 syllabus. These topics include minerals, rocks, earth's interior structure, rock weathering, natural disasters etc. Students who performed well at the secondary level education will enter to universities to obtain a degree. Therefore, this is an essential stage to promote geoscience and encourage students to follow Geoscience degree at university level. However, still few concepts of Geoscience included only in pre-secondary stage in Sri Lanka. As a result of this many students deviate from Geoscience education at university level.

4 Methods utilize to promote Geoscience at school level in Sri Lanka

The Geological Society of Sri Lanka has been organizing "Earth Science for schools "workshop for school teaches in each year. This is the main event utilize to promote Geoscience at school level in Sri Lanka. At this workshops university lecturers conduct lectures and practical for school teachers. The topics covered in these workshop include; physical geology, minerals, rocks, natural diastases, groundwater, environmental geology, geomorphological processes etc. Also all teachers are provided geology related teaching materials including minerals and rocks sample boxes to utilize in their schools. Teachers will share the knowledge that they gained by attending these workshops with their students. Therefore, this method can be considered as a useful method to promote Geoscience knowledge among school students. However, if a teacher unable to transfer the knowledge that he or she gained, students do not have an opportunity to get that knowledge. Other than these workshops, there aren't any method those directly related to promote Geoscience at schools. The Ministry of Education and few other organizations organize few inter-school quiz and debates competitions, exhibitions but these events cover little Geoscience related concepts. Compared to these methods, the Earth Science Olympiad competition can be considered as a very good method to promote Geoscience at school level. Students will learn many Geoscience related topics by participate at this competition.

5 Sri Lankan National Earth Science Olympiad competition

The Earth Science Olympiad competition is introduced in Sri Lanka in 2009. Only thirty eight students from twenty one schools representing five districts out of twenty four districts participated at the first Sri Lankan National Earth Science Olympiad in 2009. After 2009 the syllabus of the competition has prepared according to the International Earth Science Olympiad (IESO) syllabus. However, the syllabus comprised only the basics of broad topics like Geosphere, Environmental Science, Hydrosphere, Climatology, Atmosphere and Astronomy. Each main topic divided into few sub topics as listed in the Table 1. Compared to the other national Olympiads like biology, physics and biology organized in Sri Lanka, this was a very poor participation. The main reason for the poor participation of students in Earth Science Olympiad is the lack of awareness about geoscience among school students.

Table 1. Syllabus of the Sri Lankan Earth Science Olympiad competition

Main Topics	Sub Topics
Geosphere	Mineral, Rock Cycle, Rooks, Plate tectonics, Physical Geography, Geological structures
Hydrosphere	Surface Water, Groundwater, Sea waves, Processes in water cycle, Water quality Tide and current
Atmosphere and Climatology	Basics and energy of the atmosphere, Moisture, clouds, and precipitation, Air pressure and motion, Weather systems and patterns, Climate and climate change, Weather forecasts
Astronomy	Sun – interior, sunspots, Solar system, Terrestrial plants, Outer planets Comets and asteroids
Geography	Map interpretation, Drainage pattern. Geomorphological features

The National Earth Science Olympiad is conducted only in English medium and not in students ‘mother tongue. This is another reason for lack of participation at the Earth Science Olympiad competition in Sri Lanka.

The Geological Society of Sri Lanka very clearly identified this barrier to promote geoscience at the school level and found a solution to overcome this situation. Promoting Sri Lankan National Earth Science Olympiad by organizing workshops and seminars for school teachers is one of the very useful steps followed by the Geological Society of Sri Lanka. At these workshops, the Society had organized to introduce the International Earth Science Olympiad syllabus and how Sri Lankan students can take part at this competition. It is observed that the participation of school students in the National Earth Science Olympiad gradually increased from 2009 to date (Fig. 3).

Students representing three, six, nine and thirteen districts out of twenty four districts participated in Sri Lankan National Earth Science Olympiad competitions 2009, 2010, 2011 and 2012 respectively (Fig. 4). However, it was observed poor representation of few districts like Northern, Southern and Uva provinces.

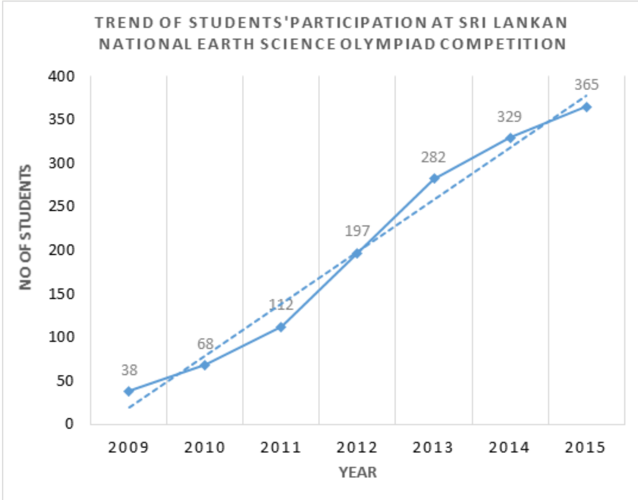

Figure 3. Trend of students ‘participation at Sri Lankan National Earth Science Olympiad competition

When comparing the results of four years competitions, it has been observed that the best results were recorded from districts like Central, Western and Southern provinces. Students in these districts have the opportunity to utilize more learning resources and facilities. These facilities include access to internet and library facilities etc.

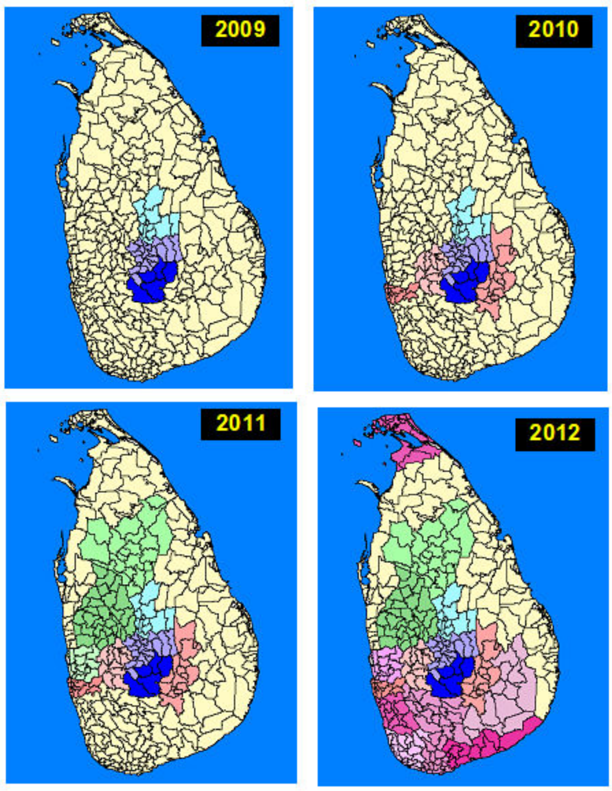

Figure 4. Expansion of Earth Science Olympiad competition in Sri Lanka (as districts) from 2009 to 2012

6 Participation of Sri Lankan team at International Earth Science Olympiad competitions

Best four students were selected at the first Sri Lankan Earth Science Olympiad competition to participate at 3rd International Earth Science Olympiad competition which was held in Taipei, Taiwan from 14 – 22, September, 2009. This was the first time that a Sri Lankan team took part at an International Earth Science Olympiad competition. It was a great experience for both students as well as mentors. After participated at the 3rd IESO competition, the syllabus of the national competition has been modified according to match with the IESO syllabus. Also formulate the procedure of selecting the national team members (see **Figure 4**). Since 2009, Sri Lankan team has been participating for four IESOs held in Indonesia, Italy, India and Brazil in 2010, 2011, 2013 and 2015 respectively.

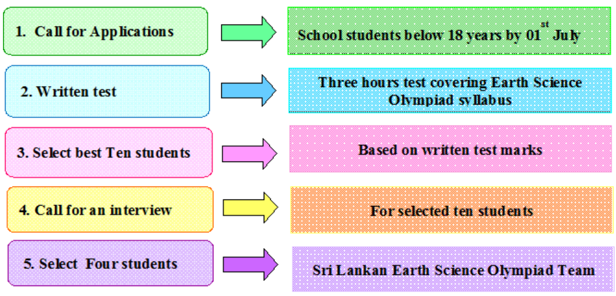

Figure 5 Selection procedure of the Sri Lankan National team for IESO

7 Conclusion

There are few methods has been implementing to promote Geoscience at school level in Sri Lanka. However, in some methods, there is a little involvement of students and they do not much aware about the subject. For example, training of teachers by organizing workshops and seminars will not be directly benefited by students if teachers will not transfer the knowledge that they gained by attending these workshops and seminars to students. However, when preparing for the Sri Lankan National Earth Science Olympiad competition, students have to utilize materials related to Geoscience (books, materials available in websites etc.) and learn about the topics covered in the syllabus of the competition. Students have to learn about Geoscience by themselves while preparing for the competition Therefore, when compared to other methods introduce to promote Geoscience at Sri Lankan schools, Earth Science Olympiad competition is a better method.

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GEOLOGICAL FIELDGUIDE TO THE ROOTS OF AN ANCIENT MOUNTAIN RANGE OF GONDWANA AND THE BEGINNING OF GOLD MINING IN BRAZIL

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Abstract — This fieldtrip guide of a region situated NW of the São Paulo Metropolitan Area traverses parts of densely populated cities and protected areas at the periphery of São Paulo city as well. It offers a glimpse of the São Roque unit, whose Neoproterozoic tectonic evolution integer the development of the roots of an ancient mountain belt: the Ribeira Belt, when tectonic plates amalgamated to build Gondwana supercontinent. In the visited outcrops, rocks and structures related to folding and faulting allow to present a summary of the tectonic evolution. Remnants of historical mining places give an opportunity to remind the first gold discoveries in Brazil by the 16th century. The region currently produces limestones for crushed rock and a few other mineral resources. The field guide presents and discusses didactic material based on the regional and local geological knowledge, which may help teachers of basic education to strengthen their scientific knowledge on Geology, Geomorphology and Environmental Science. From this framework, we try to clarify the origin of some environmental problems; one good example refers to the consequences of a doline collapse within the urban area of Cajamar city, formed in August 1986 as an unpredicted geological hazard. The municipality settled a square garden to replace the big hole in the same place.

Keywords — Teaching-learning, teacher training, mining, copper, gold, History of Geology, Structural Geology, science popularization.

Thematic Line — Communication and Dissemination of Geosciences.

1 Introduction

This fieldtrip guide to a region situated NW of the São Paulo Metropolitan Area traverses parts of the cities of Jundiaí, Cajamar, São Paulo (Fig. 1) and Pirapora do Bom Jesus, aiming to approach the geology and tectonic evolution of the Neoproterozoic São Roque Group. There we can review data about the mining history of Brazil. A few local environmental problems, as seen along the traverse, reveal the importance of basic geological concepts to understand environmental dynamics.

The information gathered in the fieldtrip guide interconnects geological-historical data to methodological aspects of fieldwork practices. Viewing the geology of São Roque Group, the rock types, magmatic activity, ductile folds, faults and fragile structures, each participant can imagine the origin of a large cordillera whose roots composed the Gondwana supercontinent: the Ribeira Belt. The excursion should create conditions for a direct observation in the field of structures and rocks that are unaltered or partially decomposed. Some structural superposition may be reconstituted and integrated. Each visited outcrop "invites" the participant to observe the geological-structural record and the geomorphological context, seeking to characterize them.

The area is interesting from the educational point of view, although geologically complex. There are exhibitions of typical features of the transition between two geological domains: the Atlantic Plateau and the Peripheral Depression.

The area presents sparse well-documented examples of critical situations of structural influence of rocks on surface dynamics. There are several identified situations of geological risk in the mentioned cities, mainly at the periphery of them. They reflect the intense dynamics of surficial processes under tropical climate, with contrasting imbalances provoked by certain urban inadequate constructive practices on a mountain relief (Fig. 2). Geology, with its various basic or applied branches, is essential to resolve many conflicts between geological infrastructure and human occupation.

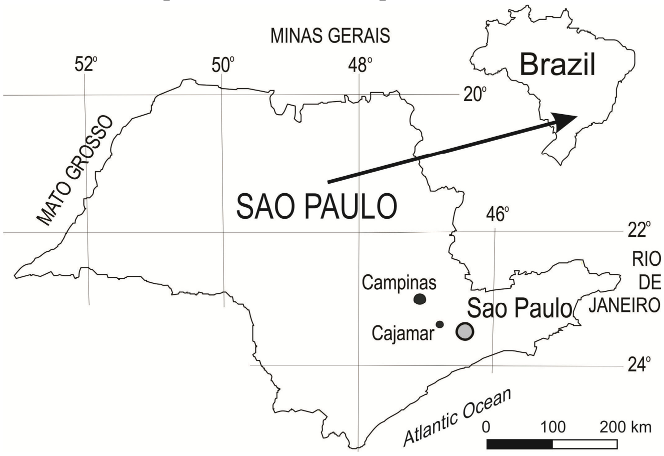


Figure 1. Situation map of the main visited cities

Figure 2. Dense tropical forest and grass around the protected Jaraguá State Park, which includes the urban Jaraguá peaks

Figure 3. A view from the Anhangüera Road of remnants of the *Bairro Britânia Cave*, mostly hidden by a huge debris cover

1.1 A glimpse on the History of Mining in Brazil

A reconstruction of the fascinating history of gold discoveries was the objective of a research devoted to the preservation of some remarkable vestiges of ancient gold mines (Carneiro et al. 2011) (Figs. 3, 4, 5). It is probable that the first discovery of gold in Brazil occurred in 1560, by Brás Cubas, the founder of the Santos city. In the 16th century, the area was part of the Captaincy of São Vicente. The Jaraguá gold caves, also known as "Morro Doce caves", next to the Jaraguá Peak (Figs. 2, 5), located in the close vicinity of São Paulo city, represent a memory of times when mining of metals started in Colonial Brazil.

The Municipal Council for Preservation of the Historical, Cultural and Environmental Heritage of the City of São Paulo (CONPRESP) has decided on March 17, 2011, to protect the caves (Fig. 4) (Carneiro et al. 2011).

2 Objectives

The fieldtrip guide allows achieving objectives of greater or lesser complexity. To exemplify, we indicate below some objectives for undergraduate students in Geology. Possible didactic use of the visited exhibitions should involve reformulation and adjustment of the objectives to the scope of the planned field activity.

After completing the proposed activities, the participant should be able to:

1. recognize types of regional metamorphic rocks and their products of alteration by weathering;
2. recognize diagnostic features of structures of tectonic origin present in the area;
3. recognize the importance of scale in describing structures and modeling;
4. discuss the notions of homogeneity and heterogeneity of natural bodies;
5. apply the notions of superposition, intersection and correlation of structures;
6. recognize some species of minerals present in different stages of decomposition of rocks;
7. understand the relationships between space and time scales for reconstructing geological history;
8. develop hypotheses on relationships between rocks and structures, potential potential geological hazards and distribution in the units visited (Fig. 5), which can be used to integrate environmental issues that affect the communities of this populous region, and other mineral resources.

The guide derives from a selection of relevant points for visiting within the limited time available. Educational material based on geological knowledge makes it possible to integrate environmental issues that affect the communities of this populous region with economic issues related to sustainable mining of limestone for Portland cement or crushed rock (Fig. 5b), gravel and other mineral resources. Some effects of the frequent alteration in the landscape intensely promoted by human occupation and by economic activities can be seen, given the complex and growing urbanization.

The tour will allow us to address a critical aspect of data acquisition in this field: the researcher's dependence of an access to good exposures and/or direct and indirect measurements of sub-surface rocks. Road construction and mining activities are sources of data.

3 Regional and local geology

The visited area integrates the Brazilian geotectonic unit of Ribeira Belt, which composes the Mantiqueira Province (Heilbron et al. 2004). The Neoproterozoic Ribeira Belt has affected the Archean-Paleoproterozoic basement (Almeida 1967), in a complex sequence of processes grouped under the designation "Brasiliano-Pan-African Orogeny" or, more simply, for the purposes of this itinerary, the Brasiliano cycle, whose activity lasted until Cambrian-Ordovician (Almeida et al. 1976, Almeida et al. 1978, Hasui et al. 1990).

The collisional stage of the Ribeira Orogen in southeastern Brazil controlled deformation, metamorphism and magmatism (Heilbron et al. 2004). Shortening and crustal thickening developed granitic bodies and deformation structures predominantly oriented to NE, under a compressive regime. The last stages of the Brasiliano collage (640-480 Ma, Heilbron et al. 1995 and Machado et al. 1996) belong to the final stages of consolidation of South American Platform (Almeida 1967, Almeida et al. 2000). The evolution continued towards a tangential tectonic regime of thrusting and then to a transcurrent regime (Hasui et al. 1988).

The São Roque group includes phyllites, metarenites, quartzites, shales, limestones, amphibolites and metaconglomerates (Hasui et al. 1969), with subordinated types. Regionally, the evolution of granitic bodies is correlated to tectonic folding and refolding features. Tectonic deformation has affected foliation and the folds (Carneiro et al. 1985), under metamorphic degrees varying from low greenschist facies to high amphibolite facies.

The volcanic lava flows of Santana do Parnaíba (Figueiredo et al. 1982, Tassinari et al. 2001) provide Neoproterozoic ages that correlate the rocks of the São Roque Group to the Brasiliano Cycle. The field guide focuses on a small portion of what is interpreted as roots of a vast mountain belt developed during Ribeira Orogeny, which culminated in the amalgamation of Gondwana Paleocontinent (Heilbron et al. 2004).

4 Field guide

STOP 1. Km 40, Anhangüera Highway, near Jordanésia village, Cajamar, SP

In this road cut, we find purple phyllites with nice alternation of light and dark bands. The banding reflects the original stratification of a metasedimentary rock and is referred to as relict stratification, identified as S_o. The gentle folds develop subvertical axial planes. The well-developed axial-plane foliation (Fig. 6a) represents a typical differentiated banding S_2, which is a diagnostic feature of ubiquitous distribution in metapelitic rocks of São Roque Group. The relationship between the surfaces indicates that the outcrop is located in a hinge area (apex) of a large regional fold.

STOP 2. Cinco Pires Quarry. Cajamar Municipality, SP

The quarry operated by the Lafarge Brazil Co. (Fig. 5b) exploits calcite limestone for production of gravel, used in concrete, blocks and paving. Formerly, the production was destined to the manufacture of Portland cement, in the locality of Perus, being the transport done by steam locomotives and small wagons, which are currently object of recovery, to be integrated in the future to some railway museum. Mining uses large equipment to divide the rock massif on benches. On the steep western front of the quarry, there are large folds alongside deeply foliated areas. The relict stratification of the carbonate metassediment draw the folds, while the foliated zones include features of shearing and milonitization. The visitor may observe minor joints, faults and folds, as well as zones rich in calcite, whose white color stands out in the middle of the black limestone.

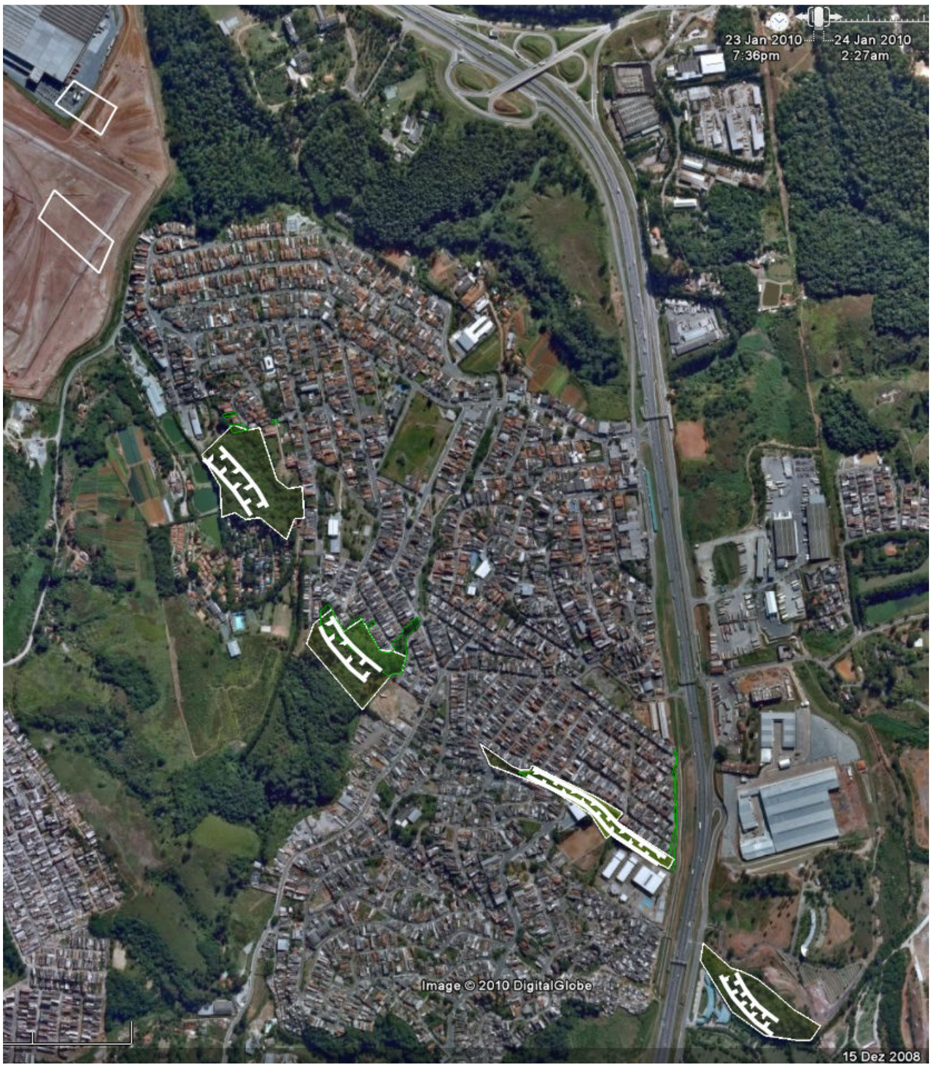


Figure 4. The urbanization of São Paulo city has restricted the ancient gold caves to narrow scattered remnants (white bold lines). Source: satellite images from Google Earth 2008

The discontinuous rock body presents approximately lenticular format, oriented according to the general direction ENE (Fig. 5b). The intense fracture of the massif facilitates the mining activities.

STOP 3. Waldomiro dos Santos Street, now Alfredo Soriz Square. City center of Cajamar, SP

Collapse phenomena is common in areas of occurrence of carbonate rocks (Sallun Filho & Karmann 2012), but the existence of soil cover can hide the problem and increase the risk. In this place, the "Cajamar Hole" has developed in 1986. This is a good example of covered karst because the city was built over carbonate rocks covered by thick soils and colluvial material accumulated over time. By the early morning of August 12, 1986, in the Lavrinhas neighborhood, residents heard noises like thunderstorms and explosions. The collapse occurred at about nine o'clock in the morning; within a few hours, it swallowed houses and reached about ten meters in diameter by ten meters deep (Nakazawa et al. 1987).

The collapsed doline engulfed a few houses, fortunately without fatalities. It rose to over 25 meters in diameter. After the removal of residents, a square was constructed, as it is currently observed. The unusual character of the phenomenon led IPT to map in detail the risk area (Prandini et al. 1987) (Fig. 6c) and the surrounding region (Santoro et al. 1988). At the time, the studies revealed that the phenomenon was a result of an intensive extraction of groundwater.

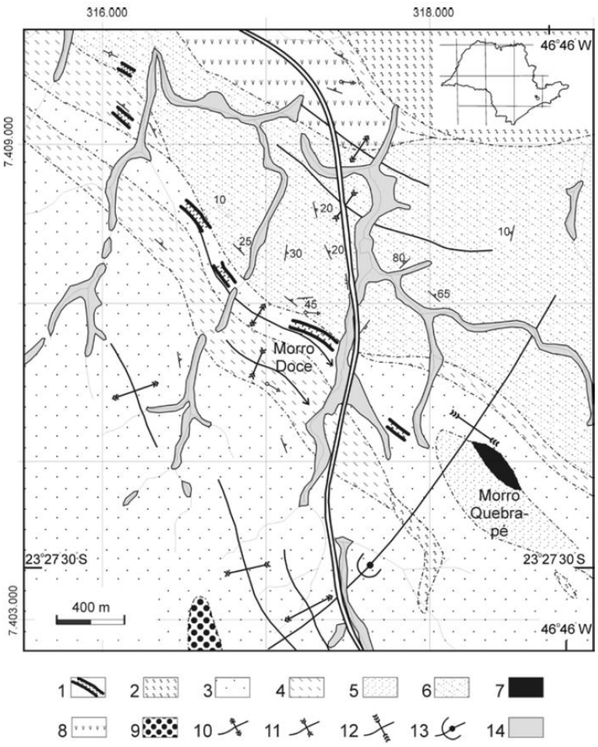


Figure 5. Distribution of remnants of the ancient gold caves crossing the Anhangüera Road at *Bairro Morro Doce*. Description of rock units and symbols can be found at Carneiro et al. (2011)

STOP 4. Cajamar to Santana de Parnaíba Road, secondary access to Portal do Ipê village, nearby the Polvilho village, Cajamar, SP

Recent cuts installed on decomposed rock allow a visualization of a sedimentary cover represented by gravel and silt-clayey sediments of probable Neocene age. At the top occur horizons of soil capping thin line of pebbles.

Although the relationships between the sedimentary deposits and the basement folded phyllites are not very clear, it is possible to observe closed folds with thickened hinge lines and inclined axial planes in purple-gray phyllites. There is a clear alternation of bands, sometimes lighter and sometimes darker, coming from reddish to grayish colors.

STOP 5. Km 21 Anhangüera Highway. Neighborhood of Morro Doce, São Paulo, SP

Knecht (1950, p.25) admits that the first gold discoveries in the Jaraguá region occurred between 1588 and 1597, although there are earlier records. Nowadays, the preservation of vestiges of the colonial time mining activities is under severe threatening. Figure 6d and figure 6e have been produced in different times: 1981 and 1996.

Carneiro (2002) described by as a testimony of the "Historical Gold Jaraguá Caves" the exhibition that we can see close to the Anhangüera Highway. The illustration accompanying the classic publication of Knecht (1950) coincides with the same place. The Brazilian mineralogist José Bonifácio de Andrada e Silva considered ancient the open-sky ruins, by 1822, during a visit to the Province of São Paulo. In the São Vicente captaincy, the pioneer extractions announced the mining vocation of the area – by the end of the 16th century – along with those of Paranaguá, Paraná State. Before the most recent protective regulations, urban occupation was destroying this valuable historical patrimony. The excavations (Figs. 4, 5) are linear, with abrupt walls, installed in decomposed rock. The main cave, marginal to Anhangüera Highway, is covered by bush, soil, garbage and waste. Research galleries opened from the main excavations (Fig. 6f) were destroyed in 2007 when the highway has been expanded.

STOP 6. Cut of Mario Covas Rodoanel Highway, near Itahyê tunnel, 1.5 km long, located between Anhangüera and Castello Branco highways

The long road cut shows metaconglomerate whose highly deformed rounded pebbles (Fig. 7) are composed of different varieties of gneisses, granites and quartzites. The forms are spheroidal, almond-shaped to ellipsoidal. At some points very long quartzite pebbles occur. The rock matrix is metarenitic, slightly greenish. In the vicinity, there are metasedimentary rocks of medium granulation such as metarkoses and metarenites. The Jaraguá metaconglomerate was discovered by Coutinho (1955). The visited cut is the best exposure, which is mapped as narrow linear bodies (Fig. 6d) (Carneiro 1983, Henrique-Pinto & Janasi 2010, Henrique-Pinto et al. 2012).

STOP 7. Mining area of the Posocal Mining Co., km 44, Romeiros road, between Santana do Parnaíba and Pirapora do Bom Jesus

The phyllites exhibit remarkable foliation and differentiated banding. The foliated structures induce an intense displacement phenomena and favor the extraction of the ore. The decomposed rock, formed exclusively of clays, is used after fine pulverization as support for industrial products.

The axial-plane foliation is associated to folds of several scales; it is very distinct especially by the alternation of fine lighter and darker bands, including microfolded surfaces, affecting previous schistosity. Mica-rich dark bands are composed by sericite, muscovite or biotite; lighter bands are formed by quartz. This type of crenulation cleavage is a differentiated banding, visible on a submicroscopic scale. The tight crenulation cleavage is ubiquitous in the São Roque Group foliated rocks, even that very fine, such as phyllites. When decomposed, the mineral species give rise to colored clays.

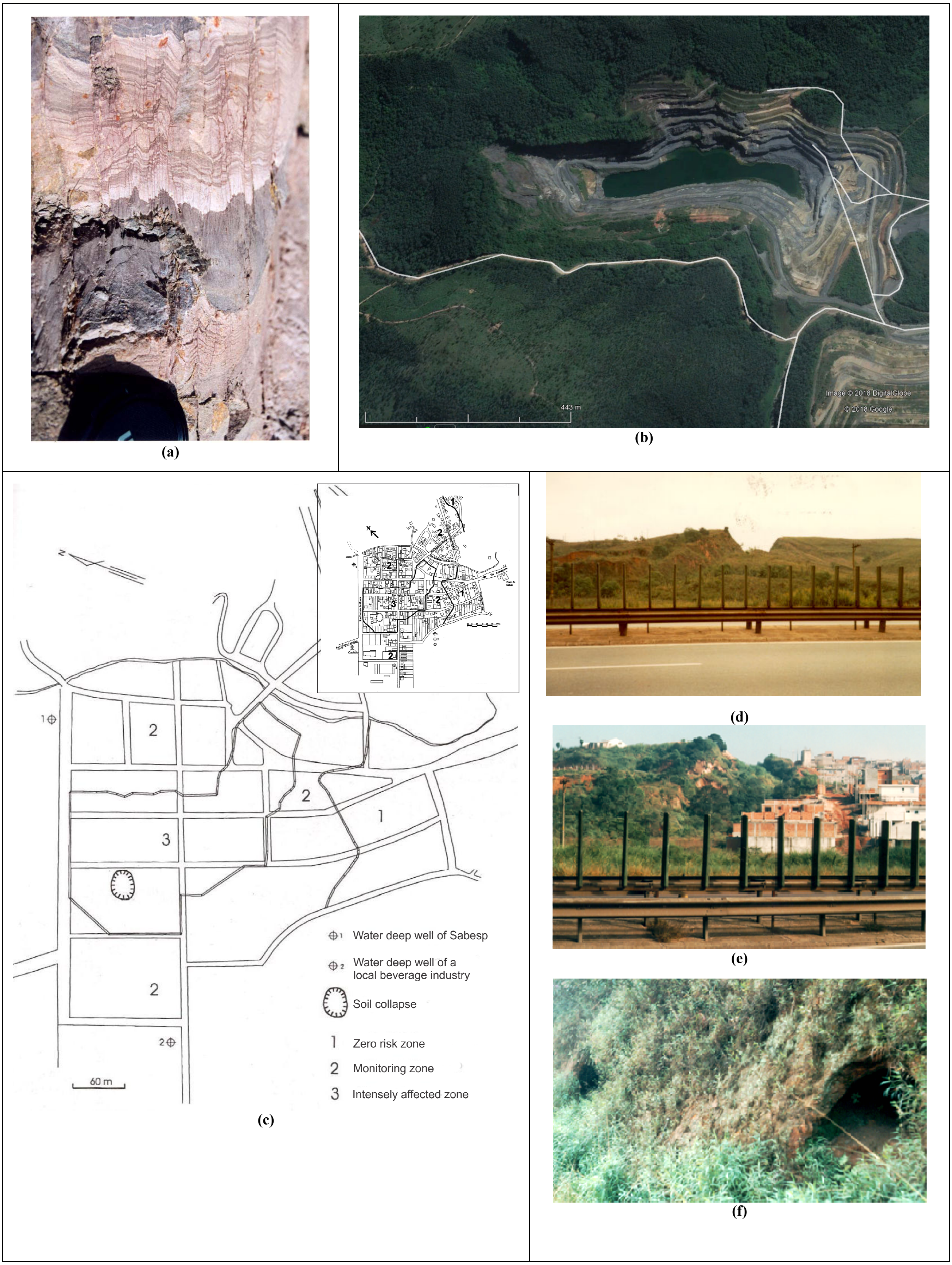
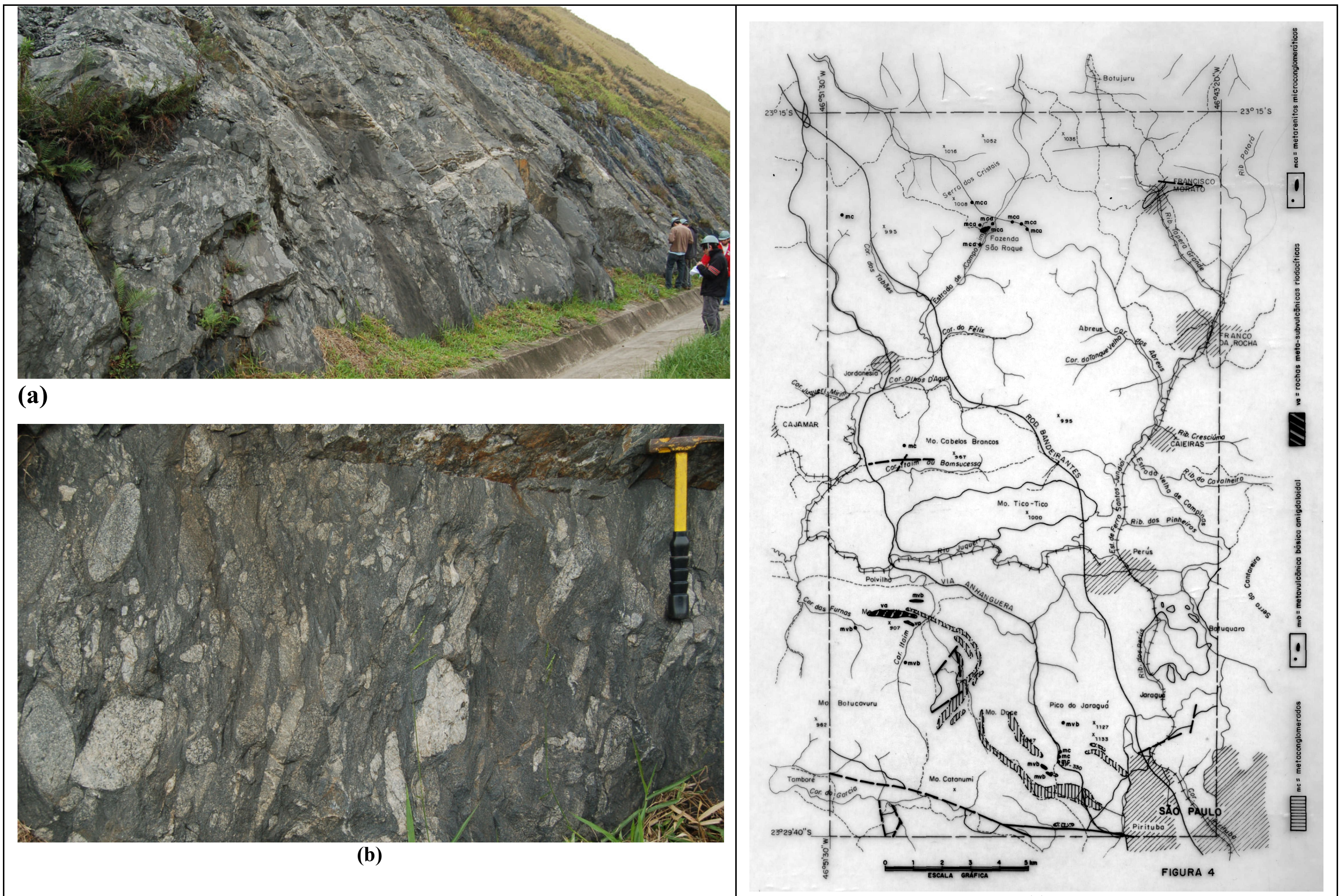


Figure 6. Axial-plane tectonic foliation perpendicular to fine banded clayish weathered metasediments (a). General view of limestone mining in Cajamar (b). Limits of risk zones in the urban area of Cajamar (c). An ancient gold excavation, as seen by 1981 (d). The same cave by April, 1996 (e). Two research galleries with an upper part of rounded shape, approximately 1.2 m high (photos by CDR Carneiro)



(a)

(b)

(c)

Figure 7. General view of the #6 outcrop of Neoproterozoic conglomeratic metamorphic rocks (a). Detailed view (b) and distribution of elongated bodies of the Neoproterozoic conglomeratic rocks, NW of São Paulo (c)

STOP 8. Pillow-lavas in decomposed rock, Alaor Viegas Av., Pirapora do Bom Jesus, SP

In this outcrop we can see pillow-lavas full of rounded shapes of small to medium sizes (Fig. 8). Filling materials between pillows exhibit smooth undulations. The relationship between older basement rocks and the Neoproterozoic São Roque Gr. rocks remain poorly clarified, but this outcrop is of great importance because it helped to establish more precisely the age of São Roque unit.

5 Discussion

The research method applied in the development of field activities such as this one seeks to privilege inductive activities and even in some cases investigative activities, according to the classification of Compiani & Carneiro (1993). In this case, we tried also to establish a historical context, considering that the area is abundant in examples of this nature.

Piranha & Carneiro (2007) highlight some actions of training and conceptual deepening for in-service teachers, so that they are able:

- to present and to put in evidence facts, features, phenomena, agents, materials, processes and products, recognizing links between them and building a systemic understanding of Geosciences;
- to develop a reflective thinking that help teachers understand and dimension human responsibility and commitment to the environmental reality.

Figure 8. Exposition of pillow-lavas at Pirapora do Bom Jesus

Such opportunities – amplified by the contents related to Geosciences – should allow each participant to strengthen values, principles, motivations and potentialities. The application of geological knowledge must consider another central character, as pointed out by Potapova (1968) and Frodeman (1995), among other authors, that Geology is a historical science that seeks to organize knowledge on the past in such a way that the succession of events, facts, phenomena and features can be more and more clearly evidenced. By this way, human actions can be correctly related to their complex consequences.

6 Conclusions

Among the countless vestiges of ancient mining of metallic substances in the Precambrian part of the São Paulo State, those at Jaraguá have a singular geographical distribution, linked to folded structures and local lithological associations. During XVI century the Jaraguá caves were the closest mines to the provincial capital, São Paulo. The scientific interest of the site may be evaluated not only from the historical aspects, but from the spreading of individual copper and gold mining prospects, from the 1970's to the 1990's, in the region between Morro Doce and Santana do Parnaíba, situated westwards. Probably, the area is still of interest for deep underground mining. Gold is still there...

The guide seeks to help participants to observe, to collect, to gather and to interpret different kinds of information that constitute a logical foundation of the problematic studied. By means of an increasing use of such approach, Geology can be strengthened as an interdisciplinary area as proposed by Cuello Gijón (1988). We can perceive the fundamental importance of basic geological knowledge for the complete understanding of situations of geological risk and environmental disasters, such as the cases of doline collapses, as the Cajamar one, and numerous landslide situations, or similar phenomena affecting steep slopes and highway cuts.

The author expect that offering this fieldwork route to basic education teachers, and to the local population, their awareness on the historical importance of the site will improve. This would not only interrupt the accumulation of garbage and waste there, but also benefits the knowledge about environmental dynamics, thus improving their quality of life.

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NEW IDEAS FOR AN EFFECTIVE GEO-SCIENCE COMMUNICATION

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Abstract— The storytelling, as a new style in scientific communication, has been often misunderstood, confusing science communication and science fiction, natural and supernatural. This is a new way in proposing an integrated information, indispensable component in a contemporary, intergenerational education, especially in a country as Italy is, so full of different land settings, so exposed to natural hazards. The protagonist of the following proposals is Landscape: so full of significance, it is a high potential vector of scientific information, particularly referring to Geo-Sciences. The study of the landscape can be described through a series of steps, but should be understood as a process whose phases, related to different disciplines are integrated rather than simply in succession. A holistic approach requires a different point of view compared to that own of the specific disciplines, and gets closer to the natural aptitude to observation. In this sense the study of the landscape contrasts with the fragmentation of knowledge: it requires a collective action, in which everyone is aware of putting their discipline in the service of a cognitive strategy. At the same time, it offers new perspectives in the transmission of knowledge, while opening a dialogue between teachers and students, as well as between technicians, decision makers/ politicians/citizens.

Keywords— Landscape, Geo-Sciences, communication, movies, cycling.

Thematic line— Communication and Dissemination of Geosciences.

1 Introduction

Often science subjects are considered difficult by many students: this is a shame since science is synonymous with knowledge. Perhaps it is the fault of the definition of disciplines that do not suit the modality of teaching required by the times.

We live in an era defined as postmodern. The disconnect between progress and society and the effects on the planet. Yet, more and more, socio-economic developments require a knowledge that keeps pace with the dizzying speed of technological evolution, which by now appears self-directed. The only possible solution is a shared awareness, and this can only be reached through knowledge, which is provided by science.

The young generation is the focus of a desirable and necessary dynamics for change; they are a starting place for a new active approach to science and its applications, a catalyst for the process of engagement of the "facies sociale" of adults, leaders and people responsible for the current state of affairs, yet far too often deprived of future prospects and conditioned by the obsession of the "here and now". With the following project we aim to bring about new behaviour in students and, thanks to them, in society, and thus to arrive at participation in decision making, a desired outcome in a democracy.

2 The project

The strategy for the project is to involve students in active, effective, and long-lasting participation in the world of Geo-Science. It is structured on a series of methods that make scientific material first accessible, then intriguing enough to engage students, in order to constitute a solid base towards a professional future.

A multi-step and holistic approach is the nucleus of the formative methodology, with connections both with the scientific terms to transmit and with the young recipients of the trial. In other words, the possibility to fully explore in integral way the components/scientific subject matter that are interrelated (holistic approach), guaranteeing a fluidity that can be defined as multi-stepped, with connections to the subsequent levels of acceptable and achievable complexity.

Broadly, the project aims to bring students closer to scientific competence by favouring learning in relative disciplines through self-directed education, thus cultivating autonomy and creativity, recognition of one's own aptitudes, and teamwork. The only demonstrated way to do this is through planning and realisation of an objective. The originality of this project lies in proposing innovative projects to capture "universally and across-the-board" the attention of young people, taking into consideration the heterogeneity of socio-economic situations that characterise the world of the younger generations.

Which subject matter are able to involve the attention, attitude and passion of youth towards Geo-Sciences?

We strongly believe, following years of experience first in teaching, then in research and finally in scientific communication, that it is necessary to build a bridge between diverse realities and between diverse communicative codes. But the first bridge that should be built is that between dreams and reality, as this is a first step in a cognitive-behaviour process both for those who teach and for those who learn.

The appeal to themes that best embrace the collective imagination, cinema and sport, is therefore profoundly motivated as it facilitates phenomena of identification and engagement.

Both fields respond to the need to arouse curiosity and vision, which lead to the planning and realisation of a polyhedral objective thanks to teamwork.

The holistic approach mentioned above finds fertile terrain of application, the same which favours plurality of points of view that is the only valid way to knowledge, through recognition of one's own attitudes and capacity of integrating those of others.

Considering the difficulties that on various levels condition the possibility of career paths of women, the proposals of this project are particularly appropriate for encouraging female participation. For example, scientific communication, a common denominator of all possible activities in the project, requires creativity and rigour and a narrative capacity, often traits characteristic of women.

2.1 Science and cinema

Cinema, due to its nature and its modality of consumption, can act as a medium for scientific communication if utilised in appropriate educational planning.

Landscape is a fundamental component of any narrative and introduces many scientific topics, in particular Geo- Sciences, Natural Sciences, Landscape ecology. *The* term "landscape" encompasses a perceptible expression of the result of the endogenous and exogenous forces that mould the Earth's surface. In this sense, the natural scenery of narrative works, in cinema, can be used to transmit scientific information to a mass audience as well as facilitating integration in society of, for example, immigrants. It also inserts the theme of sustainable development, of natural resources and raw materials, as the challenge for future and shared well-being and survival. The use of GIS enables an integrated study of all the components of Landscape at different levels of analysis by way of a user friendly software that is easily accessible. Moreover, it allows an implementation of models, introducing young people to one of the most complex requirements for contemporary dynamics. Especially today with the use of 3D, GIS gains additional expressive worth. Even science fiction, if proposed as a possible future, can represent fertile ground for highly potential creativity in young people as authors with a concrete and energetic Geo-Sciences preparation and a new attitude to contemporary technology (special effects: at the same time content and film technique in a sci-fi film).

2.2 Science and sport

Another bridge between dreams and possible realities in our proposal is the pairing of science with sport, in particular with outdoor sports. Skiing and cycling represent possible choices that best lend themselves to our project. Cycling is an excellent sport, mostly performed in the environment "en plain air", loved and practised by all, and is more and more becoming a means of providing independence and integration for disabled people. Its characteristics means that it is a transport solution with zero environmental impact and thus a fundamental resource for making smart cities possible.

Moreover, as a sport that enjoys a large following at the competitive level, cycling favours the processes of identification and thus has high potential for widely spreading scientific information. For example, the "GeoloGiro" is a project for the popularization of scientific knowledge explaining the geological setting of the landscapes crossed by the cycling race "Giro d'Italia" (the synergy established between the Geological Survey of Italy-ISPRA, the National Council of Geologists). The morphology of the territory becomes a key component in the race context; uphill, downhill and flat, if explained by the geologist, can offer to the public a new and interesting point of view of the landscapes, linking scientific information to the agonistic value of the stage (Figs. 1, 2).

Figure 1. Dolomitic stage of the Giro d'Italia

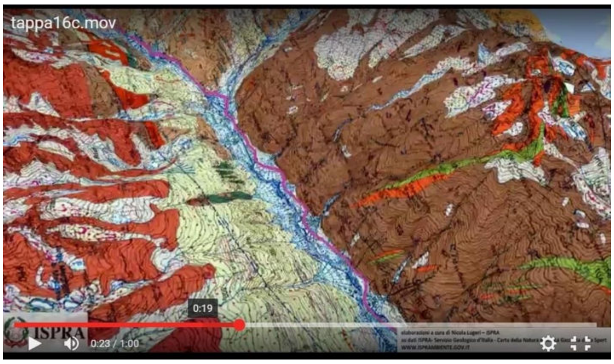

Figure 2. screenshot of the 2d movie representing the geological map of the area crossed by the stage

Begun in 2012 and in continual development, this project has proved to be very effective, even in tying together science, sport and fair play, reinforcing the assertion of "clean" sport against doping and open to everyone, with particular attention to para-cycling.

Analogous considerations and possibilities can be made for the various elements of skiing, both downhill and cross-country skiing. Both proposed sports are happily applicable in remote locations often abandoned by young people for their lack of future prospects, thus the project offers concrete possibilities of development by means of new professions tied to sport. Last but not least is sailing that, especially for Italy, is a necessity and an instrument of sustenance apart from it being a sporting discipline, one that is too often carried out by the elite of society.

2.3 Final Remarks

A balanced approach is needed to make clear how the environment can be source of risks or resources, providing technical and cognitive tools. An altered perception of risk, due to sense of omnipotence (youth), to other problems (adults), and to resignation (elderly), causes damages to the environment and compromises the development. The proposed approach is new is based on cognitive-behavioural mechanisms that are activated by recognition of something (landscape) we are tied to, in a reciprocal belonging or ownership.

The same factor that has inspired the narrative style preferred in writing the papers included in this work, following the qualitative social analysis paradigm, as well as the related participative observation research, still the best way in approaching new communities, trying besides to link them. Such research strategy requires a full immersion of the researcher in the natural environment of the studied group, directly interacting with its members, in order to understand behaviours and motivations by identification processes. A set of indicators is selected, considering the proposed experiences: empathy, identification, continuity, participation; development of the project, further projects: all of these factors contribute to sharing knowledge and culture (Fig. 3).

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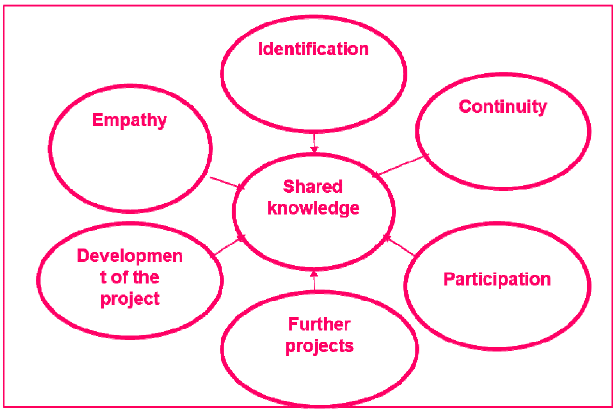

Figure 3

3 Conclusion

From the Earth and Environmental Sciences in all their possible declinations (Landscape Ecology, territory, raw materials, sustainable development) to the Human Sciences, moreover to psychology: cinema and outdoor sports offer a range of research options, as well as an overall vision on the social-environmental system, constituting an excellent starting point for a holistic approach.

The objective of this work consists in spreading knowledge; the methodological assumption – based on a holistic approach – and the experience, lead us to perform plans for a concrete popularization of sciences. Information must be assimilated by individual/community/society, in order to become conscious knowledge. The traditional scientific communication has not produced remarkable effects until now, in our as well as in other countries: this should make us reflect. The years of intensive experience in the field, have revealed a gap to be filled, a lack of connection between research world and media.

Knowledge becomes Science through encoding processes that make it universal. However too often code-sharing is bound to restricted number of users. Today it is mandatory to make available to the public, all those information that allow us a better quality of life. To this aim it is essential the function of those informative vectors that make information accessible to the whole society.

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THREE EXAMPLES OF EDUCATIONAL PRACTICES BY MUSEUMS OF GEOLOGY AND PALEONTOLOGY IN BRAZIL

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Abstract— The present paper aims to summarize three examples of activities offered by institutions and museums that dedicate part of their collection and exhibits to the contents of Geology and Paleontology in Brazil. The examples of some of their educational practices are from: the Museum of Dinosaurs (*Museu dos Dinossauros*), in the city of Uberaba, the Catavento Museum (*Museu Catavento*) and the Geosciences Museum of USP (*Museu de Geociências da USP*), in the city of Sao Paulo. Earth Sciences is often lacking, as formal disciplines in the Brazilian basic education schools, in part because of the poor formation given to teachers that teach those subjects. Moreover, the schools restrict the role that museums can play, just as a mere complement to formal teaching-learning, in order to contribute to the communication and comprehension of those important fields. There is a list of more than 45 institutions, open to the public and dispersed in the country, which display collections and exhibitions with contents of Geology and Paleontology. The Uberaba Museum of Dinosaurs (*Museu dos Dinossauros*), and the Geosciences Museum of USP (*Museu de Geociências da USP*) mainly focus on exhibitions of samples related to Geology and Paleontology, and offer guided visitations and/or field trips to visitors. Hands-on activities are present at the USP Museum: interactive displays for visitors to touch and to handle real fossils. The Catavento Museum (*Museu Catavento*) privileges a hands-on approach, focusing on interactive elements and presenting activities using technology to enlace visitors and to foster the learning process. These three museums highlight the importance of teaching of these fields of study, asking for maintenance and conservation.

Keywords— Museums, geosciences, paleontology, education.

Thematic line— Communication and Dissemination of Geosciences.

1 Introduction

Part of what we know about the biogeological past of the Earth derives from geological and paleontological studies. These sciences open a window to the past; based on this understanding, every student is invited to estimate the impact of the modern society on the future. The Geology is the science responsible for the study of the Earth in its entirety: composition (rocks and minerals), structure (internal and external), physical properties, history and processes. This science is important for teaching us how these concepts act and how we apply them in our everyday lives. Paleontology, in turn, through the study of fossils, shows how the life was on the Earth in the past, how this evolved during the time and how this was affected by the processes that act in the Earth (Schwanke & Silva 2004). Fossils are found often in sedimentary rocks. Bones, shells, trunks and other materials are preserved with their organic matrix exchanged with mineral components, while tracks, footprints and other traces often are preserved in a substrate that has undergone different processes, enabling them to resist the weather and be found much later. These interpretations are possible thanks to the correlation of information between geological and paleontological studies, derived from the works of late 17th century Danish scientist Nicolas Steno that serve as basis for the field of Stratigraphy, and highlight their importance and relevance (Toledo et al. 2014).

However, in Brazilian education, the National Curricular Parameters (Parâmetros Curriculares Nacionais, PCN) approaches these themes in a succint manner. In addition, in December, 2017, the Federal Government has instituted the National Common Curricular Basis (Base Nacional Comum Curricular - BNCC), mandatory in all stages of Brazilian Basic Education, and that ignores the Geosciences as relevant subjects for the curriculum of Brazilian students (Brasil 2017). Therefore, the elaboration of textbooks, using the PCN as basis, may suffer interference of several factors that alter their didactic role (Souza 2015). Moreover, teacher training courses could approach these themes, but in general fail to correctly transmit contents in Earth Sciences (Araújo & Toledo 2014). Many times, this situation blocks the production of classes by teachers, thus reducing the potential interest of the students for these subjects (Faria et al. 2012).

In this context, it is possible to search for alternatives in order to complement the teaching of these subjects in spaces other than the classroom. The museums can be just such places (Anelli 2002). Furthermore, the lack of didactic collections in many high schools enhances the value of museums as a way for students to access the world of fossils (Schwanke & Silva 2004).

The authors understood museums as essential spaces for scientific teaching and dissemination, in special Geology and Paleontology. The objectives of the paper are to summarize a few Brazilian museums whose thematic involves Geology and Paleontology, and to present recent examples of educational museum practices and scientific dissemination by analyzing three Brazilian museums: the Museum of Dinosaurs (*Museu dos Dinossauros*) in the city of Uberaba, and the Catavento Museum (Museu Catavento) and Geosciences Museum of USP (*Museu de Geociências da USP*), both in the city of Sao Paulo.

2 A brief history of Natural History museums

Since their beginning, museums had a strong bond with scientific research, and specially with academic disciplines of big European universities, assuming a goal to contribute with evolution of scientific knowledge (McManus 1992). Even today, many museums are subordinated to universities or academic institutions. These institutions and their researchers are often responsible for the implementation of museum spaces for scientific dissemination, combined with scientific research using their collections. Through the research made in museums, the construction of the knowledge about the samples deposited in them takes place, together with the expansion of their collections, made possible by the incentives to research in other places and interchange between institutions (Boylan 1999).

Museums are places that have their own form of developing their educative dimension (Marandino 2009). As spaces of non-formal education, this characterization aims to differentiate the museums from the formal educational experiences, like those developed at school, and the informal experiences, often associated to the family environment.

3 Earth Sciences in Brazilian museums

Academic knowledge should not be exclusive of universities, professors, researchers and their peers. In that sense, the museum rises as a window for scientific dissemination and academic research, especially that which takes place in museums that are linked directly to universities and their extension and research programs.

According to Almeida et al. (2015), there are about 268 cultural-scientific places in Brazil, such as museums, planetariums, botanical gardens, zoos, aquariums, mobile science units and associations that develop popularization of science and technology in the country.

Lopes (1989) has listed the institutions that directly work with teaching and dissemination of Geology in Brazil, while Pássaro et al. (2014) highlight as Brazilian paleontological heritage about 318 thousand catalogued fossils.

Table 1 shows a compilation made by the authors of the museums listed by Pássaro et al. (2014) and the museums referred by Almeida et al. (2015) that work with the themes of Geology and Paleontology, resulting in 46 institutions, put in ascending order of inauguration date. The Museum of Geosciences of the State University of Londrina (*Museu de Geociências da Universidade Estadual de Londrina*), in the city of Londrina, and the Catavento Museum (*Museu Catavento*), in Sao Paulo, were also included.

The presence of these institutions that dedicate at least a part of their collections to the dissemination of Earth Sciences teaching in Brazil may contribute to complement learning. Although many museums are reference centers in areas tied to paleontological research in Brazil, the main attraction of these institutions are their exhibits (Schanke & Silva 2004). So, practical activities aimed to stimulate and to inform the visiting public of museums are often developed.

4 Educational practices as dissemination actions

It is important to understand the social and educational role of museums, and the education in museums constitutes a relevant thematic of study, both at a national and international level (Marandino 2015).

Officially, museums are defined as permanent, nonprofit institutions, at the service of society and its development, open to public, that acquire, research, communicate and exhibit, for study, education and leisure means, the testimony and material and immaterial heritage of peoples and their environment (ICOM 2016). The Brazilian Institute of Museums (Instituto Brasileiro de Museus – IBRAM) defines the term museum as following:

> "The museum is a place in which sensations, ideas and images irradiated by objects and references gathered there illuminate essential values to the human being. It is a fascinating place, where one can discover and learn, broadening knowledge and deepening the conscience of identity, solidarity and sharing. By means of museums, social life can recover the human dimension that evades in the rush of time. The cities find the mirror that reveals their faded faces in the turmoil of everyday life. And each person greeted by a museum ends up knowing more about herself. In the cultural universe, the museum assumes the most diverse and enticing functions. A yearning for memory seduces and conduces people in search of ancient and new records, guiding them to the field of museums, which doors are always a bit more open. Museology is shared today as a practice in service of life." (IBRAM 2018).

Museums and their exhibitions do not exist without the public to contemplate and reinterpret them (Murrielo 2006). At the museum-society relationship, the public is the core audience, being one of the main reasons for the survival of museums through the centuries. Museums are places of cultural, social, preservation of memory and historical heritage importance.

Table 1. Museums that contemplate the themes of Geology and Paleontology in Brazil, adapted from Pássaro et al. (2014) and Almeida et al. (2015)

	Name	Year	City - State
1	National Museum (*Museu Nacional*)	1818	Rio de Janeiro - RJ
2	Museum of the State of Pará "Emilio Goeldi" (*Museu Paraense Emilio Goeldi*)	1866	Belém - PA
3	Science and Technique Museum (*Museu da Ciência e Técnica*)	1884	Ouro Preto - MG
4	Earth Sciences Museum (*Museu de Ciências da Terra*)	1930	Rio de Janeiro - RJ
5	Museum of Ceará (*Museu do Ceará*)	1932	Fortaleza - CE
6	Geosciences Museum of USP (*Museu de Geociências da USP*)	1934	São Paulo - SP
7	Cultural and Historical Museum "Vicente Palloti" (*Museu Histórico e Cultural Vicente Pallotti*)	1935	Santa Maria - RS
8	Museum of Paleontology "Irajá Damiani Pinto" (*Museu de Paleontologia Irajá Damiani Pinto*)	1945	Porto Alegre - RS
9	Museum of the Cultures "Dom Bosco" (*Museu das Culturas Dom Bosco*)	1951	Campo Grande - MS
10	Museum "Dom José" (*Museu Dom José*)	1951	Sobral - CE
11	Department of Geology of the UFPe (*Departamento de Geologia da UFPe*)	1959	Recife - PE
12	Museum "Câmara Cascudo" (*Museu Câmara Cascudo*)	1961	Natal - RN
13	Museum of Sciences and Technology of the PUCRS (*Museu de Ciências e Tecnologia da PUCRS*)	1967	Porto Alegre - RS
14	Geological Museum "Valdemar Lefrève" (*Museu Geológico Valdemar Lefèvre - Mugeo*)	1967	São Paulo - SP
15	Natural History Museum and Botanical Garden of the UFMG (*Museu de História Natural e Jardim Botânico da UFMG*)	1968	Belo Horizonte - MG
16	Museum of Rocks and Minerals (*Museu de Minerais e Rochas*)	1968	Recife - PE
17	Zoology Museum of USP (*Museu de Zoologia – USP*)	1969	São Paulo - SP
18	Rocks and Minerals Museum "Heinz Ebert" (*Museu de Minerais e Rochas Heinz Ebert*)	1970	Rio Claro - SP
19	Antares Astronomical Observatory (*Observatório Astronômico Antares*)	1971	Feira de Santana - BA
20	Mineralogy and Petrology Museum "Luiz Englert" (*Museu de Mineralogia e Petrologia Luiz Englert*)	1972	Porto Alegre - RS
21	Natural Sciences Museum of the FZBRS (*Museu de Ciências Naturais da FZBRS*)	1974	Porto Alegre - RS
22	Geological Museum of Bahia (*Museu Geológico da Bahia*)	1975	Salvador - BA
23	Museum and Geological Information Centre (*Museu e Centro de Informações Geológicas*)	1981	São Leopoldo - RS
24	Science Museum of the PUCMG (*Museu de Ciências da PUCMG*)	1983	Belo Horizonte - MG
25	Paleontological Research Laboratory of the UFAC (*Laboratório de Pesquisas Paleontoló-gicas da UFAC*)	1983	Rio Branco - AC
26	City Museum of Marabá (*Museu Municipal de Marabá*)	1984	Marabá - PA
27	Museum of Paleontology "Plácido Cidade Nuvens" (*Museu de Paleontologia Plácido Cidade Nuvens*)	1985	Santana do Cariri - CE
28	Crato Regional Office, Superintendence of the DNPM-CE (*Escritório Regional do Crato da Superintendência do DNPM-CE*)	1986	Crato - CE
29	Museum of Paleontology "Professor Vingt-un Rosado" (*Museu de Paleontologia Professor Vingt-un Rosado*)	1988	Mossoró - RN
30	Museum of Dinosaurs (*Museu dos Dinossauros*)	1989	Peirópolis - MG
31	Araraquara Science Centre (*Centro de Ciências de Araraquara - CCA*)	1989	Araraquara - SP
32	Natural History Museum of the Federal University of Alagoas (*Museu de História Natural da Universidade Federal de Alagoas*)	1990	Maceió - AL
33	Paleontology and Stratigraphy Museum "Prof. Dr. Paulo Milton Barbosa Landim" (*Museu de Paleontologia e Estratigrafia Prof. Dr. Paulo Milton Barbosa Landim*)	1992	Rio Claro - SP
34	Museum of Paleontology "Prof. Antonio Celso de Arruda Campos" (*Museu de Paleontolo-gia Prof. Antonio Celso de Arruda Campos"*)	1992	Monte Alto - SP
35	Museum of Geosciences of the State University of Londrina (*Museu de Geociências da Universidade Estadual de Londrina*)	1993	Londrina - PR
36	Natural History Museum "Prof. Dr. Mário Tolentino" (*Museu de História Natural Prof. Dr. Mário Tolentino*)	1995	São Carlos - SP
37	Museum of Geology of the Brazilian Geological Service/CPRM (*Museu de Geologia do Serviço Geológico do Brasil/CPRM*)	1995	Porto Alegre - RS
38	Museum of the Earth and Life – CENPALEO (*Museu da Terra e da Vida - CENPALEO*)	1997	Mafra - SC
39	Phoenix Paleontological Foundation (*Fundação Paleontológica Phoenix*)	1999	Aracaju - SE
40	Earth Sciences and Natural History Museum "Barra do Jardim" (*Museu de Ciências Natu-rais e História Barra do Jardim*)	2001	Jardim - CE
41	Natural History Museum of Taubaté (*Museu de História Natural de Taubaté*)	2004	Taubaté - SP
42	Pre-historical Museum of Itapipoca (*Museu de Pré-história de Itapipoca*)	2005	Itapipoca - CE
43	Catavento Museum (*Museu Catavento*)	2007	São Paulo - SP
44	City Museum "Parque do Saber Dival da Silva Pitombo" (*Museu Municipal Parque do Saber Dival da Silva Pitombo*)	2008	Feira de Santana - BA
45	Geodiversity Museum (*Museu da Geodiversidade*)	2009	Rio de Janeiro - RJ
46	Zoobotanical Museum "Augusto Ruschi" (*Museu Zoobotânico Augusto Ruschi*)	2010	Passo Fundo - RS

The work of McManus (1992) characterizes museums in three generations, divided by the themes that generated them, with the first generation being directly linked to natural history, the second related to science and industry, and the third generation tied to scientific concepts and phenomena.

The last generation of science museums differ radically from the others by not only relying on collections of historical objects, but by presenting ideas instead of objects, mediated by more interactivity with equipments, with the goal of valuing scientific and technological development by enlightening the public, in the sense of provoking communication between the visitors and the historical collections exhibited, with the intention of leading them to assimilate scientific principles (Cazelli et al. 1999).

The museum is responsible to create and organize exhibitions aimed at the external community, with its collection used to build permanent exhibitions, adopting an adequate theme to present its content. It is also common the creation of temporary exhibits, with a different thematic of the permanent exhibits of the museum (McLean 1996). The museum may also create travelling exhibitions, that may be transported to many places outside of the museum, taking with them their content to places where the access to these institutions is not available and contributing to the dissemination of the knowledge conceived in them (Xavier 2013).

5 Examples of museums and their activities

The following part is a succinct description of some examples of the main dissemination and practical activities of the visited museums, associated to the themes of Geology and Paleontology.

5.1 Museum of Dinosaurs

A visitation to the Museum of Dinosaurs (*Museu dos Dinossauros*), close to the city of Uberaba, state of Minas Gerais, was made by author T.D.V.S. Aquino in June 2016, with the aim to observe educational practices and dissemination actions. The Museum's collection comprised over 4,000 samples of different groups, in a good state of preservation, with samples of sauropod and theropod dinosaurs, crocodyliformes, testudines, amphibians, fish, mammals, mollusks, crustaceans, ferns and ichnofossils. These fossils are related to the Uberaba and Marília Formations (Ponte Alta Member) of the Bauru Basin, dated Upper Cretaceous, c. 70 million years old (Ribeiro et al. 2012, Ribeiro 2014).

The space inside the museum highlights windows with paleoenviromental reconstructions of some of the fossils found in that region. There are also rocks with exposed fossils, sand and sediments placed around the museum, referring to the climate of the region millions of years ago, while also referring to the sedimentological studies developed by researchers from different regions of Brazil and around world.

The main educational practice of the museum is guided visitation for schools and, at times, spontaneous groups. There is also a guided field trip to one of the main excavation sites figured in the museum's exhibit, known as "Ponto 1 do Price" (Price's Point 1), named in honor of Llewellyn Ivor Price, an old Brazilian paleontologist.

5.2 Catavento Museum

The Catavento Museum (*Museu Catavento*), administered by the Social Organization of Culture Catavento (*Organização Social de Cultura Catavento Cultural*), associated to the Secretariat of Culture of the State of Sao Paulo, is situated at the former "Palácio das Indústrias" building, built in 1924, presenting itself as a cultural and educational space that presents science and social issues to the public in an interactive manner. This museum was visited by the authors C.A.D. Cerri and T.D.V.S. Aquino in the month of January, 2018, in order to register educational activities, especially the interactive ones, which are the main attraction of the museum.

Figure 1. Guided visitation of students at the Museum of Dinosaurs. At the center is the fossil of Uberabasuchus terrificus, found at "Price's Point 1". Photo by the authors

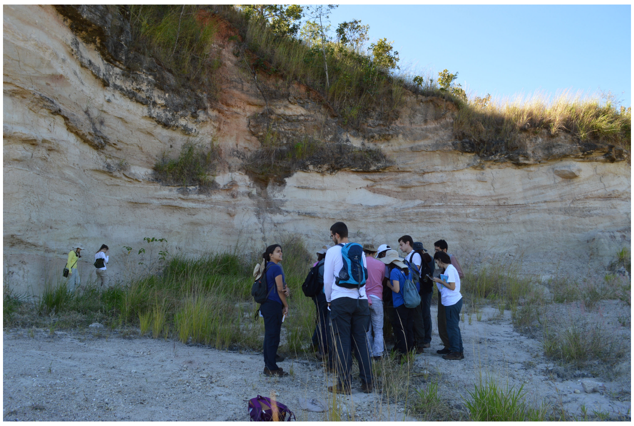

Figure 2. "Price's Point 1", during visit by a group of students in field activity. Photo by the authors

The museum's collection is divided into four thematic sections: Universe (*Universo*), Life (*Vida*), Mill (*Engenho*) and Society (*Sociedade*), and the themes related to Earth Sciences are under display in the Universe section, which is itself divided into subsections. Many activities of the museum have some sort of interactive bias, mainly by means of videos and scientific models. Inside the Earth subsection, one of the main attractions is the activity "Earth's topography in 3D". Using technological tools, the museum assembled a sandbox where a model of the current terrain inside the box is constantly projected over it, and it is updated as the visitors move the sand around the box, creating geological features in real-time, while also enabling the visitor to "make it rain" over the terrain by placing their hand over the box, simulating a raincloud. This activity works with the concepts of maps and contour lines, and enables the visitor to explore the relationships between the different topographical features: elevations, depressions, lakes and oceans.

Besides interacting with the activity, the visitors are also instigated to make correlations with day-to-day life by means of panels and texts. In this particular example, different applications for the maps and contour lines, such as in Agriculture and Civil Engineering, are suggested to the visitors in the background panels.

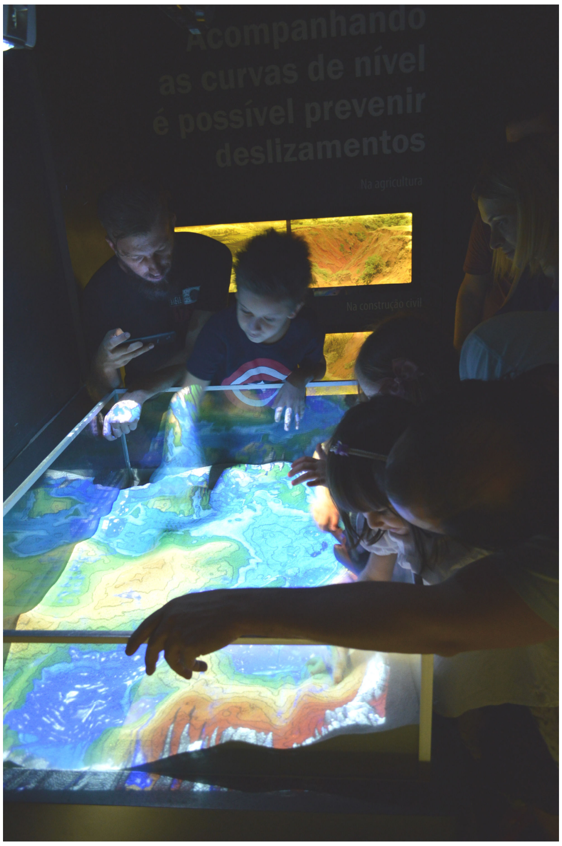

Figure 3. Activity “Earth’s topography in 3D”, at the Catavento Museum, with visitors interacting with the sandbox. Photo by the authors

5.3 Museum of Geosciences of the University of São Paulo – USP

Created in 1934 as the former Museum of Mineralogy of the Department of Mineralogy and Petrology of the Faculty of Philosophy, Science and Letters (FFCL), the collection of the Museum of Geosciences of the University of São Paulo – USP (*Museu de Geociências da Universidade de São Paulo – USP*) was, throughout the years, enhanced with private collections and field sampling from the researchers and students of the Institute of Geosciences. Nowadays, the museum boasts a collection of approximately 15 thousand samples, with around 5 thousand of them on permanent exhibition.

Besides its communication and dissemination role, the museum also works as a practical studies lab for the graduation-level disciplines of the Institute. By means of guided visitation, it also hosts groups of students from schools of the city of Sao Paulo and other locations. It also offers extension courses and lectures in schools, organizing thematic and temporary exhibitions, field trips and orienting in organizing science fairs.

In exhibition at the museum when visited by the authors, in January 2018, is the “Fossils from Araripe” exhibition, put together with the main samples (about 5 thousand) originated from seizures of the Federal Police at the Chapada do Araripe, at the northeastern region of Brazil. These are samples of bony fish, winged reptiles, plants and invertebrates, amongst other ones, regarded as some of the best-preserved fossil samples in the world, and common target of international fossil traffic. The main practical activity available at this exhibition is the possibility of visitors to touch and interact with real fossils, under monitoring by museum educators.

Figure 4. “#touchonAraripe” activity, where the visitors may handle real fossils of bony fish from the Cretaceous period. Photo by the authors

6 Conclusions

Assuming that teaching Geology and Paleontology is important for citizenship formation, and that the formation of the teachers that work with these subjects in basic education in Brazil is deficient, the museum is an important agent of teaching and scientific dissemination of Earth Sciences. The museum can enable complementation of these subjects outside the classroom.

By analyzing the bibliography related to the museums that work these contents in Brazil, it is possible to attest that these contents are available as thematic in these institutions since the creation of the National Museum (*Museu Nacional*), in 1818. Since then, there are 200 years of history and activity of these institutions, promoting teaching and science dissemination. The museums are important ways of accessing knowledge, as landmarks or in their relations with its surrounding communities.

The museums help the visitors to understand a scientific subject usually restricted inside the Academy. The possibility to interact with samples, models and exhibitions related to the themes of Geology and Paleontology differs from common classroom practices, usually presented in a theoretical way, and can make a difference regarding learning processes.

The activities analyzed and discussed in this work represent direct efforts of the professionals responsible by these museums in the dissemination of the knowledge produced from their collections. The museums enable the visitors to approach the scientific content in a playful way, giving effective value to the presence and constant maintenance of these places, and the teaching of Geology and Paleontology in Brazil.

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Thematic Line

Education, Teaching of Geosciences and Teacher Training

A STUDENTS PERCEPTION ON INTERNATIONAL EARTH SCIENCE OLYMPIAD

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Abstract— The International Earth Science Olympiad is an annual competition for school students selected by the respective National Olympiad. Is one of the main activities of the International Geoscience Education Organization. This work would like to determine if this Olympiad encourage friendly relationships among young students from different countries, and promote talented and gifted students in Earth science. Questionnaires were submitted to students that participated at the 11th International Earth Science Olympiad in 2017. The results of this survey were analyzed. The main finding is that through the cooperative activities proposed by this Olympiad friendship grow among participants. The students are almost all interested in Earth science and they enjoy to learn more about Earth science. Although the percentage of students interested in pursuit studies and a career in Earth science is quite high, there is a significate amount of students that already know that they do not will study subject related to Earth science, especially among males.

Keywords— Science Olympiad, students perspective, friendly relationship among international students, raise students' interest in Earth science.

Thematic line— Teaching of Geosciences and Natural Sciences for School-Level Education and Teacher Training.

1 Introduction

The International Earth Science Olympiad (IESO) is an international science event for secondary school students. IESO is promoted by the International Geoscience Education Organization (IGEO). Its main goal is to promote geoscience education at all levels in each country both quantitatively and mainly the qualitatively. For those reasons, IESO is one of the main IGEO activities.

Each country participating includes a team of 4 students, who were selected through a national process. The team is led by two mentors, usually science teachers or university professors who are also in charge for the selection and training processes. The mentors act as international jury with assessment task and translating the written assignments into their native language when it's necessary. For that reason, it is important that mentors are expert in education and Earth Science. The national selection differs from country to country and could be made of different number of tests and stages (Calonge & Greco 2011, Greco, Hlawatsch & Bronte 2013, Greco, Ifanger 2014). It's quite common that after national selection students pass through a training, which could be of few days till several encounter along the year (Greco & Ifanger 2014). In this context, it is important to point out a huge gap between countries that invest hundreds of thousands of dollars in preparing their teams for the Olympiad and countries that rely on what was learnt by the students in their schools and conducts only limited preparation.

During IESO students pass through written and practical tests, both contribute for the final assessment of the competitive part of the Olympiad. IESO is probably the only science Olympiad that includes cooperative activities. These cooperative activities are the International Team Field Investigations (ITFI) and the Earth System Project (ESP). ITFI and ESP are based on team work. The team are made by 6-8 students from different countries.

ITFI consist in field investigation: students receive a written task and then go into the field in order to collect evidence and information to solve the task. Then they make an oral presentation, as scientist do in a congress, in front of the international jury that assess their research and finding. ESP is a bibliographic research based in literature.

The teams received a task, they collected infomation, make relations and present their finding in a poster fomat. The poster is assessed by the international jury.

IESO is an annual event, every year host in a different country. The first IESO edition was held in 2007 in South Korea. In 2017 was held the 11th editions. In 2017, 34 countries were involved, 29 of them with students' team and 5 just with observers

IESO is ruled by two basic documents the Statutes and the Syllabus.

The Syllabus contain all Operative Objectives, Contents Principles and Pedagogic Principles for students' preparation and general Skills and Abilities that students should acquire towards the IESO. It contains Key Ideas and Skills and Abilities related to the following topics: The Geosphere and Earth Systems; Hydrosphere and Earth Systems; Atmosphere and Earth Systems; The Planetary System and Earth Systems.

The main objectives of IESO that emerge from the Statutes are:

- To raise students interest in and public awareness of Earth science;
- To enhance Earth science learning of school students;

- To improve the teaching of earth science in schools;
- To promote talented and gifted students in earth science;
- To promote international cooperation in exchanging ideas and materials about earth science and earth science education;
- To encourage friendly relationships among young learners from different countries.

This paper focuses on the perspective of the students who attended at IESO related to the above objectives.

2 Methodology

An inventory was specially developed for assessing the participants' attitudes towards the IESO in general and their interest in Earth Science in particular. The inventory included a closed part of a 17-items Likert-type questionnaire where students were asked to grade their attitudes on a five-point scale that ranges from “definitely disagree” to “definitely agree”. The second part included 11open-ended questions. The open questions were analysed by categories of answers.

The inventory was submitted to all participants (108 students and 9 guest students) of the 2017 IESO, host in France in August 2017. It was submitted at the sixth day of the IESO (the last day) during the students’ free time between International Team Field Investigation and the Earth System Project presentations. The final sample included 106 questionnaires of 66 males and 40 females answered them. This sample presented 27 of the 29 countries that were attended IESO. The students average age is 17 years old and 8 of them (8%) already took part in other international Olympiad (6 males and 2 females).

3 Results and discussion

Attitudes towards the IESO event: The analysing of the Likert-type part of the questionnaire indicated the vast majority of the participants liked IESO because they learnt more about Earth Science (89%) and got international friends (86%). 75% mentioned the interaction with a scientist as a source of their positive attitudes. Only 4% found IESO boring.

The majority of the students (83%) mentioned that they learnt a lot of the ITFI, but only half of the participants (53%) felt that they learnt a lot of ESP. However, 88% of the participants mentioned that they enjoyed to cooperate with colleagues from others countries and 82% indicated that they got a lot of international friends. Only 16% students found the written test easy and even less (11%) found the practical test easy. About half of the males (55%) expressed negative attitudes towards the written test, because that it was too difficult, while only 29% of the females expressed such negative attitudes concerning this aspect. However, more females (54%) expressed negative attitudes towards the practical test than males (45%), but they did not complain about the level of the test, rather they complained about the confusing instructions that the organizers provided.

In addition, 93% of the females indicated that they made social connections and international friends, while only 76% males indicated social connections.

The analysis of the open questions of the survey supports the findings of the Likert type questionnaire. Almost all of the participants (99%) wrote a very positive comments concerning their experience during the IESO, as can be seen from the following representative citations:

> “…That was pretty cool. I learned a lot of things from the others, from the activities…”;

> “…This was one at the best things that happen to me. I feel like I have become another person with new thought, new motivation for life. I just feel so happy. Thank you very much!”;

> “…Participating in the IESO increased my appreciation of Earth as a whole system of interacting subsystems, since I used to only consider geology. I loved making new friends from other countries and I hope we can find future collaborators from this event. Joining IESO has further reinforced my interest in pursuing a career in geology/geoscience”.

At the end of the "open" part of the questionnaire the participants were asked to write free any comments they have. About more than 60% of the students wrote enthusiastic comments such as, "It was my best time"; "It was my best week"; "It was great, thanks"; I love IESO; "I made new friends".

The participants expressed very positive attitudes towards both collaboration project-based assignments of international teams, the ITFI and the ESP. About 80% of the students wrote positive comments about the ITFI (good, enjoyable, great, cool, fun, interesting, liked the collaboration with others and liked the location). Only 13% of the participants wrote negative remarks such as stressful, exhausting, difficult and intense. The ESP received similar positive comments but slightly lower than the ITFI. The amount of students who wrote negative comments about the ESP were above the ITFI. About 20% wrote that they were confused about what they had to do in this project and 6% referred to a lack of time for finishing the project properly.

About 40% of the participants wrote that the written test was interesting or good and about 30% expressed positive statements towards the practical test (good/cool/fun).

3.1 Attitudes towards the preparation to the IESO

The analysing of the Likert-type part of the questionnaire indicated that 72% of the participants enjoyed the preparation process, but for one third of the students (34%) it was stressful.

The analysis indicates that the sources of the participants' interest in Earth Science are varied. The main sources are school (34%), home; (22%) and contact with nature (21%). In addition, 21% of the participants pointed the competition itself as a source of interest. This finding fits to the finding that 23% of the participants declared that they are mainly focus on the competition. While third of the males perceived the IESO mainly as a competition only 13% for females expressed this attitude. This might explain the findings that most of the males enjoyed the preparation towards the IESO (78%) while only 62% of the females enjoyed it.

Although the program committee of the IESO adopted the earth systems approach at 2005 as the official context of the IESO, the 2017 edition was the first IESO that the earth system approach was fully implemented. The finding that half of the participants indicated that their preparation for IESO was different compared to the assignments they had to deal with, might point on the difficulty of many countries to adopt the earth systems approach.

The finding that only 38% of the students were assisted by their school teachers for the preparation process is quit problematic, since it can indicate that for most of the participants, their school teachers were not involved with the preparation towards IESO.

The analysis of the open questions indicates that almost half of the students mentioned an official national training program for the Olympiad. Reading scientific textbooks was the most common tool for the preparation (mentioned by 41% of the participants), followed by solving past IESO test (22%), browsing on the internet (19%), discussing with peers (about 10%) and the same amount did it alone without external assistance. It is important to note, that only about 10% mentioned the teachers as a source for assistance. Thus this finding supports the quantitative data concerning the marginal involvement of the schools with IESO.

3.2 Attitudes towards future studies

The quantitative analysis indicates that only 39% of the participants stated that there is a high probability that they will study something related to the geosciences during their higher education studies. However, 31% of the students claimed that they most likely will not choose to study earth science after graduate the high school.

The qualitative analysis revealed the same attitudes, while only 40% of the participants mentioned that they are looking for a higher education degree in a geoscience area and only 18% mentioned a geoscience area as future job of their dream.

However, half of the females (48%) declared on their interest to study a geoscience subject in the university while only one-third of the male students believe that they will continue with the geosciences in their higher education studies. This differences is probably an indication of the competitiveness-practical nature of the males that mentioned above.

4 Conclusions

This survey allows us to present the students' perspective about the IESO. The quantitative and the qualitative data that was collected are in agreement and both indicate the very positive attitudes of the students from the unique structure of the IESO and mainly the ITFI and ESP, which are based on collaboration of mixed international teams. Most of the participants perceived that IESO as meaningful life experience that touched and influenced all the components that are involved in of a genuine learning event namely emotional, cognitive and social.

The positive findings mainly reflect the success of the IGEO's committee that planned and designed the structure and the content of the event and the success of the local committee to implement the earth system approach content and the complicated structure mixed international teams assignments.

However, beside the above success, the findings indicate that after 11 years of operation the IESO is still far away from achieving its other objectives. In most of the countries the schools are not involved with the preparation process and without involvement of teachers and school there is no chance to influence the quality of the earth science education in schools. The finding that even after their participation in the IESO only small amount of the participants believe that they will choose to study geoscience in the university reflects the situation that for many countries IESO is not part of an educational long term process, but rather a Had Hoc competition.

Additional research will be necessary to better understand the influence of the specific approach in each participating country on the participants' outcomes.

Acknowledgements

We are glad to acknowledge all the students that answer the questionnaire.

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AN EARTH SCIENCE COURSE AT KAMNOETVIDYA SCIENCE ACADEMY, A THAI SCIENCE-ORIENTED SENIOR HIGH SCHOOL

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Abstract— A new conceptual earth science course was conducted at a science high school in Thailand. The course contents composed of 32 topics, 50 minutes on each topic, spanning a period of two months. The course is equivalent to 0.5 credit for grade 12th students, as a compulsory subject. The course was conducted mainly in English via lectures given by a Japanese visiting teacher, while resources and the examination were fully supported by a Thai teacher. An adviser from Silpakorn University gave supports and advices on the teaching process. The contents consisted mainly of geology and geophysics. The course also covered a few contemporary controversial issues such as earth-quake prediction, dinosaur extinction, and climate changes. Complimentary exercises and experiments were conducted at the same time, concurrently with the PPT presentation of each lecture. Questionnaires were used to assess the course outcomes. Feedback from students clearly indicated that the course was successful.

Keywords— Thailand, Earth Science, Geology, Geophysics.

Thematic line— Geoscience Education in senior high school level.

1 Background of the school

Information on Kamnoetvidya Science Academy (KVIS) can be found at http://www.kvis.ac.th/About_EN.aspx) under the section 'Discover KVIS'. An excerpt of the content is shown below.

> "KVIS is a full boarding school providing education with special emphases on mathematics, science, and technology to students of three-year levels comprises Year 10, Year 11, and Year 12 with full scholarship each. With a strong intention to provide customized training to the need of individual student, KVIS thus set out for a small class size. KVIS therefore caters for only four classes for each year level having only 18 students in each class. The total number of students on campus at one time would therefore be 216 students. To effectively "growing wisdom" in gifted young minds, KVIS carefully selected high-performing teachers and staff members while providing salaries and fringe benefits at levels well above country averages.

The school uses English as the main medium of instruction. Apart from laboratory exercises that go hand in hand with lecture components, each student need to complete a research project prior to graduation. Students are trained to make good uses of extensive databases available online to formulate their research projects. Each student has to do a presentation on research proposal, writing a mini-thesis when the research is completed, and to finally present the final results to other students, staff members and invited guests of the school. These activities place heavy demands on staff members and facilities. It is the duty of the school to provide them with good and sufficient scientific equipment and supporting supplies to meet their needs."

To realize those goals, the school currently employs 43 teachers, including foreign visiting teachers and 10 senior advisers who are mainly from co-operating universities. For the academic year of 2017, the M6 (year 12th) students took the earth science course in the first semester. We developed a completely new curriculum and contents of the earth sciences class in co-operation of a foreign visiting teacher and a senior adviser.

2 The KVIS Earth Science team and Curriculum

In our school the subject matter on earth is called 'earth science'. Also, this year is the first time to establish the subject nature of earth science as a compulsory subject. The KVIS earth science team consists of two teachers and one adviser.

At first, the constructing contents and main lectures were carried out by a Japanese visiting teacher (Yoshio Okamoto) who has a long career in teaching Earth Science in Japan. Yoshio Okamoto is also now teaching at Osaka Kyoiku University as a temporary lecturer. The second person is Janjira Maneeasan who is a chemistry teacher at KVIS. Janjira Maneeasan graduated with a PhD in biochemistry and began her work at KVIS in April 2017. She managed Earth Science class for curriculum, daily preparation for lecture resources, discussing the lecture contents and did the VDO recording of the classes. She also checked the daily attendance of students, and assisted in marking the final exams. The third person is Thanit Pewnim who was an instructor at Silpakorn University. Thanit Pewnim is currently the chemistry senior adviser at KVIS who is a specialist on SEM and X-Ray microanalysis. He supports and give advices on the curriculum, encourages the team, and motivates the class to progress in harmony. The team developed a unique ERS (earth science) curriculum, teaching resources, a final exam, assessing students' performances, and grants credits to students.

The ERS course was delivered to four classes of 12th grade students. Each class consists of 18 students.

These classes were confined to the period of 31 July to 29 September 2017 to fit the Japanese visiting teacher's schedule.

The course is divided into two categories, the basic course and the advanced course. The basic course covers basic knowledge and concepts of earth science, while the advanced course extends to the study of scientific methods, the special topics, and the applications of earth science.

3 The ERS course contents

Table of ERS course contents is as follows.

Table 1. The ERS course contents (Purple: our original unique tools, References)

<Basic course>

	Title	Aim	Contents	Tools/materials	Exercises
1	Rock Minerals I	Definition of SiO_4 families.	quartz, feldspar, mica, etc.	Mineral samples and photos	Observation of samples
2	Rock Minerals II	Identification of SiO_4 families.	Metal ions, solid-solution	Minerals Rock samples	Mineral quiz
3	Igneous Rocks I	Definition of igneous rocks	Table felsic acidic, volcanic, plutonic	Polished igneous rock samples,	Igneous rock quiz
4	Igneous Rocks II	Occurrence or igneous rocks	Dikes, sheet, batholis, xenotith	Igneous rock samples, photos	quiz
5	Volcanoes and eruptions I	Classification relation with igneous rocks	volcano classification table	National geographic videos, and protractor	Mt. Fuji summit angle measurement
6	Volcanoes and eruptions II	Eruption types and volcano disasters	Hawaiian, Stronbolian, Vulcanian, Pliniyan	Volcanic ash samples (Kanto roam, A/T ash)	Microscope observation of volcanic ashes
7	Earthquake I	How to read seismograms	Hypo-center, magnitude (Richter scale)	Seismograms, map, magnitude nomogram	Original seismograms exercise (Okamoto et.,al. 2013)
8	Earthquake II	Earthquake and focal mechanism, Seismographs	How to study the mechanism of earthquake	P-initial time and phase map of 1995 Kobe earthquake	P-arrival map exercise, Seimographs (Okamoto,2016 Okamoto & Ito,2014)
9	Earthquake and fault	Relation with fault	Fault mechanism and earthquake	Fault experiment	Flour fault experiment
10	Special lecture to all KVIS members at the auditorium	Lessons from 2011Tohoku, 1995Kobe	Disasters and human beings, Japanese cases	PPT lecture	Own-made tsunami simulations
			<1st ERS report>		
11	Continental drift	Theory: birth and defeat	Evidences and drawbacks	Photos and maps	Continental drift map puzzle
12	Sedimentary rocks	Classification	Particle sizes, compositions	Photos and samples	sedimentary rock quiz
13	Sedimentary structures	Characteristics	Turbidite, laminae, ripple marks, convolution, etc.	Photos and samples	Exercise on sedimentary structures
14	Geological structures	Characteristics	Unconformity, intrusion, faults	Photos and maps	Observation of photos
15	Geological principles	How to read geological profiles	Law of super- position, cross-cutting relationship	Photos and maps	Geological map quiz
16	Geo-history I	Fossils and Paleozoic era	index fossils, facies fossils, Paleozoic fauna and flora	Photos and Fusulina trilobite samples	Observation of fossil samples
17	Geo-history II	Fossils II, absolute ages and Mesozoic era	Radiometric dating, Mesozoic and Cenozoic fauna and flora	Ammonite samples, Exponential graphs	Observation of fossil samples, Graph sheet
18	Geo-history III	Cenozoic era and ice ages	Human fossils, ice age remnants, Mirancovic cycle	South Africa trip photos and video	Watching videos and photos

<Advanced course>

	Title	Aim	contents	tools/materials	exercise
19	Earthquake prediction I	Why so difficult? G-R law	G-R laws example, simulations of earthquakes	Semi-log and log-log graph papers, PC simulations	"Go-game model", "Sand-pile model" (Okamoto 2006)
20	Earthquake prediction II	Precursors? Characteristic earthquakes?	Earthquake prediction and time-predictable model	Psychological bias, Chikura map and graph sheet,	Random test, Time-predictable model
21	Complex systems I	What is ?	Power laws and Zipf's law	Fortune global 500 table	Zipf's law exercise (Okamoto 2016)

			<2nd ERS report>		
22	Complex systems II	Fractals, Chaos, SOC	Cell automaton	Grid sheet, rule table	1-dimensional cell exercise
23	Earth's interior I	Crust and Mantle	Moho discontinuity, seismic ray theory	1995 Kobe earthquake. Travel-time data	Vp,Vs crust thickness
24	Earth's interior II	Mantle and Core	P,S shadow zones	Jeffray's Bullen travel-time curve, seismo-grams	Fit travel-time to seismo-grams
25	Pre-Plate tectonics	Ocean floor spreading, geomagnetic survey	Magnetic polar wandering, and ocean floor geomagnetic anomaly	"Red October" video, Basalts, Iron needles, Dishes	Basalt NRM, Ocean fl our geo-magne model (Okamoto & Imura 2014)
26	Plate tectonics	Basics of plate tectonics	Subduction zone, mid ocean ridge and transform faults	Plate map, original transform fault paper model,	Paper model of transform fault, Zambia trip video 3D seismic maps (Okamoto 2011)
27	Burgess biota	Missing lives, punctuated evolution	My Burgess shale trip, and the meanings of Gould's "Wonderful life"	Burgess fauna resources, Canadian Rockys video	watching videos "Its a wonderful life", my trip video
28	Mass extinction	P/T and K/T mass extinction	K/T asteroid impact theory	Alvarez paper (Science, 1980), PPT	Dinosaurs fossil site video (Okamoto 2006)
29	Early Earth I	Hadean era and Giant Impact Theory	Origin of Moon, oceanic crust, life, BIF, Moon and life evolution	South African rocks, Barberton fieldtrip video	Old life sandstone, BIF and gold ore. Other Photos and samples (Okamoto 2017)
30	Early Earth II	Archean era and the Snow Ball Earth	Snow ball Earth, what, cause and evidences	Canada-Japan made video, my NY trip video	Watching "snow ball earth video"
31	Climate changes I	Basics of Paleo-Climate	Climate proxy indexes	Photos and Vostok core data	Coloring graphs
32	Climate changes II	Global warming controversy	Skepticism and IPCC scientific basis	documents for controversy	Checking the both side documents (Okamoto 2006)
			<final ERS report>		

<1st Report>
About the Tohoku2011 and the 1995Kobe earthquakes (7% assignment)
<2nd Report>
About the Zip's law or power laws
(7% assignment)
<Final Report>
About the Title: Our existence—chance (randomness, accidentally) or necessity (lawful consistency)?
(Any format is welcome, short story, SF, animation or something else) (7% assignment)
<Final Exam>
Multiple choice questions: 40%
Witten exam questions: 60%
Time: 90min

<Short notes>
The contents of our course are limited in geology and geophysics, while meteorology and astronomy parts will be covered by other courses at KVIS.

In the basic course, we treated the basic knowledges and thought process which are popular in Earth science common text books.

The advanced course are one of our new challenges on how to teach Earth Science for science-oriented high school students. Therefore, we adapted the college-level contents that are related to developing new science fields. For example, the complex system concerning with the disaster forecasts. For this purpose, we used completely new educational kits of our own made. It is clear that the students experienced the contemporary cutting edges of Earth science, such as early Earth and climate changes with new discoveries and hypotheses. Apparently, these contents are generally not covered in Earth science classrooms at the high school level in the country.

The assessment of this ERS class was based on 10% attendance, 20% assignment (Three reports above) and final exam (70%). It was necessary for some students to take an additional exam or extra works when their overall scores were lower than 60%.

4 Teaching methods

We used the Microsoft PowerPoint for lecture presentation and the printouts for certain exercises. Our classroom had a large white board in front of the room and we could use color pens to further explain and discuss the subject matters, as well as doing exercises directly on the PPT images projected on the white board. This kind of setup did facilitate students to do exercises effectively. Also, a counterpart Thai teacher, sometimes facilitated the teaching if the students got confused or did not understand English. The teaching fundamentary carried out with a PPT lecture, including question-based process with some practical materials or exercises. If needed, writings on a white board could also be used.

We adopted the followings when conducting the ESR course.

1) Used real samples (minerals, rocks, seismograms and film-based videos etc.) instead of virtual information as much as we can.

2) Began with earthquake and volcanic-based content, including their disaster forecasting methods.

3) Used short experiments and practices rather than lecture only.

4) Included certain topics beyond the high-school level, such as complex systems related to earthquake prediction.

5) Simulation-based techniques or PC models were employed in conjunction with the (4) above.

6) Included cutting edge controversies or hypotheses in Earth science which had never been cover in a standard high school level.

5 Examples of teaching resources

The next pages show photo examples of the practices discussed above.

(Style text) Some exercises used our original tools and data. Using these tools, they could learn not only scientific knowledges, but also the methods on how science reveals the complexity of nature. Also, they recognize the vast scale of the Earth as well as its history.

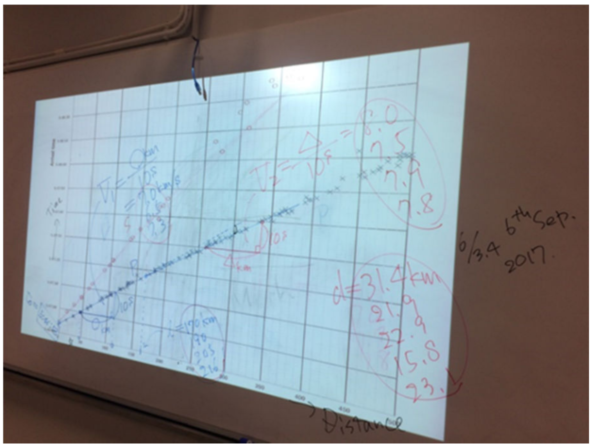


Figure.1 A classroom of 17 students

Figure.2 White board writing on a PPT image

Using real materials

Figure.3 Microscope observations of volcanic ashes

Figure.4 Watching a sample box of sedimentary rocks

Graph Exercises

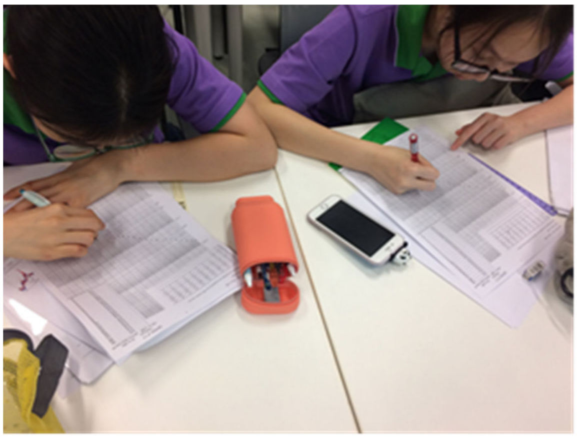


Figure.5 Gutenberg –Richter law

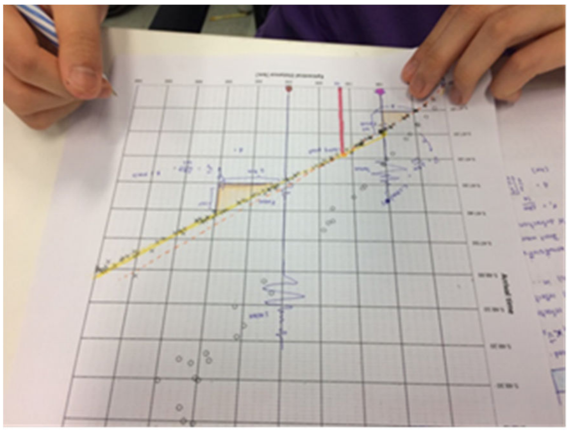


Figure.6 Travel time curve (Moho discontinuity)

Puzzle games (hand simulations)

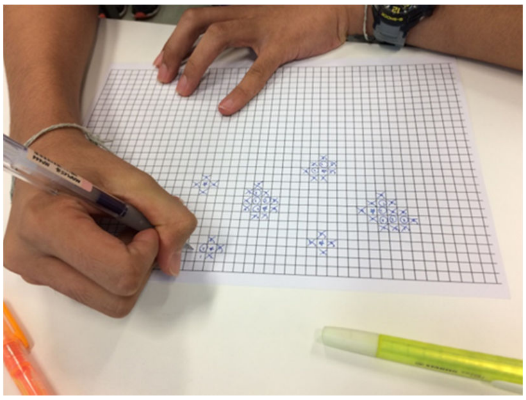


Figure.7 "Go-game model" for earthquakes

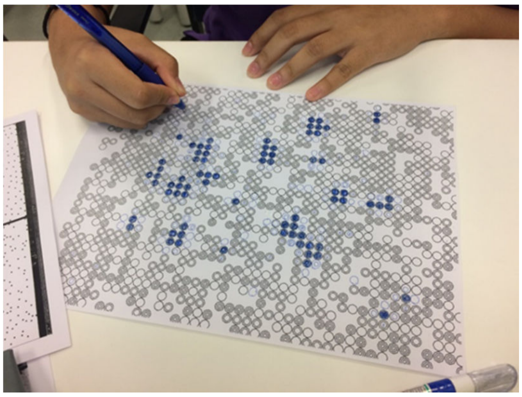


Figure.8 "Sand-pile model" for earthquakes

Table experiments

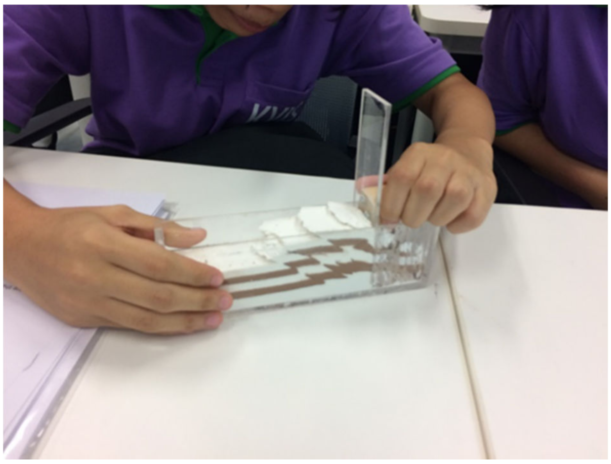


Figure.9 "Flour and cocoa fault" experiments (Okamoto 2003)

Figure.10 Thermal remnant magnetism of a basalt

6 Evaluation of the ESR course

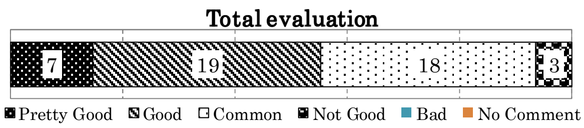
6.1 The total evaluation of our course by the students

At the end of **the ESR course**, we gave a final questionnaire to each KVIS student (response rate 69%).

The result of the final evaluation of the students is shown below. It should be noted that some students are absent so the total number is less. Also the final question is only shown).

More than half of students evaluated our ERS course as "good" or "pretty good". There were only three students evaluated the course as "not good". There were only

three students evaluated the course as "not good". There were no students expressing opinion on the course as "bad" or ticked "no comment". This is a registered questionnaire, so some flatters were included. However, the overall result showed a positive evaluation for our ESR course.



WITHOUT SUBTITLE

6.2 The most interesting topics by the students

The numbers of students, expressing opinions regarding the most interesting topics, are ranked in the following order of preferences:

Earthquakes related:	*14*
Dinosaurs and fossils (including paleontrogy):	*8*
Climate change (including "snowball earth"):	*7*
Rocks and minerals:	*6*
Mathematical models:	*3*
Volcanoes and eruptions:	*2*

The following topics, plate tectonics (including continental drift theory) and Earth's interior, were not chosen as the most interesting topics

6.3 The comments for ERS course by the students

Examples of comments from students regarding the ESR course are shown below:

Positive comments [sic]

1. "It is your first time teaching foreign students in English. I am very impressed by your teaching skills. This is my first time studying ERS and it has really moved me, I believe it is mainly because how and what you teach. I will definitely look more into the contents, seems how close we are to the subject of understands our world"

2. "I love your teaching methods, you have a lot of easy tasks for students to follow to understand the concept, for example the log-log plots, cell automaton, and rocks observation. I like when you share your experience when you traveled around the world; they were very fun. Hope to seeing you soon. Thank you."

3. "I have new contents of Earth science that I have never known before. The picture and details are interesting. Too much classes per one week. Would like to learn more about rock & mineral compare to seismic graph. Thank you so much for two months of this Earth science class. And sorry for sometimes sleeping. You are good teacher and put an effort to teach us."

4. "Tell me about your trip, I love to listen to you talking about it."

Negative comments [sic]

1. "Actually your learning agenda is very interesting, but with the graph(difficult to understand), your slide looks difficult to understand. We, as a Thai students, have never learnt about this topic as you have taught deeply. Therefore, it is hard for us to be familiar or can catch up in your contents."

2. "Many topics are the topics that I think we don't need to know like earthquake which too much deep in details and I cannot use that knowledge. I think we should study the way to survive when earthquake occur, it could benefit to our life."

3. "I think this course is too detailed and memory intensive. The amount of information both in the sheets and your lecture is too much to wrap my head around."

4. "Some topics were quite hard to understand. More examples or exercises should be given."

Actually, the negative comments suggested that our power point slide contained a lot of materials. Also, some topics such as earthquakes and volcanoes are not popular in Thailand. These negative comments are quite useful for us to improve our course next year.

7 Discussion

This ERS course has a lot of contents on earthquakes and volcanoes the phenomena of which are rare in Thailand. So, the disapproval comments such as shown above are of course expected by the Japanese visiting teacher. However, for him, this is the first trial in Thailand to teach Earth science. It can be inferred, therefore, that using these natural disasters as parts of major themes in composing an Earth science course similar to those of Japan or the US, where the earthquakes or volcanoes are quite common in these countries, has been somewhat really a challenging trial in the Thai context.

Thailand is a lucky country where earthquakes are rare (Yoshio Okamoto 2017, maps of earthquakes in Asia-Pacific from 1975-2016) and practically there is no volcanic eruption of the recent past. The results show that some students felt a strong positive impact from the course, thus expressing interests with these contents. This results show some trade-off and a difficult problem for earth science education in a country with low degree of occurrences of natural disasters. This is a big issue for teaching earth science in continental countries such as Europe and Southeastern America. So, we have to learn about the same challenges in such countries. We are very welcome to these suggestions.

Also, the challenge of teaching modern themes such as early Earth or climate changes are divided among the two evaluation outcomes as good and bad. Because these issues need more basic knowledges about the Earth and science, so some students were confused with such themes. A point worth noting is that students sometimes could not understand technical English terms, so they frequently needed to use their smart phone dictionary.

8 Conclusions

Even though there are always rooms for improvements, the conducting of the ESR course in Thailand as described is unique and challenging in the following aspects:

1) It was an attempt to teach high level Earth science to the science-oriented high school students in English.

2) The class carried out by a co-operation of a foreign visiting teacher, a Thai counterpart teacher and an adviser.

3) The contents and curriculum are new and unique, and are quite different from the common traditional methods.

4) The purpose of the initial plan was almost successfully completed.

9 Look into the future

For next year, the Japanese visiting teacher will be able to stay for a longer period of time, so the time schedule of our ERS class will not be so tight compared to the current year. We have been preparing for the improvements of our ERS course both in curriculum and contents.

Also, this year we could not carry out field trips due to the limitation of time and space, but next year we will take students to geological outcrops. For this purpose, we have already checked a few geological sites not-to-far from the school for field trips. Our school has an SEM (Scanning electron microscope, Hitachi TM3030 Plus) equipped with EDX (Energy-dispersive X-ray spectroscopy) that can well be used for Earth science study and research. We have tested it out successfully and plan to use the SEM-EDX for the mineral identification as well as the fossil characterization. Particularly, the radiolarian cherts are common in Thailand, so students will have chances to work on micro fossils identification using the SEM-EDX with the help of the KVIS adviser.

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We thank to Dr. Thongchai Chewprecha, KVIS principal, and Dr. Pailin Chuchottaworn, the chairman of the KVIS governing board, for their supports and encouragements throughout our work. Their appreciations on our school-made seismographs that could detect an artificial earthquake (underground nuclear test) and several natural earthquakes that occurred during ESR course of September to October 2017, gave us motivation to work for a better ESR course. The development of our teaching tools were partly supported by Kakenhi No.25350200.

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CAN GEOETHICS FACE THE HUMAN SAGA OF CHANGING THE GEOLOGICAL ENVIRONMENT?

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Abstract — Although all men have inevitably depended entirely on Earth resources to live, until a couple of centuries ago both the world population and the tools used were of little impact. After the Industrial Revolution machines became more and more common and powerful, so the effects of their use were increasingly deleterious. The first mentions of how Man was transforming the Earth date from around mid-19th century, and other similar mentions occur periodically over the next hundred years or so, but none of them produced any meaningful reaction or response. A book published in 1962 is often mentioned as the one that marks the beginning of humanity's consciousness about how human activities were affecting the Earth, but only from the point of view of the biological sciences. The first signs of the geoscientific community recognizing that the Earth, as an abiotic entity, was in danger date from the last two or three decades of the 20th century, but then moved quickly. In 2012 a group of scientists officially agreed that the impacts of human activities had driven the planet into a new epoch, the Anthropocene. Not a meaningful number of geoscientists, however, seem to have adhered to this point of view. Going on with the progressive thinking, five main concepts have been created to deal with this new reality: Geodiversity, Geoconservation, Geotourism, Geological heritage and Geoethics. Considering this historical background and the new concepts, this paper intends to stimulate debate as to how can geoscientists in general learn to put in use and, for those in teaching positions, to teach, new behavior and new practices more aligned with these new, more geoethical, attitudes toward the Earth.

Keywords — Geoethics, Geosciences, Teaching-learning, Environment, Engineering.

Thematic Line — Geoconservation, Geotourism and Geoheritage.

1 Introduction

Even though this fact is sometimes taken for granted, the inevitable reality is that we all depend on the Earth's natural resources for everything. From the most sophisticated electronic equipment we use, down to the buildings we live and work in, farther down to the food we eat, and, at the very basis, even our own bodies come from the Earth. Therefore, inevitably, humanity has been utilizing Earth resources from the moment, eons ago, when the first human being appeared on the surface of this same Earth.

Even though from the moment that the first human picked up a stone probably to use as an implement or as a weapon, humans have been modifying the natural geological environment, with a small population and only manual activities, the influence on the environment was small. About 10-12,000 years ago, during the Agricultural Revolution, Man abandoned life as a wandering gatherer and established himself in fixed communities; remnants of constructions attest the use of clay bricks and rocks as early as 9.000 years ago. In the Occidental World, the first records of systematic and meaningful interventions seem to appear during the Roman Empire: changes in the course of rivers, drying out of swampy areas and mining. In one particular site in Las Médulas (Castilla y León, northern Spain), ruins of Roman mines show extensive changes on the landscape, still clearly recognizable. As humanity developed its technology, it drew more intensively on natural resources, but up to the end of the 18th-century, as activities were still essentially manual or with relatively simple machines, the burden, and changes imposed on our planet were still relatively small and bearable.

The Industrial Revolution, however, brought a change of scale. When machines started making ever more sophisticated machines, and always in larger number, our capacity of drawing on our resources increased enormously. Three centuries down the road, we face today the fact that we are exploiting our resources well above the level that our Earth can provide and withstand with sustainability.

Our capacity of changing the environment, for good or for bad, that started when that first human picked up that stone, has grown exponentially. The first written mentions about the influence of Man on the landscape seem to have been made by G. P. Marsh, in the United States. He published a remarkable book (Marsh 1867), which carried an equally remarkable quote from Horace Bushnell, a preacher and theologian:

> Not all the winds, and storms, and earthquakes, and seas, and seasons of the world, have done so much to revolutionize the earth as MAN, the power of an endless life, has done since the day he came forth upon it, and received dominion over it. (H. Bushnell, *Sermon on the Power of an Endless Life*, apud Marsh 1867).

These men, it seems, were ahead of their time, as over the following fifty years or so, only short passages, most of them two to three pages long, can be found in a number of books, including textbooks, about men's deleterious influence on the landscape.

We owe one of these references to a book author called Euclides da Cunha, who originally was an engineer, but had a solid geological knowledge from his interactions with Brazil's first full-time geologist, Orville A. Derby (for Cunha's connections to Derby, see Santana, s/d). Cunha wrote a short but meaningful line in his masterpiece book "Os sertões". Referring to the origin of the desertic conditions existing in Northeastern Brazil, and also revealing a remarkable conscience for his time – the book was finished in 1901 – Cunha wrote: "We have forgotten, however, a notable geological agent — Man". (Cunha s/d).

The next author to specifically recognize and alert about the power of mankind to significantly modify the physical aspects of the earth seems to have been Robert Lionel Sherlock, who in 1922 published in London a book called "Man as a geological agent: An account of his action on inanimate nature" (Sherlock 1922). In this book he describes the effects that mining, road construction, drainage, alterations of the sea-cost, opening of tunnels for underground transportation systems, the accumulation of debris, and many other human activities can have on the Earth's surface. Four years later, Vladimir I. Vernadsky published, in Russia, "The biosphere" (Vernadsky 1998), in which Geology, albeit less prominent, is present. Unfortunately, again, both books gathered little attention.

In the 1930-1940's, Aldo Leopold wrote few but important articles, focusing on the conservation of land as a basis for life and for agricultural production. By studying desertified areas in the American Midwest he introduced some key concepts, like: an ethical relationship with the land requires both "heart" and "mind" (today we would probably say both "rational intelligence" and "emotional intelligence"); rules are not enough, there is need for "a conscience" (nowadays we would say "ecological conscience" or "environmental conscience"). He does not include Geology as a theme – his contribution are essentially philosophical advances.

In the middle of the 20th century a new worry appears, today called "environmentalist", but it's still focused on the biosphere and water. Our fellow bioscientists had been noticing some bad effects of human activities, like the extinction of animal species, the desertification of previously forested areas, etc., for a while, but, once more, very few people outside the academia paid much attention to those facts. Then, in 1962, came a book called "Silent Spring" (Carson 1962). It focused heavily on the evil effects of the indiscriminate use of pesticides, and the public's reaction was as if humanity had finally discovered that it had been doing wrongs for centuries.

Environmentalism continued to be essentially biological, but in the background we geoscientists were moving slowly. The next important author with a geological approach is George Ter-Stepanian, an Armenian geotechnical engineer and geologist, graduated in Russia, and also an activist of geoconservacionism in his native land. He wrote technical papers and even a fiction book warning about the importance and urgency of taking conservationist measures to avoid the environmental catastrophe that threatens our future. In 1988 he published an important article, developing the concept of Technogene, a new name proposed for the current geological period, starting in the Holocene, characterized by the influence of human activity, which triggers processes whose speed exceed the natural processes "by many orders of magnitude". In the professional environment of geological engineering, he gathered admirers, but in the geoscientific environment, he went practically unnoticed for a long time.

So, in the last two or three decades of the 20th century and first two decades of the 21st century, humanity has been worrying about a number of issues, among them a growing concern about the degradation of the environment, which brings about a number of changes in the social mentality. Some of these new ideas are specifically pertinent to the geosciences:

- the Earth is a system; that means that whatever affects a part of it affects the whole;
- Humanity is a part of this system;
- natural resources are not infinite; they are both vulnerable and finite;
- some natural resources – air, water and others – belong to humanity as a whole;
- man really IS a geological agent.

We are now forced to recognize that despite his infinitesimal physical size compared to the Earth, humanity can operate, and has operated, many, profound, and meaningful changes to the planet. In March 2012, in London, in the event "Planet Under Pressure", scientists validated ideas and forecasts of those pioneers and of recent researchers, recognizing that:

> Humanity's impact on the Earth system has become comparable to planetary-scale geological processes such as ice ages", and "consensus is growing that we have driven the planet into a new epoch, the Anthropocene (Earth Sky 2012).

Details would be beyond the objectives of this paper, but, it is quite clear that at the dawn of the 21st century, man's interventions on Nature reach levels that can be considered really worrisome – to the already known deleterious influences on the biotic realm, we now have to add worries about the air, the seas, fresh water, and even the geological base itself.

2 The attitudes of geoscientists

In this new context, what can be the attitude of geoscientists as a professional category, and of those who teach geosciences or even introductory geoscience's concepts at various levels, from, we can say, kindergarten to post-doctorates?

To answer this question, it is interesting to introduce a few new concepts. In a sort of liberal approach, they can be considered as the geoscientists' approach, or view, of some similar concepts in other areas of knowledge, reflecting this category's responses to the above mentioned new social ambience. Simply put, more as concepts than as rigid definitions, they are:

1) Geodiversity: variety landscapes, rocks, minerals, fossils, soils etc.; many of these items make up the very basis of life on Earth.
2) Geoconservation: conscious, responsible and sustainable use and protection of the resources of geodiversity.
3) Geotourism: touristic activity that respects the principles sustainability, in which geological information, adequately transmitted, plays an important

role; geotourism is basically a cultural activity, not a physical one.

4) Geological heritage: special portions of geodiversity, materialized in geosites (outcrops with special characteristics), or in museums (conventional, closed museums, or open-air spaces, ranging in scale from an outcrop to a landscape), which deserve being protected for future generations.
5) Geoethics: this is a recently-coined word, but of utmost importance – to the point that there is even an International Association for Promoting Geoethics (IAPG); its site (IAPG s/d) presents the following answer to the question "What is Geoethics?":

> Geoethics consists of research and reflection on the values which underpin appropriate behaviours and practices, wherever human activities interact with the Earth system. Geoethics deals with the ethical, social and cultural implications of geoscience education, research and practice, and with the social role and responsibility of geoscientists in conducting their activities (IAPG s/d).

Going back to the original question, what can be the attitude of geoscientists in this new context, it is here posited that geoscientists in general, in their professional activities, and particularly those who teach, at any and all leves, any subject touching or bordering the geosciences, should be a model of geoethical behavior. Practice and teaching must go together.

This may be more easily said than done. Vasconcelos & Almeida (2014) point out (in a literal translation by this author) that:

> (…) as a matter of fact, traditionally, the role of geologists has been to serve the most outcrying examples of mutilation of nature, of which mineral exploitation is the paradigmatic example, and equally of some of the most shameful forms of human exploration (Vasconcelos & Almeida 2014).

On the other hand, if shared with geoscientists, both young and old, the above five concepts may help in opening their eyes to the possibility of a more respectful behavior, at least in terms of their relationship with our planet.

This paper's intention is not to go into specific points. It is rather to provide some historical background information and a broad view of the possibilities, trying to stimulate debate, which could hopefully bring some well needed changes in the way some professionals act. Fortunately, in recent years the subject of geoethical behavior is becoming increasingly present in publications, particularly in Brazilian ones. To name just a couple of them, Mantesso-Neto (2010) presented an invitation to geologists in general to adopt a conservationist posture; Vasconcelos & Imbernon (2015) point some important steps to be taken in the educational environment, including the formal, non-formal and informal contexts; and Mansur et al. (2017) present a long discussion on the subject, suggestions of specific behavior and procedures to be adopted, and a text particularly rich in Brazilian examples.

3 Conclusions

There has been a growing amount of discussion, or, as Mansur et al. (2017) put it, of a "long overdue discussion" about how geoscientists could – and should – improve their (geo)ethical standards in their professional activities, and the inclusion of such theme in Geosciences teaching. Results, however, are still very scant. It is expected that renewed invitations to discuss and to implement a real change of behavior may be helpful.

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DEVELOPING SCIENCE CORE COMPETENCY ANALYZING TOOL

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Abstract— This study was to define what science core competency is needed and what components there are in each core competency to produce creative problem solvers demanded in science education for the 21st century. To develop this tool, I collected the data from top-down (from theoretical review) and bottom-up (from experienced science educators through surveys), which were coded to make categories consisting of a few components in each core competency with practical indicators. The 5 science core competency in the revised science curriculum of 2015 has 19 components in total with operational definitions to be observable and measurable in the classroom. This tool can be useful as a guideline for science teachers to develop textbooks and teach science in the classroom for equipping students to be more able as creative problem solvers in their daily lives.

Keywords— Science core competency, scientific thinking, scientific inquiry, problem solving, communication, life-long education.

Thematic line— Geosciences and Natural Sciences for Basic School.

1 Introduction

The purpose of science education has been scientific inquiry, which is defined as follows; ability to make decision of right or wrong about social scientific issues which people face from daily lives in NRC (2000) and Park (2010). For this purpose, students had been taught in getting more scientific knowledge to understand the issue, in learning how to carry out experimentation if needed, how to make claims with evidences from the experimentation to be logical in science, but students must learn why we need to quit some science and technology development in terms of ethics, morality, and so on in Choi et al. (2011) and MOE (2015). This is what scientific inquiry is, that is, students must learn the mentioned above aspects in doing science at schools as well as out of schools. In addition, many researches have been done in how teachers promote scientific inquiry in their teaching and how students learn science as inquiry in their classroom.

In Korea's revised scientific curriculum of 2015, science core competency has been emphasized to make scientific inquiry more practical for the purpose of preparing students to be creative problem solvers in the 21st century in MOE (2015) and Rychen & Salganik (2003) and Sanders (2009). The way of how to teach and learn science has been also changed in the classroom to produce the creative problem solvers. The STEAM (Science, Technology, Engineering, Arts and Mathematics) education is very dominating teaching and learning context in science classroom recently to meet this goal of science education for the last decade. This STEAM education policy of Korea has roots in STEM education which spreads internationally. STEAM education is new context where how science is taught and learned to meet the goal of science education, creative problem solver. But what kind of characteristics do creative problem solvers hold? How can we know that students are equipped with abilities to be creative problem solvers for the 21st century? Even MOE (Ministry of Education) released newly revised science curriculum with 5 science core competencies, there is not much information what they are in detail, how we recognize those competencies included in the textbook or program, or if science teachers can teach or students can learn science with the focus of those competencies, and so on.

In this study, I redefine those 5 competencies from curriculum to be more practical to science teachers and science educators so that they can employ them in developing textbooks or program and in teaching them. This tool can be applicable in planning science lesson and evaluating them in the classroom as well as out of classroom. This tool consists of each competency with a few components with practical indicators. We can say how creative problem solvers look alike in terms of this tool or how well developed science progrma looks alike also. The Table 1, introduces what science core competencies are in revised science curriculum of 2015 but just about what they are briefly, from which teachers are struggling to figure them out to implement them into the classroom.

The research questions will be as follows: (1) what components of each science core competency are; (2) what indicators can be found in each component to describe each competency.

The significance of this study is science teachers' expertise in teacher education as well as science curriculum from K to 12.

Table 1. Science Core Competency in curriculum (Moe 2015)

core competency in science	definition
Scientific thinking	Thinking skills necessary to explore the relation between scientific evidences and claim
Ability of scien-	Skills of producing new scientific

tific inquiry	knowledge or understanding its values in the process of collecting data, interpreting and evaluating them from experimentation, investigation and discussion for problem solving
Ability of scientific problem solving	Ability to solving individual or public problems with the use of scientific knowledge as well as scientific thinking
Science communication	Ability to adjust between my position and others to improve the process and its products of scientific problem solving in the community
Science participation and life-long learning	Ability to make decision of SSI through scientific participation individually as one of community members with responsibility as well as reasons through the life-long education

2 Methodology

To develop the science core competency analyzing tool (Sci-Co-Co-AT), I employed the following steps Figure 1.

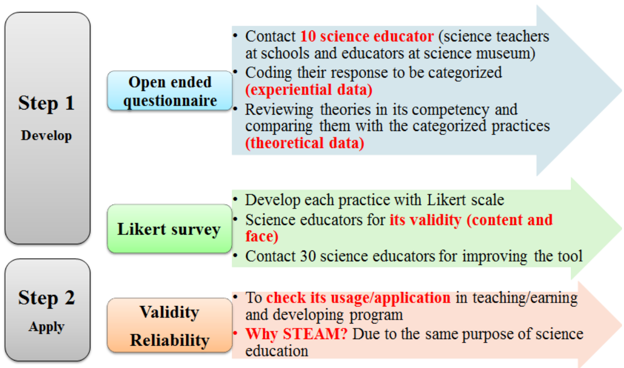

Figure 1. The flow of methodology

2-1. 1st Experiential Data Collection and Coding

I contacted 10 experienced science educators (science teachers at schools and science communicators at science museum) by purposive sampling. 19 participating science educators provided their own operational definitions for each competency with concrete examples/incidents. The researcher coded them to be categorized into a few components in each competency with practical indicators. The researcher constructed the validity of coding process with other science educators through discussion to be consensus.

2-2. the 2nd Theoretical Data Collection

The coded categories were compared with theoretical data in the 2nd process of data collection. The researcher, for example, compared 3 components of scientific thinking competency with the theories about scientific thinking. From the coding, there were 4 components of scientific thinking; logical, critical, creative, and reasoning thinking. The researcher, however, excluded "thinking from reasoning" after comparing with theories of scientific thought, since there is much overlapped with three other ideas. In this way, the researcher modified components and practical indicators of each science core competency. During this process, the researcher discussed with other science educators to be consensus for content validity and its reliability.

2-3. the 3rd Data Collection through Likert Survey

The science core competency analyzing tool has been reformatted by Likert survey to be distributed into another 20 science educators so that they can check if each component in each science core competency with practical indicators is understood. If not, they could leave some opinions for the researcher to use in its modification. This process is how to construct face validity as well as content with its reliability.

2-4. Construct the Validity and Reliabiltiy

The completed science core competency analyzing tool has been employed into STEAM program to check its usage. First of all, the researcher with other science educators tried to check what components of each competency were observable and measurable. After checking its application in 2 STEAM programs, the researcher tried to describe what components and how much each science core competency could be found. This is how to construct tool's validity and realiablity.

3 Results

3-1. The Science Core Competency Analyzing Tool

From the analysis and interpretation of data, 19 components were developed with practical indicators in 5 science core competency (Tab. 2). Scientific thinking consists of logical, critical, and creative ones (3 components) while students do scientific inquiry activities. Scientific inquiry is the process of making hypothesis, collecting the data, analyzing and interpreting the data, and concluding and generalizing the results (4 components). Scientific problem solving is the ability of recognizing the problem and selecting the best solution from evaluation (4 components). Scientific communication is the ability to represent opinions through different types of communication in science through argumentation, adjustment, and understandings from different media (4 components). Finally scientific participation through life-long education is ability to find out the problem from daily lives such as social scientific issues (SSI) and learn new science and technology through self-directed participation (4 components). These all competencies are critical ones for students to be creative problem solvers expected in science education of Korea.

Table 2. Science Core Competency Analyzing Tool

compe-tency	component	Indicator
Scientific thinking	Logical Thinking	analyze and explain the phenomena with evidences
	Critical thinking	evaluate the phenomenon with argumentation
	Creative thinking	represent the ideas through various ways
scientific inquiry	make hypothesis and design	make hypothesis and design it about SSI
	collect the data	collect the data through inquiry skills like observation, prediction, inference etc
	analyze and interpret the data	analyze and interpret the factors from data and its relationship
	conclude and generalize	make conclusion and generalize commonality and patterns from analyzed the data
scientific problem solving	identify problems from daily life	identify the problem from daily life and interpret it by science
	selecting the data and evaluate it	select and evaluate the most appropriate data for solution
	suggest the possible solution	propose the possible solution for problem
	explore its implementation	select the practical ways for solving the problem
scientific communication	use various type of communication	represent the ideas through various types of ways, verbal or writing one, and drawing
	make argumentation with evidences	prove scientifically about right or wrong of the situated problem
	adjust with other opinions	adjust opinions through argumentation
	understand the information through media	learn and understand information by various media like computer and visual materials
scientific participation and lifelong education	identify the problem in the community	understand the problems in the unit of community
	communicate SSI	suggest my idea for SSI
	self directed participation	keep participating in science activity self-directly
	learn and apply new science technology	learn and apply new science technology

3-2. The Application of Science Core Competency Analyzing Tool into STEAM program

The researcher used this tool in two STEAM programs to see what components of science core competency can be found and how much. The STEAM program has been developed earlier than this tool but the reason why the researcher used this tool was to see if STEAM program included the opportunities of those competencies' fostering. The purpose of STEAM education is pretty to produce the creative problem solvers equipped with those science core competencies. Even though the STEAM program has been developed earlier rather than their introduction of science core competencies in the revised science curriculum of 2015, the pursuing goal of science education, producing creative problem solvers, is same, therefore, it is meaningful to check if science core competencies are included in STEAM program.

Two different STEAM programs at middle school levels designed by the researcher group in 2012 were selected in this study. One theme is climate change and the other one water shortage.

Table 3. Climate Change STEAM program

#	Topic 
1	What is plastic from CO_2?
2	How does climate change?
3	Does climate change in our city? How can we know?
4	What is greenhouse effect?
5	Why does greenhouse effect happen?
6	Is CO_2 greenhouse gas?
7	What characteristics of greenhouse gases are?
8	What are microalgae?
9	Making Carbon dioxide reduction device
10	How to reduce CO_2?

In Climate change STEAM program Table 3, students at middle school were expected to learn basic scientific concepts and apply those concepts to understand the function of Carbon dioxide reduction device. They also use App to know how much they personally produce CO_2.

Table 4 shows the topics of water shortage STEAM program where students learn scientific concepts about water function and water system and understand the function of water purification and storage. When students develop equipment, they were not allowed to use various materials but followed the steps of making equipment with the same materials. This released that there was limitation in engineering and technology of STEAM program in the classroom.

Table 4. Water Shortage STEAM program

#	Topic 
1	Find out possible water resources
2	Deliver water where you need it
3	How to remove used water and rainfall
4	Construct water purification equipment
5	How effective is my equipment?
6	Develop water storage equipment
7	From water storage to water management
8	Develop water management system in my city
9	Contest of city water management system
10	City water management, I can do it.

When the researcher applied science core competency analyzing tool into this program, the trend of science core competency in climate change was as follows; science communication competency was most dominating competency and scientific problem solving was the least one. In scientific thinking, logical thinking was used most. In scientific inquiry, analyzing and interpreting the data was used most. In scientific problem solving, proposing the possible solution for problem was not found at all, since students followed the steps of making equipment. In science communication, making argumentation and adjusting them was balanced in their use. In scientific participation and life-long education, each component was found in some degree Figure 2 and Table 5.

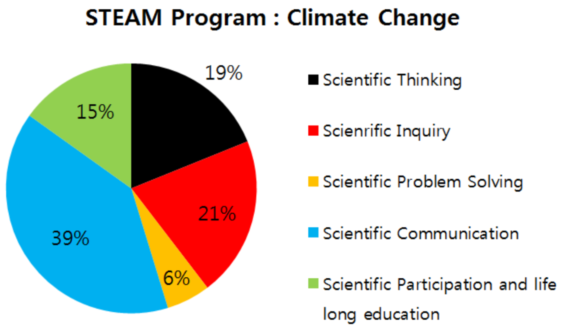

Figure 2. Science Core Competency in Climate Change STEAM program

Table 5. Distribution rate of science core competency in climate change STEAM program

Scientific Thinking			Scientific Inquiry				Scientific Problem Solving			
S.T 1	S.T 2	S.T 3	S.I 1	S.I 2	S.I 3	S.I 4	S.P.S 1	S.P.S 2	S.P.S 3	S.P.S 4
7/53	2/53	1/53	1/53	3/53	4/53	3/53	1/53	0/53	1/53	1/53
13.1%	3.8%	1.9%	1.9%	5.7%	7.5%	5.7%	1.9%	0	1.9%	1.9%

Scientific Communication				Scientific Participation and Life long education			
S.C 1	S.C 2	S.C 3	S.C 4	S.P.L 1	S.P.L 2	S.P.L 3	S.P.L 4
2/53	8/53	8/53	3/53	1/53	3/53	3/53	1/53
3.8%	15%	15%	5.7%	1.9%	5.7%	5.7%	1.9%

In case of water shortage STEAM program, scientific problem solving competency was not much dominating but the other 4 competencies were used similarly. Suggesting ideas in scientific communication competency and scientific participation and life-long education competency were not found but other components were distributed in their usage in water shortage STEAM programs Figure 3 and Table 6.

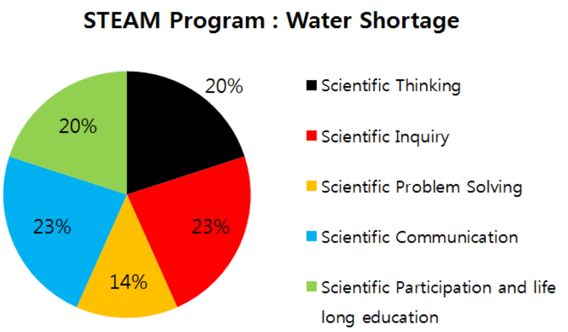

Figure 3. Science Core Competency in Water Shortage STEAM program

Table 6. Distribution rate of science core competency in water shortage STEAM program

Scientific Thinking			Scientific Inquiry				Scientific Problem Solving			
S.T 1	S.T 2	S.T 3	S.I 1	S.I 2	S.I 3	S.I 4	S.P.S 1	S.P.S 2	S.P.S 3	S.P.S 4
3/60	3/60	6/60	5/60	7/60	1/60	1/60	4/60	0/60	2/60	2/60
5%	5%	10%	8.2%	11.7%	1.7%	1.7%	6.7%	0	3.3%	3.3%

Scientific Communication				Scientific Participation and Life long education			
S.C 1	S.C 2	S.C 3	S.C 4	S.P.L 1	S.P.L 2	S.P.L 3	S.P.L 4
1/60	6/60	4/60	3/60	6/60	0/60	4/60	2/60
1.7%	10%	6.7%	5%	10%	0	6.7%	3.3%

4 Conclusion and Implication

First science core competency analyzing tool was developed and useful with sub components with practical indicators. So, this would be helpful for science teachers to understand what science core competencies are and how they can be described with practical indicators.

Second, this tool can be useful in prescribe what competency can be found or not so that we can make up the missing competencies to make the program better in meeting the goal of science education, producing creative problem solvers.

Finally, I can make implication in teacher education for teachers' expertise in their profession in teaching and learning science. This tool can be used for planning and evaluating the science teaching and lesson plan to see what and how much science core competency is included.

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DEVELOPMENT AND APPLICATION OF A GEOLOGICAL FIELD TRIP APPLIED ON SOCIAL CONSTRUCTION OF SCIENTIFIC MODEL

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Abstract— The purposes of this study are to develop and apply on a geological field trip applied on social construction of scientific model. This study was carried out by eight students of three groups who participated in the study 'G' gifted education center. Students were conducted to the theme of 'Formation of Mt. Gwanak' which located in the Seoul National University on two field trip classes and three modeling classes. Before and after class, students participated in pre-posttest to understand formation of Mt. Gwanak and semi-structured interview to confirmed concept. Results as follows. First, there are two sites called upper-steam and down-stream valleys. These valleys have outcrops including granite, gneiss, xenolith, joints, fault plane etc. Second, we analyzed understanding of concepts formation of Mt. Gwanak based on pre-posttest and semi-structure interview. 7 students reported volcanic eruption caused the formation of Mt. Gwanak in the pretest. After classes, all students explained how granite was formed during formation of Mt. Gwanak in the post test. At the same time, it was given to answer that this field trip had a good opportunity to learn neighbor geology by a student. This study suggests an example of applied on social construction of scientific model on geological field trip. It contributes to teachers to help doing geological field trips.

Keywords — Learning on geological field trip, social construction of scientific model, granite.

Thematic line— Education, Teaching of Geosciences Teacher Training.

1 Introduction

Recently, Earth scientists and Earth Science educators have developed science literacy to improve the ability of students who will decide about worldwide issues such as climate change, geological hazards (Wysession et al. 2012).

Globally, the importance of Earth Science literacy is a main issue to K-12 living as modern citizens. It necessary to get ready on how to teach students to have Earth Science literacy in the school. It means that one of the principal issues of Earth Science education is how to teach in K-12 students in the school.

Geology is specially representative for learning of Earth Science. The importance of Geology cannot be emphasized enough, but Earth Science is not central to the middle, high school curriculum. Therefore, K-12 Earth Science education in most of the world has not high quality (King 2008, 2012). We try to find a way to overcome some limitations, which have not been presented to a school Earth Science teacher (King 2008).

To do so, we suggest the use of geoscientific models. Historically, James Hall [1761-1832], who was geologist in United States, used a model to explain a fold that he observed in a mountain range. Typically, he may bring the model and modeling in this field to demonstrate the way a fold is formed, known as the 'Hall's compression box' (Graveleau et al. 2012). Even though students are not geologists or scientists, they can have real experience that observe natural phenomena by using a geological model in the school.

A geo-scientific model can help not only to connect a theory into a phenomenon, but also to think and to use analogical reasoning to explain them (Oh & Oh 2011, Jee et al. 2010). To perform the process, students can make their own model to demonstrate the phenomena, step by step. It is essential to stress that many models may cause social interaction to be confirmed.

In the Vygotsky perspective, science learning is a process of participating in cultural activities rather than making a personal mechanism (Kwak 2001). After making a model, students should have interaction with other members, who can be a peer, a friend, or a teacher, as if they were scientists.

So we suggest in this study a teacher tool that we call *Social Construction of Scientific Model*. The goal of this study is to provide an example of geological field trip applied on social construction of scientific model to improve the students' scientific literacy as long as they develop a field trip experience. This research gives an example of the origin and geological formation of the area where the students live.

We hope not only students develop basic geological knowledge to explain their area but also they expand their knowledge by learning the geology of Seoul. For applying a social construction of scientific model on learning during a geological field trip, we have to develop and apply a class, by exploring cognitive and affective domains to better understand the effectiveness of class instruction.

2 Research methods

Mt. Gwanak is 632m height and located in Seoul Gwanak including Ahnyang, Gwacheon, Gyuong-Gi province in Korea. Most of basic rock is the Jurassic Granite and the rest one is Precambrian gneiss.

2.1. Field Trip and Class Outline

Table 1 is a class outline including guidance, pretest, field trip, social construction of scientific model class, posttest and interview.

Table 1. Class outlines

Step 1.	Step 2.	Step 3.	Step 4.	Step 5
Guideline field trip, Pre-test	Geological field trip (outdoor class)	Social construction of scientific model class	Post-test	interview

First, before class students participated in a pretest to check what they knew related to granite, rock, mineral etc. in the theme formation of Mt. Gwanak. At the same time, the researcher suggested guidance of field trip. Second, the Field trip was conducted. To choose a field course, we consider previous research about reasoning by teachers who do not practice geological field trips. They have difficulties in geological field trip due to some reasons, as follows: easy/difficult access, administrative work, cost, safe issues, get ready for outdoor class and awareness of field trip etc. (Caliskan 2011, Kean & Enochs 2001, Meezan & Cuffey 2012). In this study, we selected sites in Mt. Gwanak considering: (a) distance of class, (b) the 2015 revised national curriculum in Korea, (c) safe issues. Also, Seoul is the second largest city after Gyeonggi province in the school population in Korea. But, there are few geological field sites in Seoul. So, we try to develop the Mt. Gwanak field course to suggest example of field trip.

Third, after field trip students tried to make their own personal and group model about how Mt. Gwanak was formed, based on a modified GEM cycle (Yu et al. 2012).

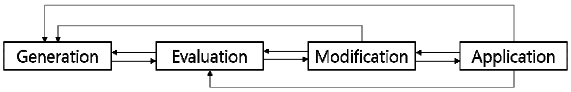

Figure 1. Modified GEM cycle

Fourth, students participated in post-test including theme which formation of Mt. Gwanak additional work that formation of Mt. Ahcha in the other place in Seoul after one week.

Finally, some students engaged in interview with researcher to discuss their personal and group model entries in more detail. During interview, researchers and students discussed what they learned about kinds of their knowledge or not while engaging in the class.

2.2. Data collection and analysis

This research was conducted as part of 'G' talented education center Earth Science class, in terms of geological field trip. The researcher has conducted the case study for eight students who agreed to participate in the research. We have collected pre and post-tests; all recorded discourses of field trip and social construction of scientific class and interview. The records of personal and group models were transcribed.

We analyzed these types of collected data in a search to confirm what students know formation of Mt. Gwanak which have characteristics of plutonic rock, granite, gneiss, mineral etc. Especially, we focused on pre-posttest, students' personal and group model recorded including drawings/writings to explain formation of Mt. Gwanak. In addition, students were asked about their model which take account for process of mountain formation. It can be helpful to understand what students' know or do not know about concept of rocks.

In order to analyze data, researchers can identify the need of a member check when researchers had different opinions or interpretation, trying to discuss and coming to an agreement, one to each other.

3 Results

The purposes of this study are to develop and apply a geological field trip for social construction of a scientific model, based on the 2015 revised national curriculum in Korea including plutonic rock, metamorphic rock, mineral, weathering, erosion, geologic ages etc.

3.1. Field trip courses

There are two sites in the courses. The first one it is located in N 37.4660, E 126.9479, we called downstream valley, like Figure 2.

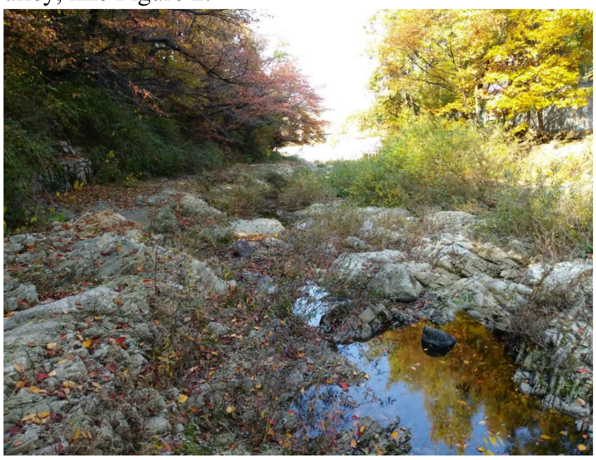

Figure 2. Downstream valley

Downstream valley have outcrops which are granite, joints on granite, gneiss[1], fault plane. Base rock granite

[1] Gneiss is not real Mt. Gwanak's metamorphic rock. Actually, it was used to construct during restoration of valley. But, this type of gneiss is

not only can be observed downstream valley but also can be compared to gneiss. It is a nice place to a comparison of two rocks. The teacher can help students to observe a lot of outcrops to make their model formation of mountain after field trip. Students can be well-acquainted with observing things to make model to explain formation of mountain.

First, students should be able to think how granite was distributed. It means it is essential that students have understanding of the granite formation process.

Second, the joints give an idea useful for explaining uplift during formation process. As magma become cool in the basement, the plutonic rock was under high pressure. After that, when the plutonic rock (granite) rises, pressure decreases. It causes expansion of the plutonic rock. Joint is the result of expansion.



Figure 3. Joint Figure 4. Gneiss Figure 5. Fault plane

Then, it is next upper stream valley which Figure 6. N 37.45873, E 126.9476 located in.

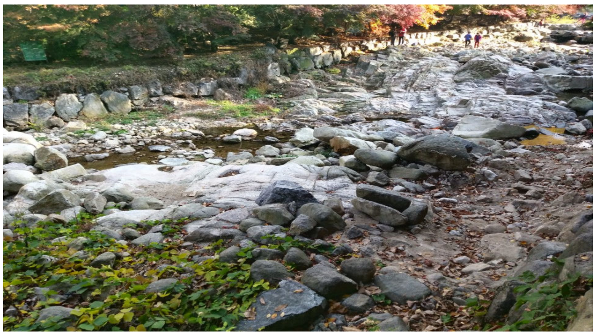

Figure 6. upper stream valley

Observing the downstream valley, students take a similar opportunity when observing the upper stream valley which have xenolith, joint on the granite, particles. Figure 7 shows chemical weathering in a joint. Students can be able to infer what was generated at fist by observing xenolith.

Finally, because students were allowed to seek particles in the valley, this make it possible to deduce what rock is the top in the mountain. At the same time, they can learn mineral such as feldspar, quartz, biotite and rocks.



Figure 7. Joint Figure 8. Xenolith Figure 9. Particles

3.2. *Educational effectiveness of instruction*

In order to confirm the educational effectiveness, we analyzed the pre-posttest and semi-structured interview.

Most students (N=7) described how the mountain was formed, explaining a volcanic model which they wrote in their Pre-test before class, like Figure 10. By the other hand, all students (N=8) changed their own model like Figure 11 which is a plutonic rock model in the post test.

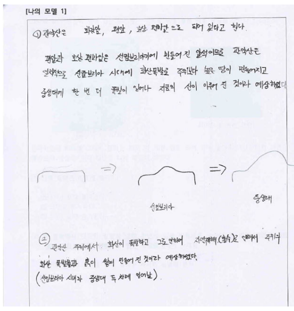
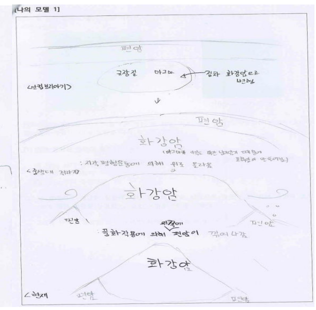

Figure 10. Volcanic Model Figure 11. Plutonic rock model

At first students described a model that formation of mountain involved a volcanic eruption. In other words, the students explained that volcanic eruption (magma eruption) was the main reason that formed mountain. It is one of a typical misconception about igneous rocks (Francek 2013, King 2008).

Most students told this type of misconception from Jeju island Mt. Halla in Korea during modeling class. At the same time, students observed granite in the field course, being asked how granite and joints are formed etc. A process of model change by three groups was revealed on their group model. For example, students were asked ‘how granite is formed?’, ‘how could we insist on uplift of this area?’ After questions, they look for evidence to explain curious questions formulated during modeling class.

Finally, during interview, we received unexpected answers. “I have never been thought about geology of Gwanak-gu area where I lived for 15 years. It was a nice opportunity to learn about my neighbor area.”

4 Conclusions and Implication

In order to carry out this research, we developed a geological field trip in Mt. Gwanak considering novelty space (Orion 1989).

Students were able to explain not only formation of their residential area but also the process of formation of similar mountains. One student showed a positive feedback of field trip. It will have a good impact on affective domain in the future.

Overall, our findings highlight to be possible to apply social construction on scientific models learning on geological field trips. While this research is significant for the geoscience educator, we believe that our findings

typical metamorphic rock. During the field trip, this study provides it. By the end of class, we have informed this fact to students.

have important implication not only for science educators in other countries where students tend to participate in quite similar field trip examples. We will conclude this presentation by suggesting which examples of activities seem suited for geological field trip as well as discussing implications of this research for geoscience teachers and educators to suggest new ways to study.

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EARTH2CLASS: A MODEL FOR CONNECTING RESEARCH SCIENTISTS, CLASSROOM TEACHERS, AND STUDENTS

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Abstract—Earth2Class (E2C) is an effective, multifaceted professional development program based at the Lamont-Doherty Earth Observatory of Columbia University. For twenty years, E2C has presented Saturday workshops in which scientists can present their cutting-edge discoveries to area teachers and students. The E2C website provides archived versions of these workshops, as well as a vast collection of educational resources for use by classroom educators and their pupils. The website is widely known and accessed by educators in the USA, averaging more than 70k hits per month in 2017. E2C also offers opportunities for teachers to earn graduate education credits through courses designed to enhance understanding of course content and learning activities. Recently, the Earth2Class model has been adopted and expanded by Brazilian professors at the Universidade Federal dos Vales do Jequitinhonha e Mucuri in Diamantina, Minas Gerais.

Keywords—teacher professional development, scientific research outreach, educational workshops, online educational resources.

Thematic line—-Teaching of Geosciences and Natural Sciences for School-Level Education and Teacher Training.

1 Introduction

Earth2Class (E2C) is a unique professional development program that connects research scientists, classroom teachers, and students to explore cutting-edge investigations in the geosciences. E2C has been hosted at the Lamont-Doherty Earth Observatory of Columbia University since 1998. One component of E2C are monthly workshops in which Columbia scientists present selected aspects of their discoveries to teachers and students. The teachers and students learn about "real" scientific findings and methods. To date, E2C has presented nearly 180 monthly programs.

A second important component are the online resources posted on the E2C website, https://earth2class.org/site. Archived versions of most of the workshops allow those not able to attend to gain some of the important concepts by viewing the slideshows and other files. The website provides a vast array of teaching and learning resources available for classroom educators and students studying Earth Science and other courses. These are well known among USA educators, as evidenced by the average of more than 70,000 hits per month during 2017.

E2C professional development options also include opportunities to earn graduate education credits. We partner with St. Thomas Aquinas College, located near the LDEO campus, to offer courses associated with the E2C workshops in the fall and spring semesters. We also offer E2C-based courses on the campus in the summer, and as online-only options during the academic year.

Finally, E2C has partnered with UFVJM (Universidade Federal dos Vales do Jequitinhonha e Mucuri) in Diamantina, Minas Gerais, and other educators in Brazil. This may support current and future classroom teachers in undergraduate and professional development activities.

2 Earth2Class Workshops

The E2C program began in a small way with three Saturday morning talks for teachers by LDEO scientists who volunteered their time. Inspiration for such a program came from the long-time tradition at Lamont of Friday afternoon seminars in which scientists present their cutting-edge research to the entire community. Because teachers cannot get to the campus at that time to learn about such cutting-edge discoveries, Passow obtained permission from the LDEO Director to offer the weekend events.

Shortly before the third series, he was contacted by the North Hudson Electronic Empowerment Project about providing content for their distance learning professional development program. Based at Teachers College, Columbia University, the NHEEP team worked with Passow to create an expanded set of seven workshops which would be supported by a website. This connected Assumpcao, the NHEEP Instructional Technology expert, and Baggio, the Information Technology expert, together with Passow, a partnership that has lasted for more than 18 years.

By the end of the current academic year, there will be 179 monthly workshops. More than 90 LDEO scientists have presented a program, and a few have given multiple talks about different aspects of their research. Over 400 teachers have attended one or more programs; some regulars have been at more than 125.

The format for workshops usually follows this schedule:
8:30 – 9:30 Arrival, 'caffeine and carbs,' welcome
9:30 – 10:15 Introductory slideshow (Passow)
10:30 – 12:00 Scientist(s) presentation(s)
12:00 – 13:00 "Lunch with the Scientist(s)"
13:00 – 16:00 Curriculum Development activities

This arrangement provides time for participants to arrive at the Lamont campus from wherever they are in the New York City metropolitan area, and interact with colleagues or explore the displays about Lamont research in the building. Most participants are science teachers in middle or high schools, but also include retirees who still want intellectual stimulation. We also welcome students with special interest in learning about "real" science, compared with what is usually taught in classes and textbooks, and others who are interested in coming to the programs.

The introductory slideshow is created by Passow and the scientist(s) to assure that all participants, regardless of background, are familiar with important concepts and terminology that will be used by the presenters. This enables the scientists to focus more on their work, and not need to go off-topic with frequent explanations.

Most presentations begin with brief descriptions by the scientists of what they do and some of the influences in their early lives that awakened their interest in the Geosciences. They describe methods used in their research, examples of supporting data and it they were collected, and significant meanings of their work for their field and broader outreach for Society.

LDEO has been among the leading research institutes since its founding in 1949. The discoveries presented in E2C workshops cover a wide range of topics, ranging from the atmospheric and climate sciences through dendrochrology (tree rings) and plankton studies, meteorite impacts, earthquakes, volcanoes, and other natural hazards to remote sensing, scientific ocean drilling, and water resources.

Much of the research has been supported by the National Science Foundation, the US government's major funding agency for scientific research. Approval for proposals requires demonstration of both innovative science and plans for educational outreach activities. The E2C format has proven to be an effective strategy for achieving such goals.

Afternoons focus on exploring relationships between the research topic and Science Education Standards that guide what should be taught in courses. There is no national curriculum for US schools, but many States are influenced by the *National Science Education Standards*, as well as their State Standards. Lamont is located in New York State, which has a long tradition of quality Earth Science education, and most of the teachers come from New York schools. So the curriculum development conversations often focus on what New York teachers need.

Participants pay registration fees that offset the costs for refreshments and lunch,and provides Lamont with some funding for keeping the building open on the weekend. Some workshops are supported by NSF grants, but for many, the scientists volunteer their time.

Formative assessments of the E2C program have overwhelmingly been positive. During 2004 – 2006, the E2C program benefited from an NSF grant designed to explore the potential value of such outreach. The external reviews were similarly enthusiastically positive. One key finding, however, was that a major necessity for duplicating such programs is having someone like Passow who understands both the educational and scientific components. Teacher and students trust someone who is familiar through classroom experiences, and scientists trust someone who can explain their work in 'non-technical' language (and will not take their ideas and use it for his own research proposals).

3 The E2C Website

The E2C website, https://earth2class.org/site, was originally developed to support the NHEEP distance learning professional development program. After that project ended, Assumpcao and Baggio continued to partner with Passow to continue the E2C website and help it evolve into an important resource for middle and high school teachers and students across the country.

Key support came from Gerardo Iturrino, a Lamont marine geologist who had given E2C workshops and agreed to lead the team in applying for an NSF grant. In January 2004, we received a two-year grant to conduct a "proof-of-concept" study of E2C, seeking to identify aspects of the program that can serve as effective models for similar programs at other institutions. This support allowed for enhanced monthly workshops, an expanded website, and teacher conferences in the summers of 2004 and 2005.

The website was enlarged to include archived versions of the workshops, links to National and State Science Education Standards; lists of professional societies, and many other resources.

Participants at these conferences created a set of curriculum resources for teaching Earth Science. The combined wisdom of several dozen experiences and new teachers produced collections of key ideas that should be taught in each area of middle and high school courses, important vocabulary terms, and selected classroom activities and useful websites. They are available at https://earth2class.org/site/?page_id=3912.

The website resources were further expanded when Passow uploaded classroom-ready activities, slideshows, and other teaching materials he created during his 44-year career in the classroom. These are found at https://earth2class.org/site/?page_id=4969.

Dr. Kim A Kastens partnered with Passow to carry out an NSF-sponsored project to create professional development strategies designed to improve the spatial thinking of Earth Science teachers and students. E2C participants worked with Kastens and Passow during the afternoon session of E2C workshops to explore the materials created for this project. These and associated publications are available at https://earth2class.org/site/?page_id=2957.

The E2C website is very well known among Earth Science educators in the US. During 2017, it averaged more than 70k hits per month, with a maximum of over 92k in October.

4 E2C/STAC Graduate Education Courses

Responding to requests to offer formal graduate education credits in conjunction with Earth2Class, we partner with St. Thomas Aquinas College in Sparkill, near the Lamont Campus. We offer the option of registering for 2 or 3 credits that require attendance at the workshops plus additional coursework related to the scientists' presentations. There is also a requirement to create a lesson plan suitable for the participant's teaching assignment, based on one of the important concepts presented in the workshops.

We also partner with St. Thomas Aquinas College to offer three courses designed to enhance subject content knowledge and classroom skills. Themes for these courses are "Weather and Climate," "Minerals, Rocks, and Resources," and "Astronomy." Many of the lesson components for these are resources derived from the E2C website.

Links to these courses and others supported by the E2C program are available at https://earth2class.org/site/?page_id=7820.

Most of the content on the website is posted by Passow using WordPress. Baggio and Assumpcao provide technical support and additional content, especially in the Educational Technology section.

5 E2C in Brazil / E2C em Brasil

Assumcao and Baggio returned to their home in Sao Paulo after she earned her doctoral degree, and invited Passow to visit them. That first visit opened a new area of activity for the Earth2Class program through links with scientists and educators in Brazil. Resources associated with this part of the E2C program are available at https://earth2class.org/site/?page_id=4324

For the American Geophysical Union 2010 Joint Meeting of the Americas, Passow partnered with two Brazilian professors to host the first GIFT (Geophysical Information For Teachers) Workshop held in Brazil. Resources from "Rain, Rocks, and Climate" are posted on the E2C website at https://earth2class.org/site/?page_id=4887.

More recently, Passow is partnering with geography professors at UFVJM (Universidade Federal dos Vales do Jequitinhonha e Mucuri) to create "*O projeto Earth2Class Diamantina*" The E2C web pages provides a platform to share accomplishments from the UFVJM faculty; see these at https://earth2class.org/site/?p=12652.

In November 2017, Passow joined his UFVJM partners in Diamantina for the I E2C Workshop. Three professors shared efforts they and their students have been doing with an audience of other students and UFVJM graduates now teaching in nearby schools. Images and other resources are available at https://earth2class.org/site/?p=14369.

EPISTEMIC DISCOURSE IN ELEMENTARY CHILDREN'S ROCK OBSERVATION: PRACTICAL EPISTEMOLOGY ANALYSIS

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Abstract— This study investigated epistemic discourse in which Korean elementary children observed sedimentary rocks. The investigation employed the perspective of practical epistemology analysis. Through the outcomes from the analysis we sought to understand the processes how children collect data by observation, identify evidence, and construct explanations about rocks. An intern teacher, Silvia taught 16 third grade children with her mentor teacher's assistance. Topic of science practices in the class was to observe mudstone, sandstone, conglomerates, and limestone and to find the evidence for differentiating those rocks. The discourse data was collected from Silvia's class for 40 minutes. Video and voice recordings were all transcribed. Practical epistemology analysis of the discourse data were implemented along with four categories such as encounters, stand-fast, gap, and relations. During the processes of practical epistemology analysis the cases of four categories were identified and the sequence of encounter, stand fast, gap, and relation was to show how children observed sedimentary rocks and how they came to learn the difference among the rocks. The epistemic features of children's observation discourse, although different from scientists' discourses during their practices, showed data-only conversation, already known content knowledge-driven conversation, or explanation inducing conversation. Thus we argue even elementary children are able to construct their own knowledge and their epistemic practices are productive. Also practical epistemology analysis of children's collaborative practices revealed the social characteristics of epistemic cognition.

Keywords— Practical epistemology, epistemic discourse, rock observation.

Thematic line— Education, Teaching of Geosciences and Teacher Training.

1 Introduction

Observation is a basic but at the same time one of the most important practices in geoscience learning. When children observe minerals, rocks, or geological scenes they obtain data from observation and make their own reasoning practice to construct knowledge about the objects. In that case how children take observation and unfold accompanied epistemic practices shows their epistemological stances and also has an effect on their knowledge construction. Thus, when the actions of observation are linked with scientific explanation then the actions are to be included in scientific practices (Erduran & Dagher 2014). The process from collecting data by observation through identifying evidence and establishing a model and to constructing an explanation for a scientific phenomenon is called epistemic practice (Jiménez-Aleixandre & Crujeiras 2017). For the connection between evidence and explanation, Duschl (2008) gave an emphasis on dialectic activities of epistemic discourses deciding what count as evidence, as patterns or models, or as explanations during scientific inquiry lessons. His emphasis was based on the importance of epistemic goals by which we mean identifying how we know what we know and how scientific knowledge is constructed. Thus, understanding the criteria for evaluating explanations, theories, or models, or the criteria for choosing one explanation over alternative ones is the focus of epistemic goals (Jimenez-Aleixandre & Crujeiras 2017).

This study investigated epistemic discourse in which Korean elementary children observed sedimentary rocks. The investigation employed the perspective of practical epistemology analysis (PEA) which described moment-to-moment discourse changes in a specific action for learning (Hamza & Wickman 2013, Wickman 2004). Practical epistemology is epistemological thinking which is used in a practice. PEA at a science class allows us to understand what children say and do, and how and what they learn when they participate in the interactions of scientific practices (Wickman 2004). Thus, outcomes from elementary children's PEA during their rock observation shows how they think and learn about the rocks, namely, geocognition with observation.

2 Methodology

2.1 Classroom context and participants

The science class in this study was for the third graders (about 10 years old) at a Korean elementary school, which was an attached school to a college for preservice elementary teacher education. When this study was conducted, three intern-teachers taught children sediment layers, sedimentary process, and sedimentary rocks, respectively. Authors observed those whole classes and chose rock observation class for this manuscript. The intern teacher, Silvia (pseudonym) was a junior student whose major was mathematics education but studied all of the subjects for elementary teachers. At the lead-in of her class she noticed the meanings of sediments, sedimentary processes, and sedimentary rocks then introduced goal of the class: observing sedimentary rocks. Before she handed out rock samples to children, she talked about how they observed. Children were recommended to decide the criteria when they observed and compared mudstone, sandstone, conglomerate, and limestone. A current teacher of the class guided the intern teachers' teaching plan and their teaching practices.

There were 25 children in the class, and, among them, four groups of children (four kids in each team) participated in this study with their own and parents' consents. In this manuscript, we analysed four children in a group who showed more active interactions during their observation than other three groups. They observed four sedimentary rocks one-by-one and put down on worksheets what they observed according to their own criteria.

2.2 Data and practical epistemology analysis

The discourse data was collected from Silvia's class for 40 minutes. Authors stood at the back of classroom and video recorded her class. Voice recorders were laid down on the center of tables of each group. Video and voice recordings were all transcribed. Among transcriptions I chose several episodes where children's observation talks were remarkable.

Practical epistemology analysis of the discourse data were implemented along with four categories such as encounters, stand-fast, gap, and relations. To understand the detail about PEA see Wickman (2004), Lidar et al. (2006), or Lundqvist et al. (2009). *Stand fast* is used to depict a situation in which participating children do not ask about certain actions and words because those are clearly understood by them without any question. Hence, what stands fast is a point of departure for interactions with the world. The *encounter* means by a specific situation in which children interact with something. An encounter can be made with the teacher, peers, the experimental material, books or any experiences at the classroom. When children meet an encounter where the actions or words in that situation do not stand fast to them anymore, then *gaps* occur. If a gap occurs, it needs to establish a relation between the encountering situation and what stands fast for children. To fill the gap, *relations* have to be created between what the students already know and what is new in the situation. If a relation to what stands fast is established, a gap can be filled, that is, the experience (what stand fast) can be transformed.

During PEA processes the cases of four categories were identified and the sequence of encounter, stand fast, gap, and relation was to show how children observed sedimentary rocks and how they came to learn the difference among the rocks.

3 Results

For this manuscript we showed three episodes from the original discourse corpuses, which provided us with the most significant meaning about children's epistemic reasoning with observation.

Episode 1. ***Data-only conversation***

01 Simon Let's see the grain size of rocks.	[Encounter]
02 Simon (sandstone) It's like mud.	[Stand fast]
03 Hine (limestone) There's no grain in it.	[Gap]
04 Julie Can you see it?	[Gap]
05 Sunny (conglomerate) Yes.	[Gap]
06 Simon (sandstone) There are mud-like grains.	[Gap]
07 Hine (limestone) I can't see any grain.	[Gap]
08 Julie (mudstone) It's smaller than 1 mm.	[Relation]

In this episode Simon (01) began the conversation with deciding to observe rocks and find out the grain size of them. It made clear the situation as Encounter. Simon's comment that the grain size of sandstone is like a mud stands fast to him, and it is a datum obtained from his observation. Hine, however, did not find any grain from a limestone so she said there was no grain. It is also a datum, but it does not stand fast to her. The difference between Simon and Hine made a gap. Listening the dialogue Julie asked to Sunny who observed a conglomerate. Sunny's answer to Julie's question made another gap to Julie because Sunny could see grains and it was different from Hine's talk. Since they saw different rocks it was natural their observations were different. However it was not easy for Julie to accept the difference. In the end, Julie said the grain of a mudstone was smaller than one millimetre. In fact Julie did not measure the size of mudstone grains but provided a datum about the size. From the view of epistemic practice the discourse in episode 1 was full of data. Children gave only data but did not any claim or evidence. Therefore we say epistemic feature of this discourse is data-only conversation.

Episode 2. ***Knowledge-driven conversation***

09 Julie (mudstone) What size the grain is it?	[Encounter]
10 Simon Say it is mud-like.	[Stand fast]
11 Sunny No, say we cannot see it.	[Stand fast]
12 Simon (sandstone) I can, mud grains exist.	[Gap]
13 Julie It is smaller than 1 mm.	[Gap]
14 Hine Then, we cannot see it.	[Stand fast]
15 Sunny Ah, sort of grains?	[Relation]
16 Julie It's smaller thing than 1 mm.	[Relation]

The epistemic feature of the discourse in episode 2 is different from episode 1. It was caused by Julie's encounter of line 09 asking the sort of grains in each size. In spite of Julie's question, however, Simon and Sunny talked about their observation data repeatedly, which showed Julie's attention still stood fast to Simon and Sunny. Moreover, Simon's second comment (line 12) broke out a gap against to Sunny who could not see a grain. At this moment his comment worked as evidence about grains. Then, Julie made another gap of smaller grain size than one millimetre, which also worked as evidence about the sort of grains. Julie's comment facilitated Sunny to catch up with the relation on the sort of grains. Finally Julie said that the sort of grains in mudstone was smaller thing than one millimetre. In this episode children did not yet achieve concrete knowledge about rock and its grains. Differently from episode 1, their utterances worked both as data and as evidence. Thus, Sunny and Julie's comments of relations could be a departure of knowledge construction. We say epistemic feature of this discourse is knowledge-driven conversation.

Episode 3. ***Explanation-inducing conversation***

17 Simon (mudstone) Scraped by a nail, grains come out.	[Encounter]
18 Sunny It's just powders.	[Gap]
19 Simon It is no powder. Grains come out.	[Gap]

20 Julie	We crack a grain, then it turns smaller.	[Gap]
21 Silvia	The grain size does not change.	[Gap]
22 Julie	(conglomerate) Then multi-grains.	[Relation]
23 Julie	Multi-size grains.	[Relation]

In this class Silvia, the intern-teacher, handed out nails to each group and talked to scrape rock surface with the nails. In fact it was her mistake of asking children to use a nail to compare rocks since that practice is useful to identify the features of minerals rather than rocks. Simon scraped a mudstone with a nail and watched its powders cracked out, and he thought grains of mudstone came out. This situation was a new encounter for the children. However, Sunny said they were just powders not grains which made a gap between them. On this point Julie gave an account of his already-known principle that a lump of rocks is cracked it becomes smaller and smaller. It also made a gap among the children. Julie's comment was not based on observation but on his preconception or knowledge so that it worked as evidence for the children to understand this situation. By the way Silvia talked that the grain size of a sedimentary rock did not change which meant different rocks had different grains. Her comment could be another gap to Julie. Thus, Julie made a relation between his knowledge and the teacher's comment such as there were various-sized grains. Julie's final comment (line 22 and 23) was an explanation about the sort of grains in sedimentary rocks. Epistemic feature of this episode discourse shows that children's discourse covered from data through evidence to explanation. Thus, it is the most developed discourse case among three episodes.

4 Conclusion

This study investigated Korean elementary children's epistemic discourses when they observed sedimentary rocks. The epistemic features of children's observation discourse, although different from scientists' discourses during their practices, showed data-only conversation, already known content knowledge-driven conversation, or explanation inducing conversation. Thus we argue even elementary children are able to construct their own knowledge and their epistemic practices are productive (Elby & Hammer 2001). As Russ (2014) referred to epistemology for science, learners' own idea about science knowledge and knowing is considered to be important epistemology because it can be productive when learners make meaning about the world.

Observation just itself does not assure learners of constructing knowledge about objects. Silvia sought to facilitate children's engaging with conversations about observation data, clues to defining grains of sedimentary rocks, and explanation for their observation. Her assistance allowed children's observation to be a ladder to construct their knowledge about sedimentary rocks.

Finally the way of practical epistemology analysis used in this study was strong method to understand learners' process of knowledge constructing with their own epistemic and science practices such as observation. Moreover practical epistemology analysis of children's collaborative practices revealed the social characteristics of epistemic cognition. The discourse excerpts in this paper showed, as Kelly (2016) described, geoscience knowledge was social knowledge and epistemic practices to understand geoscience knowledge were interactional and contextual.

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EXAMINING STUDENTS' INTERACTIONS OF SCIENTIFIC MODELING STRATEGY IN THE CONTEXT OF FIELD TRIP TO LEARN ABOUT MINERALS AND ROCKS: FOCUS ON SOCIO-CULTURAL PERSPECTIVE

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Abstract— The purpose of this study is the examining students' interaction of scientific modeling strategy in the context of fieldtrip to learn about minerals and rocks focusing on sociocultural perspective. This research will be carried out with three groups of 12 students who participated on the two fieldtrips. First, considering novelty space, students engaged in the theme of formation Mt. Gwanak in the field trip to learn granite applied on scientific modeling strategy class. Seconds, students are participating in the theme of formation the Hantan-River in the field trip applied on modeling class to learn about igneous, sedimentary, metamorphic rocks on the Yeoncheon and the Hantan river area in Gyeonggi province where all rocks can be only seen at the same times in Korea. All classes consist of pre-guidance stage, field trip stage, modeling stage and interview. In order to analyze students' interaction, we try to approach sociocultural perspective as theoretical background. We are seeking to students' interaction from micro, meso to macro level in the classes. This study not only suggests new lens by analyzing students' interaction on geoscience education but also will be useful to provide a framework for modeling class for geoscience education.

Keywords— Scientific modeling, field trip, students' interactions, socio-cultural perspective, minerals and rocks.

Thematic line— Education, Teaching of Geosciences Teacher Training.

1 Introduction

~~Worldwide~~ The modern world is faced with problems such as climate change, energy, natural disaster. Thus, it is essential to grow up students' scientific literacy to have insight into scientific issues (Osborne & Dillon 2008, Sanmartí & Carvajal 2015). According to Martins (2003), it is essential for students to encourage to identity problems, to explain phenomena, to develop reasoned conclusions and to develop creativity and critical thinking in order to promote students' science literacy.

To do so, we believe that make a new type of instruction tool to increase percipient ability as a citizen. That is, try to approach geoscientific modeling in the class as well as students have experience real scientist even though they are not geologist.

A field trip may described a student experience outdoor class at interactive location designed for educational purposes(Tal and Morag 2009). Also field trips may get goals as follows: (1) to provide hands-on activity, (2) to stimulate learning interest and motivation, (3) to promote personal and social relationship, and (4) to develop observation and perception of natural phenomena (Behrendt & Franklin 2014).

A scientific model is emphasized not only as a tool in order to explain and predict target phenomena (Cheng & Lin 2015) but also abstract, simplified, representation of visible systems (Passmore et al. 2009. Schwarz et al. 2009). Hence, a scientific model can be useful to describe natural phenomena for students to observation on fieldtrips. Engaging in scientific modeling practices including generating, evaluating, revising model provide an activity to construct and use knowledge with peers (Covitt et al. 2015). In shortly, students have a great opportunity to communicate each other for making their own model. Because scientific modeling practice is consistent with goal of field trip, it can be helpful to understanding of instruction of class.

So, we argue that scientific modeling activities in geological field trip class may prompt the understanding of geoscience education in meaningful modeling practices to develop deep and elaborating as students may better have social interaction.

Lemke (2001) delineated many ways that researcher can have strength from using sociocultural theories to have a new lens to seek to human activities functions on multiple scales in the class.

In doing so, purpose of this study is the examining students' interaction of scientific modeling strategy in the context of field trip to learn about minerals and rocks focusing on sociocultural perspective.

Specifically, the following questions guided our research:

1) What are aspects of students' social interactions to learn minerals and rocks from the sociocultural perspective?
2) What are characteristics at multiple scale (micro-, meso-, and macro-) level social interactions to learn minerals and rocks from a sociocultural perspective?
3) What students' interactions could help scientific model enact more sophisticated so that their model in the geological fieldtrip to learn minerals and rocks?

2 Research method

2.1 Methodology

By investigating research questions, we have integrate methodological framework of critical ethnography case study. Ethnography methods is used to let researcher know students' identify by analyzing participants non-verbal actions including eye, voice etc. (Martin et al. 2006). At the same time, this methodology enable to us make a learning environment where students actively and meaningfully engaged in this study.

The methodological design provided opportunities for all participants to examine and analyze geological field trips.

Ethnography not only provides a methodological framework for the organization and analysis of practices and social interactions as expressed and experienced in the class, but also it necessitates an approach requiring researchers to critically examine these interactions and interpretations of these interactions in light of context in which they occur in the class (Creswell & Inquiry 2007).

In general, the notion of social interaction tends to relate the methods of data collection and conceptual analysis to the purview of sociology and social psychology as a distinct from anthropology. Even taken in its broadest sense, the phrase tends to limit the observations, data analysis, and theoretical framework to a type often termed micro-ethnography, as contrasted with the broader notion of ethnography as usually applied in the field of social or cultural anthropology(Lutz, 1981). Such a tendency is unfortunately consistent with the type of ethnography or ethnographic work most often encountered in education(Lutz, 1981). Especially, When students follows sequence for scientific modeling, they have experience several types of interaction to make modeling process which means that it may need consider analyzing micro scale interaction on a vignette. On the other hands, Meso-level scale can be helpful to understand students' linguistic approach in the whole class. Finally, macro-level lens may be useful in looking for patterns of cultural sociology by engaging in modeling class on the field trip twice.

2.2 Contexts of study including field trips and modeling classes.

Table 1 shows the process of sequence class. Step 1 is a preliminary step for exploring field trip and modeling class how we have progress each one. Step 2 is the field trip course to investigation that students observing out-crops and a given preparing for modeling class. Step 3 students get making scientific model including interaction with peers in the class. Finally, all members are going to join na interview to look into interaction in detail.

Table 1 Learning on geological field trip sequence

Step 1.	Step 2.	Step 3.	Step 4.
Pre-Guidance of field trip and modeling class.	Outdoor field trip.	Modeling class.	Interview in order to students and researcher analyze their interaction.

In this study, first instruction, students are going to participate in theme formation of Mt. Gwanak including learn about granite to explain how mountain was created. To do see more detail this process, 'development and application on geological field trip applied on social construction of scientific model' paper in the same section provides it.

Second instruction, formation of the Hantan-River including igneous, sedimentary, metamorphic rocks. In this area, students can observe a lot of types of rocks and famous cites such as Aurage, Jane falls etc.

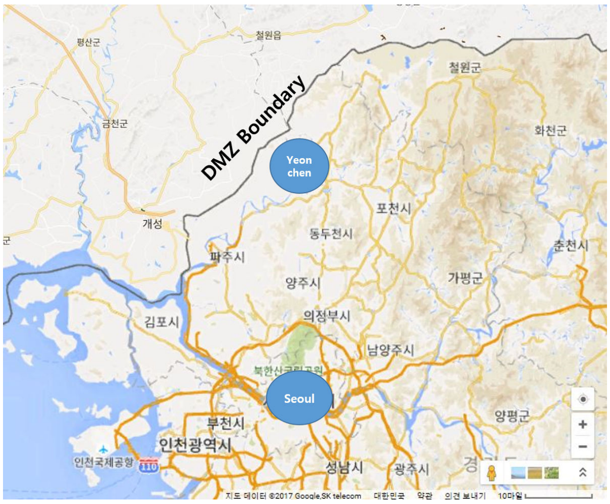

Figure 1. Location of Yeonchen and the Hantan-river

Figures 1, 2, and table 2 give information area cites near the Hantan-river shortly. Students follow the instruction sequence as written.

Third, after fieldtrip students try to make their own personal and group model how formation of the Hantan-river around the Yeonchen area based on modified GEM cycle.

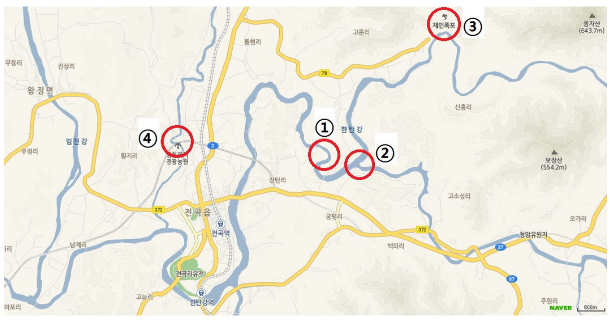

Figure 2. Location of cites to observation

Table 2. Summary of observations

Location	Area	Observation
① Seated Stone in JeonGok		Basalt, tuff, Unconsolidated Sedimentary
② Aurage		Basalt, Pillow-lava, Columnar joint, Unconformity
③ Jane Fall		Basalt, Columnar-Joint, Clinker.
④ Chatan stream Wangrim Bridge		Columnar joint, Unconformity, Basement rock Unconsolidated Sedimentary

Finally, researcher and students have engage in interview each other to investigate students' interaction entries in more detail.

2.3 Data Collection

To select students for this ethnographical case study, we are going to 2 groups of 8 students who agreed formally to participate in this research. we are going to collect students' discourse including video recording of class, filed trips and interview.

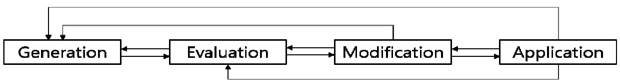

Figure 3. Modified GEM cycle

Data will be collected during two field trips, and modeling classes. Especially, we are concentrating on students' interactions each other. After that, students and researcher will have interview more detail each situation what does it happen in a section separately. All courses will be transcribed verbal and non-verbal actions micro-, meso- and macro-level.

Abide by analyzing, all participants materials which recorded including personal – group modeling, field notes, documents, note taking etc. will have been accumulated. These types of multiple sources of data which can help enable us to authenticity criteria for the study.

2.4 Data Analysis

In order to analysis students' interaction we based on multiple scale(micro-, meso-, and macro level) following sequence

- Divide transcribed verbal and non-verbal (eye, voice, action) parts to identify micro-level in the video analysis in the slow video. To do this type of analyze, we focus on nonverbal students' interactions which enable the researchers to micro interaction between students thorough the slow speed video clip in and outdoor class.
- Describe meso-level interaction among students' in real time, or normal, which let them know that compare to development of modeling process in the class. It is enable us to classify in to small groups.
- To do investigate macro-level, we are going to compare to 2 types of modeling class which are formation of Mt. Gwanak and the Hantan-River. Analysis of two class over time continuously enable researchers to have patterns that social interactions to make develop model.

Micro-level means that study of nonverbal behavior have been and will continue to be highly successful in revealing previously unnoticed features and unspoken norms of group formation and social presuppositions which affect learning. Analysis is time consuming and can deal with only small bits of interaction at a time.

Meso-level means that focusing on study of normal verbal event in group society. It is important for us to consider understanding students' activity and interconnected.

Macro-level means that add another time variable which can analyze over time. Analysis can help looking for pattern in different time of modeling class on the geological field trip.

These types of analysis not only enable us to get student's identify but also give a new insight in to social interaction in the geoscience in and outdoor class. Also socio-cultural theory noted that assist students practices among multiple scale. To make validation strategies in this study, we try to make triangulation, which make use of multiple and different sources, methods, investigators, and theories to provide corroborating evidence, peer review and member checking, researchers solicits participants' view of the credibility of the findings and interpretations (Creswell, and Inquiry 2007).

3 Results, Conclusion and Implication

This research was ongoing by the middle-May 2018. We wish this study not only have a great implication for geoscience educator to get a new insight in the field and modeling class but also to give an opportunity for student to engage in grow up scientific literacy.

Specifically, we believe that this study can be helpful in promoting geoscientific literacy in that students think based on observation and create model for explain natural phenomena with their peers. On the other hands, researcher can have theoretical new lens to describe social construction of scientific model as we called modeling class. Exploring the modeling class in the new lens, socio-cultural perspective, may be meaningful for us to understanding social basic learning. Ultimately, this type of research could be helpful a positive impact which have cognitive skill, knowledge, interest, and career in the future (Hutson et al. 2011) to overcome currently issue losing major in student geoscience. We are looking forward to anticipate will provide more detail and examples of evidence for change in the presentation in the Brazil.

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FOSSILS, CLIMATE CHANGE AND ENVIROMENT EVOLUTION, A DIDACTIC PROPOSAL FOR TEACHERS

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Abstract— The present work details a workshop carried out during a training session for teachers at the University of Buenos Aires, Argentina. In Argentina, Earth Sciences have little space in the school curriculum, and also at teacher training institutes themselves. Because of this and considering the difficulties when it comes to teaching Earth Sciences, the workshop is thought with the aim of providing them a didactic proposal that works several concepts related to this area. Taking into account the difficulties in understanding the concept of geological time and the vast volume of media information on climate change (which can make scientific concepts confusing) it is suggested an innovative method to teach these concepts jointly, using paleontology as a teaching tool. The workshop included an activity in which students analyzed a hypothetical evidence of fossil records which are described in a set of cards (summary of newspapers notes). They have to make a timeline with these cards and gather them chronologically in three groups. After that, they used maps to analyze the information. Then, they are guided to draw a conclusion whether sea level is linked to temperature change. This proposal was built from a constructivist perspective, in which the spotlight is set on the student and where their previous ideas were inquired. Additionally, as it was a workshop for teachers, this work described the subsequent analysis of the proposed activity in which teaching tools used were identified. The guided dynamic of the activity allowed a fluent analysis of the past environment and the respective climate change that they indicated. At the end of the activity, we find startling the fact that there is little difference between the way of arguing that students and teachers used. The way of expressing ideas and justifying their answers was very similar. Because of the results, we find it extremely necessary to improve efforts in order to increase the number and quality of teacher training courses in the area of Earth Sciences for the region. Teachers were interested in the proposal and considered that the activity could be applicable to the classroom and motivating for the students.

Keywords— Climate Change, Geologic Time, Education, Paleoclimatology, Stratigraphy

Thematic line— Teaching of Geosciences and Natural Sciences for School-Level Education and Teacher Training

1 Introduction

Geology and Paleontology are sciences that study events and processes that by their length or by the period of time in which they took place, they prove difficult to explain in terms of time (Alegret 2001). Geological time presents an intrinsic difficulty due to, not only involving time, as a magnitude, but also events, sequence and history (Sequeiros 1996). Involving the concepts of geological change, facies lithology, causal succession, duration and chronology (Pedrinaci 1993). Many are the research works regarding didactics that define this mentioned time as one of the obstacles when it comes to understanding both geology and paleontology (Sequeiros 1996; Alcalá 2010; Morgado 2010; Medina 2013; among others). Since the 90's, it is considered the most important and structuring concept within the Earth Sciences (Ault 1982, Pedrinaci 1987, Carrillo 1990, Sequeiros 1991, Gallegos 1992, García Cruz 1993). Pedrinaci (1993) has reported the epistemological hindrances that have been generated over the years and also the consequences that these trigger when studying this concept. He highlights as some of the obstacles, the imaginative barrier to represent the overwhelming figures with which these sciences work; gigantic figures used to explain the phenomena that take place on Earth; extremely slow geological phenomena, that at human temporal scales seem to be static. Another great difficulty is spatial scale, where a small tectonic fault may involve an immense number of kilometers. García Cruz (1998) also defines the idea of globality, that is, the integration of any phenomenon or geological process in the global functioning of the planet, as another great epistemological obstacle.

The difficulty of experimentation and the lack of possibility of direct observation poses a major obstacle in regard to many geological phenomena and processes. Immutability is what is usually observed, with the exception of very specific situations, such as earthquakes or volcanic eruptions. This feeling of fixity is detrimental to the concept of geological time, in which change takes a preponderant role (García Cruz 1998). Maybe paleontology could be a friendly way to approach this concept. Since it is a popular science, the interest it evokes among children and teenagers eases the approach of complex concepts such as geological time (Alcalá et al. 2010). Furthermore, the reconstructions of stories from the tracks left by fossils are especially attractive for students (Sequeiros et al. 1996).

Additionally, climate change is a subject of growing interest among the non-scientific community (Boykoff 2009). Nosty (2009) mentions how the media uses climate change as a fashionable resource for commercial exploitation regardless of the educational impact that this implies. This kind of practice emphasizes the present leaving the past aside. However, it is vital to understand the past of the climate in order to comprehend the present and finally the future change (Cohen 2007). It is paleoclimatology the responsible for understanding these changes, allowing the achievement of qualitative/quantitative studies of climate-environmental change in pre-instrumental times. (Ballesteros-Barrera & Ramírez 2011). It is in these particular cases that cycloestratigraphy (i.e the study of strata) is essential to interpret the chronological sequence of these changes, which allows us to understand the geological time involved in them (Martín-Chivelet 2015).

Taking into account the aforementioned obstacles in the study of geological time (and its correlation with paleoclimatic change) a workshop was devised with the goal of elaborating these concepts altogether.

Considering these difficulties, the present work sought to provide teachers with a didactic proposal with an innovative method to teach the concepts of geological time and climate-environmental change in a transversal way, making use of paleontology as a didactical tool. The objective of this proposal was to work with fictional evidence of fossil record in the province of Buenos Aires and, through abductive reasoning, carry out a hypothesis on the environmental change of the region and the climate change of the planet in the past. For this, it is of utter importance the implementation of assorted science competencies (Hernández 2005), such as observation, description, comparison, identification patterns, classification, and the formulation of questions and hypotheses.

2 Didactic Proposal

2.1 Development of the Didactic Proposal

The didactic proposal was presented in a 150 minute workshop to 23 teachers and students of biology, chemistry, geography and physics. The same one was dictated within the framework of the week of the Teaching of Science in the Facultad de Ciencias Exactas y Naturales (UBA), July of 2017.

2.2 Basis of the Didactic Proposal

The didactic proposal on climate change and environmental evolution was made considering that in order to achieve meaningful learning, a didactic strategy different from the transmissive one is necessary. In this way, students were guided to achieve a less expository and a more constructivist approach (Álvarez 1996). Moreover, it was proposed an approach with an abductive reasoning, which offered the possibility of formulating hypotheses based on the evidential description of an event (Adúriz-Bravo 2002).

The study was based on the description of indirect observations, *i.e.* through an image, of a fact that could represents some real paleontological finding. Based on this, the interpretations were analyzed and the relevant data was processed for a later use (Álvarez 1996).

From a constructivist perspective (Driver 1985, Giordan & Vecchi 1987; etc.), it is necessary to take into account the knowledge that the student already had, since it is that knowledge that the student will make use of to interpret the activities and new knowing that will arise (Pedrinaci & Berjillos 1994). Therefore, these ideas may act as obstacles that impede learning. However, these are a good starting point for a collective construction of knowledge, in a reflective, participative and motivating way (Carrillo 2010). Additionally, the formulation of productive questions, which intend to guide the student's thinking, is also extremely important. In this way, the teacher can provide students with the path to build their own knowledge, based on necessary support. These questions do not need to be asked in a certain order. On the contrary, the scaffolding is built while observing what happens to the students (Lee Martens 1999). Lee Martens (1999) claims that the strategic application of this type of questions keeps students motivated. It is expected, then, that in this way students get involved in the task in an active and responsible manner.

2.3 Didactic Proposal: Fossils, Climate Change and Environment Evolution

How to understand climate change from fossil records?

The workshop begins with the entrance of a "subway worker" carrying a saber toothed tiger skull (replica) that he has found during his shift. The reason for his arrival is a request for help to solve this strange finding. In addition, he brings a sketch of what was found during the excavation. This sketch represented an idealized stratigraphic profile in which fossils of marine and continental environments are interleaved. From bottom to top it showed a sequence of three strata. The first stratum contained the fossil remains of a saber toothed tiger, the second one (which is recognized by a slight change in color) included shell fragments and whale bones, and lastly the third stratum presented another saber toothed tiger beneath urban trash. (Figure 1)

Students are asked to formulate a hypothesis that explains this stratigraphic sequence, thus helping the unexpected visitor.

The scheme was given to the teachers in order to answer the following question:

a) How would you explain these findings? Write or draw a possible explanation.

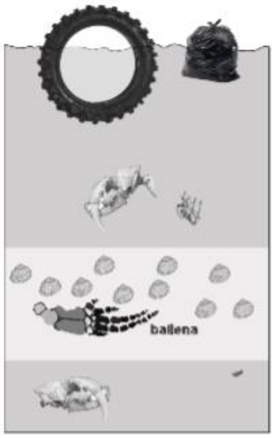

Figure 1. Scheme of what was found in the excavation of the subway

Once this first activity is finished, the main consequences of global warming are mentioned: the melting down of glacial ice and its relationship with the climate at that time and the flooding of the coast. Additionally, it is told about the immense ice caps during the last ice age. In order to rebuild the consequences of these changes, while working in groups, teachers were asked a series of questions: What is Glaciation?, How many ice ages had there been?, Are we heading into a new ice age?, Do you know what a glacier is?, How much ice is there in a glacier?, What is the height of a cap glacier?, Where does the ice of glaciers come from?, How long does it take for snow to form a glacier?, How much do you think sea level drops if there are 4000 meters of ice on the continent?, What percent of Earth is water?

These questions were formulated with the aim to guide the students to draw a conclusion whether sea level is linked to temperature change.

The goal of this part is to relate the megafauna with the ice ages and understand the relationship between the continental ice and the fall in the sea level.

Group work: Teachers are given a set of cards with fossil findings (summary of journalistic notes), in which are described what type of organism they were, the region where they were found and the relative age of the fossil. (Figure 2)

The cards depicted some odd paleontological findings, in which land animals are found in aquatic environments and *vice versa* throughout Buenos Aires.

Then, they were asked to make a timeline with these cards.

After that, every student shared their work, showing and explaining the way the cards were sorted. The students were asked to gather them chronologically in three groups. One of the cards is far from all the groups, so teachers were asked what to do with this outlier record. Finally, it was agreed that it was better to wait until there is more data about that period.

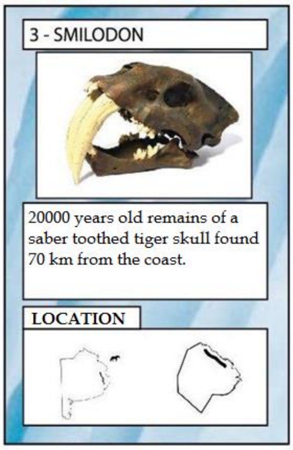

Figure 2. Image of one of the cards with fossil findings presented.

Students were asked to use a map for each period and point the findings on it.

Then, they were asked to differentiate terrestrial and marine animals.

Some more questions were thought altogether:

Is there anything strange?, What can be inferred?, What does it mean that there was water where nowadays is dry land? These questions sought to cast some light on the students, hoping that by themselves they could realize that the presence of land fossils in areas covered by the sea at the present implies a change in the environment as we know it today.

Finally, teachers were asked to draw a new coastline, theorizing about the area that the continent could have occupied due to rise and drop of the sea level.

As a plenary, a pooling was made on the blackboard and a timeline was constructed, where the temperature was plotted based on it, thus relating their observations of fossil findings to the change in sea level due to the variation of the climate.

To conclude, an explanation was once again requested for the sketch of the stratigraphic record found by the worker.

2.4 Didactic aspects of the suggested activity

A second part of the workshop was thought to deal with didactic points inherent to the activity. Now, as teachers, they were asked to identify the concepts used in the activity. These concepts were numbered: geological time, fossil findings, climate change, paleoclimatology, stratigraphy; as well as the skills put into play: explain, justify, compare, classify, analyze data, hypothesize and graph.

It was mentioned that the proposal was built from a constructivist perspective. That means that the spotlight is set on the student, and it was expected that they actively build their knowledge in a dynamic, interactive and participatory process. In this way, learning was facilitated by peer interaction and meaningful knowledge was acquired.

Hence, and understanding that the student is not devoid of preliminary knowledge, their previous ideas and preconceptions on the subject were inquired. By the end of the workshop, it was looked into whether these thoughts were still the same or if the students have changed their point of view.

The importance of productive questions to build knowledge within this framework was highlighted (Lee Martens 1999) to encourage the use of science competencies, both in science workshops and in everyday life in the classroom. Since only a good management of these science competences generate citizens with a critical look that allows them to understand their environment and actively participate in social decisions to involve them (Hernández 2005).

Additionally, the inductive, deductive and abductive reasoning methodology were differentiated, together with the teachers; Relating the last one with the didactic proposal of the workshop and highlighting its potential use in science classes for leading students to hypothesize. Abductive reasoning functions as a formal analogue of the modeling process, prototypical of scientific research (Adúriz-Bravo 2002).

Finally, a survey was handed out individually to the teachers in order to obtain comments about the workshop and improve it.

2.5 Climate Change

The last part of the workshop was focused in taking up again the climatic concepts seen throughout the workshop, highlighting the role of forcings that regulate the glacial cycles. In this way the current theoretical model that explains the existence of climate change was formalized and allowed the development of debate regarding the presumable causes of the current climatic oscillations.

3 Conclusion

By the time the timeline exercise was concluded, only two out of eight groups of teachers ordered the cards correctly. The other ones made the mistake of placing them equidistantly and not grouped according to the discrete chronological periods that were indicated in the cards. The three groups were separated chronologically very distant from each other. This mistake was observed in equal proportions among the groups of students, which would indicate a clear lack of practice in the development of quantitative graphs (Martín et al. 2017). In terms of the outlier data, none of the teachers managed to identify it, and much less had notions of how to treat it, what could reveal a lack of practice in data processing and statistics.

The guided dynamic allowed a fluent analysis of the past environments and the respective climate change that they indicated.

The final activity allowed analyzing the change of the notions of the teachers after having carried out the workshop. However, it would be necessary to evaluate if the change in their conceptual models remains in the long run, and if they can make inferences in relation to the subject treated from other evidences.

In the initial answers to the case presented, it was observed that 44% of teachers mentioned changes in sea level, of which half of them argued a possible climate change. Only 26% explained the findings due to accumulation of sediments over time or movement of the sea. Meanwhile, 9% explained it by geological change (mountains formation, erosion, movement of the Earth, catastrophes). Curiously, 13% referred to the pass of time and the time needed for fossilization. Another aspect to consider if that 35% of teachers mentioned the lower sediments as the oldest, and only 13% mentioned the existence of strata in the picture.

An important thing to highlight is that almost 50% of teachers limited themselves to just describing the scheme, which could indicate a lack of tools of the teaching community when it comes to differentiating between describing and explaining an event. A deeper analysis on the subject is needed.

When analyzing the answers after the workshop, a large percentage of them (86%), explains the findings due to climate changes, particular, 54% of this answers mentioned changes in temperature, 63% of them referred to changes in sea level and 22% of the teachers were explicit in the change of the coastline. Now, 18% identified the lower sediments as the oldest. Moreover, the 9% only explain the case with sediment changes. Curiously, 13% of the teachers insisted in answers far from the question. Surprisingly, also these numbers were similar to the ones found in the workshop for high school students (Martín et al. 2017).

We find startling the fact that there is little difference between the way of arguing that students and teachers used. The way of expressing ideas and justifying their answers was very similar. However, it was noted a greater predisposition for carrying out the activity in the case of students (Martín et al. 2017). Only 13% of high school students did not explain the problem (Martín et al. 2017).

The proposed activity could be carried out in high school. This proposal deals with the themes of the History of the Earth and Life, which is structured in the Curricular Design of the New Secondary School (NES) of the city of Buenos Aires (2015) and in the field of Earth Sciences in province of Buenos Aires for high school specialized in Natural Sciences.

Because of these results, we find it extremely necessary to improve efforts in order to increase the number and quality of teacher training courses in the area of Earth Sciences for the region.

On the other hand, based on the survey about the workshop, we highlight that the teachers were entertained, interested in the proposal and they found it quite useful. One of them mentioned that the issue of climate change can be a difficult subject to deal in the classroom or even of little interest, but that the trigger used is an important tool to draw the attention and interest the students. Another teacher said that the proposal can help to correct failures on previous knowledge. They highlighted the resources used (the use of cards), the teamwork dynamic, the didactics involved in the activity, the participation, the linking of concepts, the interactivity, the use of data to formulate hypotheses and the questions to build knowledge. They also considered that the proposal could be applicable to the classroom and motivating for the students. At the end, teachers asked for the material to carry it out.

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LEARNING ON THE ROCKS: THE 'ROCK BOX' AS A CONCISE LEARNING MODULE FOR SCHOOL STUDENTS

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Abstract— Teaching on rocks often appears difficult. The 'Rock Box' has been developed at GEO-Zentrum an der KTB in order to provide rock samples and didactic materials for successful learning on rock identification, rock formation, plate tectonics and systematic scientific work. Here we describe the contents of this teaching tool and give some examples for its application in class.

Keywords— Rocks, plate tectonics, out-of-school lab, hands-on, project outreach

Thematic line— Teaching of Geosciences and Natural Sciences for School-Level Education and Teacher Training.

1 Introduction

From 1987 to 1994 German Geoscientists and Engineers successfully completed an ultradeep drillhole in order to understand the structure of the continental crust in central Europe. Based on a two-whole concept a 4000 m deep pilot hole and a 9101 m deep main hole were drilled. Close collaboration of geoscientists and engineers provided a multi-perspective insight into the structural and geophysical conditions of the continental crust.

During the active drilling phase more than 1 million people visited the drilling location. Afterwards, the public interest stayed high. A non-governmental initiative developed the site in order to inform about the drilling and the research project. Within 20 years, and now with additional governmental aid, a modern geoscience education centre developed. Today the GEO-Zentrum an der KTB is a major out-of-school learning environment especially dedicated to geography classes. The teaching laboratory addresses both basic level and higher level school education, i.e. from pre-primary (4 to 5 years old children) to high school (18 years old young adults) level.

A succinct educational concept provides half-day to 3-day education-programs comprising teacher-centered elements, hands-on education, teamwork, self-controlled learning and outdoor teaching. The entire program of the Geoscience Education Centre follows the official curriculum valid for governmental schools. Therefore it was essential to involve both school teachers and professional geologists to develop informal learning modules useful for the formal teaching common in schools.

Besides of the plate tectonics learning module, the learning module on the identification and formation of rocks is the currently most frequented learning program.

2 Learning module on rock identification and the formation of rocks

2.1 Rocks in school

Children of all ages have a common interest in rocks and minerals. Either this results from a general interest in nature and natural processes, which is the primary case for younger children, or it comes from particular questions addressing the formation of landscapes, the origin of mineral or energy resources, the hazard potential of natural phenomena like volcanism, earthquakes or mass relocation. In most cases, teachers are asking such more focused questions in order to encourage their students to investigate nature. All questions on rocks and their formation take open-minded students onto a journey to the fundamentals of our planet Earth. Rocks do not only form the Earth, in addition they are the archive recording both long-term processes and instantaneous events. Furthermore they provide all those chemical elements the enlivened world depends on, either as basis for soil formation and thus for the entire biological nutrient circle, or as resources for the human economic welfare – with all their pros and cons.

The German federal school system thus takes rocks as a fundamental for teaching in geography on various levels: (1) in primary school the children investigate the geographic characteristics of their home area; they unravel rules of natural processes and research the interactions of such processes. (2) In 5th year in school the interior and exterior forces cover a large part of the curriculum of geography lessons; the variety of rocks is the visible and researchable result of those forces; identification of rocks educates children in techniques and procedures of systematic scientific work; furthermore natural rock and artificial stone is introduced as material

For creative work, e.g. architecture, stone masonry, painting etc. (3) In 7th year in school volcanism and earthquakes are understood according to natural processes; the expression of such processes is the variety of rocks forming under volcanic and earthquake conditions. (4) In 11th year in school students address the topic ‘plate tectonics in the focus of hazard research and research management’ using rocks as expression of the plate tectonic processes within the dynamic System Earth. (5) From 5th year in school rocks are explicitly set as the subject matter for experimentation, creative design, and scientific observation; various research techniques such as investigating, measuring, collecting, experimenting, documenting, detecting, researching, presenting and team-oriented working are realized with rocks. (6) In 9th year in school interdisciplinary education in natural sciences uses fossils and biogenic sediments as archives for evolutionary biology; in chemistry minerals and rocks provide insight into the occurrence of natural chemical elements in salts and ores. (7) In 12th year in school, as an option in geography, students deal with rocks and minerals as subject in order to understand the ensemble of relief features as results of geological processes.

2.2 Learning module rock identification and rock formation at the GEO-Zentrum an der KTB

Fourteen years ago the GEO-Zentrum an der KTB started developing a learning module on rocks. School children should research the natural material, should have time to deal with the rock, should have hands-on experiences with the rock, should realize the processes of rock formation, and should use a systematic way investigating the rock (Fig. 1). Following the definition of the explicit target group, existing teaching materials were compiled, and simple research methods got included into the syllabus. A teaching module ‘rock identification and rock formation’ was then first offered to school classes with an age level of 11 years.

The successful introduction encouraged further development of the module. In order to connect the learning module with the real life environment of the children, school children are now asked to bring rock samples from their home environment or samples collected during holiday trips. Those ‘own’ samples are now the focus of the learning module and school students of all ages develop a much higher interest in getting knowledge about ‘their own’ rock sample. The initially used popular science keys for rock identification (e.g. Kühne 2004) turned out to be either too complex scientific or too simple popular Thus, in participation with the school children visiting the GEO-Zentrum an der KTB a rock identification key got developed. This is simple enough for a satisfying description of the texture of the rock, and it involves several more or less simple experiments further investigating the rock characteristics.

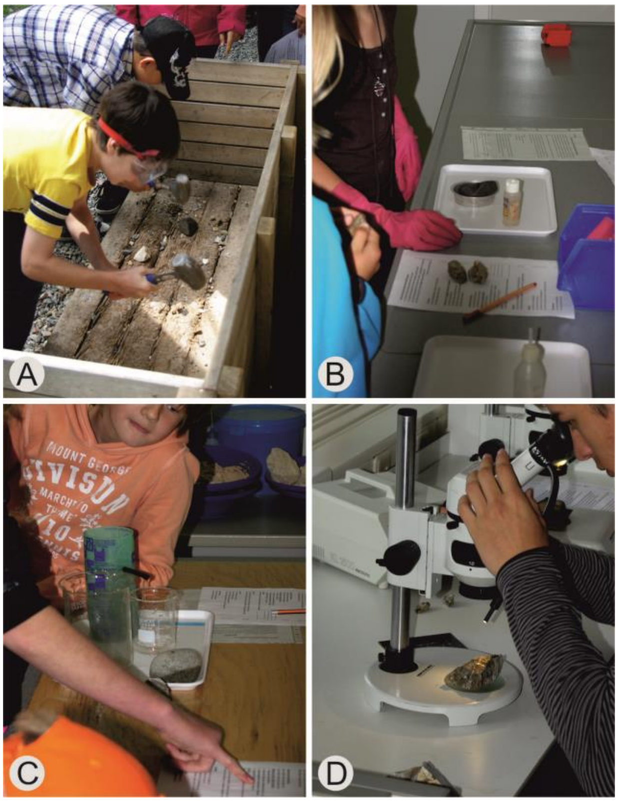

Figure 1. Learning module rock identification. School children learn self-guided by using simple research methods. – (A) Producing a fresh rock surface; (B) treating a rock sample with hydrochloric acid; (C) measuring rock density through water displacement; (D) observing microtextures

In order to allow the step from pure rock identification to understanding the formation of the identified rock, the concept of the rock cycle has been included and further developed. Now, the rock cycle used for the learning module does not only show the example of a subduction zone with the regions of weathering, sedimentation, subduction, metamorphism, melting, rise and extrusion. Now, the used rock cycle also considers mid ocean ridges, the composition of the oceanic crust, the formation of coral reefs, the accretionary wedge and thus allows addressing plate tectonics as such (Fig. 2).

In addition, the educational objective of the learning module was revised. In the beginning, a variety of rock types was to be identified and named. This was by far too ambitious. Now, after completing the learning module, school children shall understand the basic system of rocks, i.e. the distinction of sedimentary, igneous and metamorphic rocks. On a second level they then understand the subgroups, i.e. the volcanic and plutonic igneous rocks, the foliated and massive metamorphic rocks, and the clastic, biogenic and chemical sedimentary rocks.

An even more advanced step is the understanding of the dynamic adaption of those rocks according to chang-

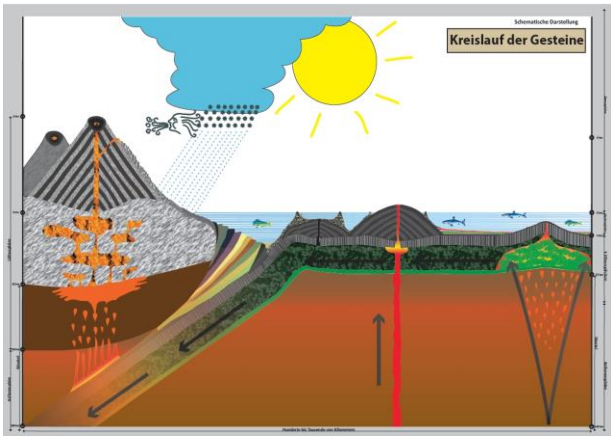

Figure 2. The rock cycle illustrates rock formation processes and connects those to plate tectonics

ing conditions. Particular rock names are of minor interest in the learning module. School children learn that these are a scientific specialist vocabulary, which is of relevance in those cases that people work or deal actively with the rock, i.e. scientists like geologists or mineralogists or people in the resources industries like quarry or mine personnel or craftsmen like stone masons. The students also learn that in all other cases the general terms igneous, metamorphic or sedimentary rock should be sufficient – unless the understanding of their formation has become common knowledge.

2.3 *The 'Rock Box'*

Based on the experiences in the GeoScience Education Laboratory at GEO-Zentrum an der KTB the learning module 'rock identification and rock formation' was set up as 'Rock Box' launched in September 2017. It was realized in cooperation of the GEO-Zentrum an der KTB and the European Competence Centre for the trades of the stone masons and stone sculptors.

The 'Rock Box' is a wooden box manufactured in a sheltered workshop. It contains 43 rock samples, i.e. 34 plates of dimension stones from all over the world and 9 hand rock samples of rocks not used as dimension stones, each with a chart providing a short geological and technical description as well as examples of the usage of the rock (Fig. 3). Further didactic material comprises an 85x119 cm large poster illustrating the rock cycle, numerous text labels for further indication of processes and names, and five sets of labels to set up the general system of rock types. A scientific handbook comprising a concise scientific approach to rocks in the dynamic System Earth and a didactic handbook comprising advice on the use of the 'Rock Box' in class and a data storage medium containing master copies for work in class completes the content of the 'Rock Box'. Currently the 'Rock Box' is available solely in German language.

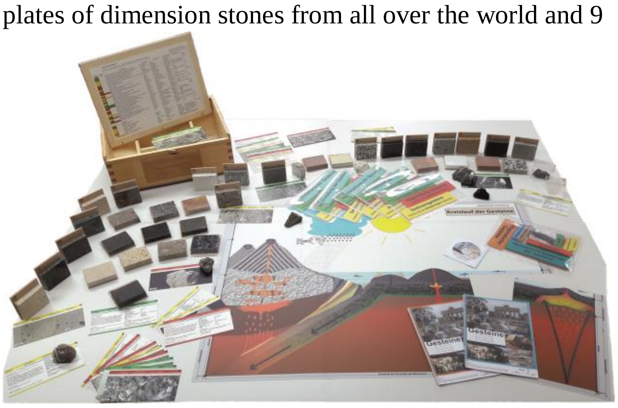

Figure 3. The 'Rock Box' contains all materials for hands-on education on rock identification, the rockcycle and its connection with plate tectonics

2.4 *Working with the 'Rock Box'*

Working with the 'Rock Box' in class may follow various thematic lines. In the described cases an essential understanding of rock identification is envisaged, then completed in the system of rocks and eventually widened in order to understand complex paths of rock formation.

(1) Basal rock identification: as preparation for the learning module the students collect a rock sample (*app.* fist-size) in their life-environment. The students individually examine the samples according to colour, texture, density, hardness etc. and record their results using the rock identification key contained in the 'Rock Box' (Fig. 1). Beforehand the teacher introduces the adequate methods and the criteria to be examined, using appropriate rock samples from the box. All necessary tools and methods are described in detail in the didactic handbook.

(2) System of rocks: the class works in small teams of up to six students. All teams take a set of labels illustrating the system of rocks. The students arrange the labels in a self-explaining system. The teacher distributes the 43 rock samples from the 'Rock Box' in a way that each team has one third igneous, sedimentary and metamorphic rock samples. The students then study the characteristics of the main groups of rocks using the texts provided in the didactic hand book and the knowledge they got from their 'own' rocks. Here the texture of the rock is in the focus (Fig. 4).

Figure 4. Specific characteristics for basic identification of rocks shown with 'perfect' samples

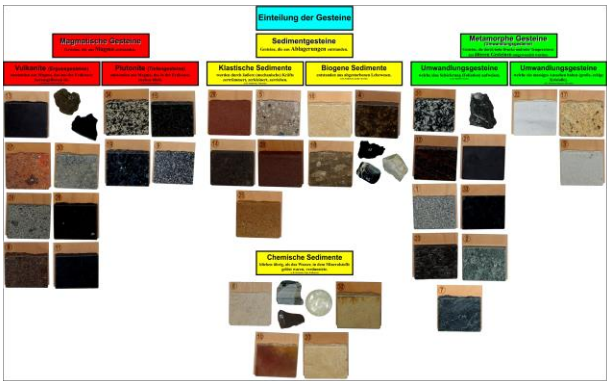

Figure 5. The system of rocks, completely illustrated with the samples contained in the 'Rock Box'

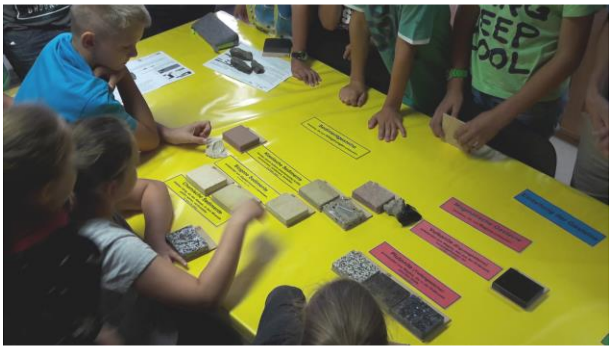

Figure 6. Guided by the teacher, school students classify the rock samples. The teacher directs the children with hints and questions

More advanced students may use the scientific handbook to find out about the relevant rock characteristics. Alternatively, the teacher introduces the system of rocks and highlights the importance of the textural rock characteristics. He then classifies characteristic rock samples. Then each student takes a sample from the 'Rock Box'. The students use the textural criteria and the characteristics they learned from the work with their 'own' rock to classify all the samples (Fig. 5). In this more teacher-guided learning the teacher asks and leads the students into the subject of systematic scientific classification of the rocks. (Fig 6). Eventually some students introduce their 'own' rock sample by using their completed rock identification key and assign it to the appropriate group of rocks. Due to time not all students can introduce their samples, thus they reason the classification of their rock sample and assign it to the appropriate group. They get feedback from class and the teacher.

(3) Developing a dynamic system of rocks: students of high-school level build upon examples (1) and (2). In small teams they use the content of the scientific handbook to understand the evolution of rock characteristics. For this advanced usage the 'Rock Box' contains further labels naming the rocks. They also allow the formation of sub-groups of rocks and to indicate textural characteristics and physical conditions. In addition students may denote processes forming the rocks. Arrows allow illustrating a succession of processes, such as the development of clastic sedimentary rocks and magmatic rocks to metamorphic rock and finally felsic magmatic rock. Here, the samples brought by the students or samples from a school collection may be included (Fig. 7).

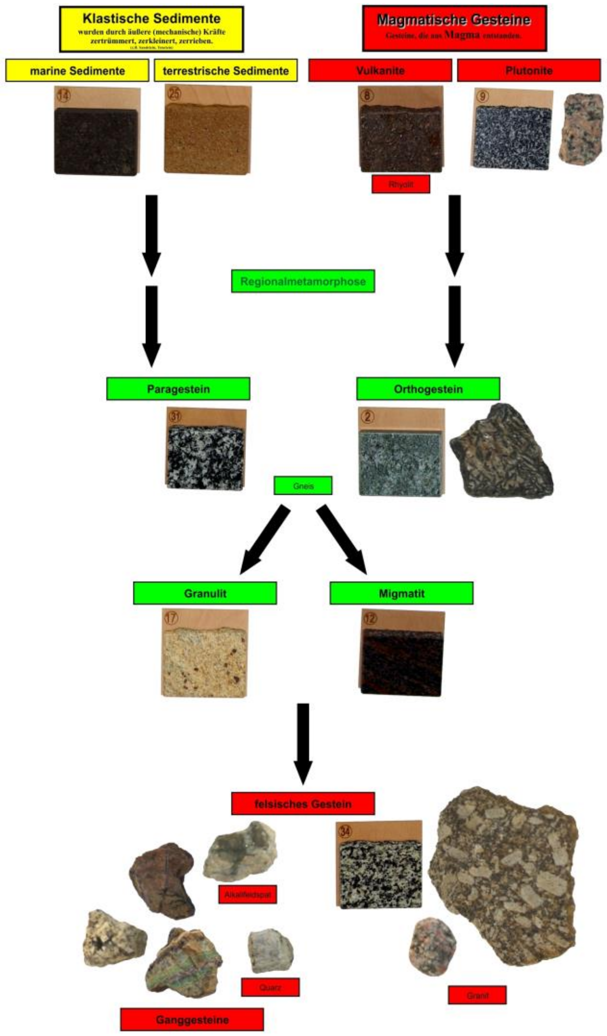

Figure 7. Layout of a dynamic path of rock formation in different plate tectonic environments to understand the formation of felsic magmatic rock and their connection with pegmatitic ore bodies

3 Conclusion

The 'Rock Box' is a teaching tool useful for hands-on teaching in schools and further educational institutions. Its content takes into account the requirements of the (German resp. Bavarian) curricula for the subject Geography in schools. The materials are durable and easy to understand. For the teachers, it is easy to get started with the indeed complex topic of rocks. The handbooks provide the necessary scientific background and the rocks are thoroughly chosen to give the best possible examples characterized by the published textbook characteristics.

So far the final 'Rock Box' has been tested in class at 14 schools in Germany and Hungary and particularly in the out-of-school learning environment of the GEO-Zentrum an der KTB. There the final box was used for teaching in to date 27 groups of school students from the age of 11 until the age of 18 years old.

This tool is available for school teachers and other teaching personnel multiplying the knowledge on rocks; currently in German language only.

Acknowledgements

The 'Rock Box' has been developed with the aid of numerous people including M. Füßl, K. Heinl, E. Hornauer, P. Jolas, A. Keck, O. Kleditzsch, M. Köcher, R. Kögler, K.-H.W. Müller, A. Regelous, M. Reimann, H. Rhein, P. Schmidt, I. Schuch, L. Tauer and C. von Seckendorff. Several thousands of school students and teachers tested the 'Rock Box' and helped us on the way from the very first idea to the final learning material.

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INTRODUCTION OF SOFT SKILLS AND CULTURE IN SCIENTIFIC HIGHER EDUCATION IN MOROCCO. EXAMPLE UNIVERSITY CALI AYYAD- MOROCCO

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Abstract — The Cadi Ayyad University (UCA-Morocco) has 13 university institutions with about 70,000 students and 600 international students. The number of students has increased considerably over the past four years. The UCA is recognized internationally for the quality of its teaching and scientific research. 1470 research professors have worked closely with more than 580 universities and research organizations worldwide, (Mobility, Co-graduations, Research projects ...). In its educational component (150 multidisciplinary courses), the studies are done according to the LMD system whose teaching architecture is illustrated according to a succession of semesters (6 Modules/Semester) and delivers the diplomas: DEUG, DEUP and DEUST, License, Master and PhD. With a view to Educational Innovation, the university has focused on the integration of digital and soft skills modules into the education and training system. The soft skills are introduced from the year 2017-2018 first in Master cycle to extend the years to come in Cycle License. The soft skills allow the student a better opening and self-training and exchange language and training. These are Modules of Foreign Languages and Culture and Soft Skills. Foreign language (English) and soft skills are designed for students who wish to improve their English communication skills and further enhance their language proficiency. It focuses on the language and skills that students need for an effective communication through a conversational approach to English, The course also stresses the different vocabulary tiers – everyday vocabulary, academic vocabulary and specialized vocabulary – around three main components: language awareness, life skills and employability. This course is reinforced by targeted readings and MOOCs aims to equip students in Scientific formations in general and Geosciences in particular with a level of vocabulary, ideas and concepts allowing them to have average knowledge to understand their immediate and distant environment.

Keywords— Cadi Ayyad University, Morocco, soft skills, scientific culture, Masters degree.

Thematic line— Geosciences in Higher Education.

1 Introduction

Soft skills allow the student a better opening and self-training and exchange language and training. These are Modules of Foreign Languages, Culture, and Soft Skills in Scientific formations in general and Geosciences in particular. Foreign language (English) and soft skills are designed for students who wish to improve their English communication skills and further enhance their language proficiency. It focuses on the language and skills that students need for an effective communication through a conversational approach to English. The course (Fig. 1) also stresses the different vocabulary tiers – everyday vocabulary, academic vocabulary and specialized vocabulary – around three main components: language awareness, life skills and employability. This course is reinforced by targeted readings and MOOCs aims to equip students with a level of vocabulary, ideas and concepts allowing them to have average knowledge to understand their immediate and distant environment. It is dedicated to Personal Development and Professional Project. It offers the student a rich and coherent program, in the form of workshops assisted by Moocs.

2 Complementary Modules

The module foreign languages and culture (48h) is composed of two elements of modules: Element1: the element foreign languages (French and English). It is composed of two parts whose objective is to develop the skills of the students in French language to equip them with an intermediate level, which would allow them at the end of the Master's degree to communicate easily, both orally and in writing, in situations of everyday, professional and academic life. The course focuses on the language and skills that students need for an effective communication through a conversational approach to English, which focuses on everyday situations. Reading, writing and grammar are included in each lesson, with various activities practiced in a variety of oral and written exercises.

The course also stresses the third vocabulary – everyday vocabulary, academic vocabulary and specialized vocabulary – around three main components: language awareness, life skills and employability. Strengthened by targeted readings and MOOCs, the teaching of general culture aims to provide students with a level of vocabulary, ideas and concepts that allow them to have average knowledge to understand their immediate and distant environment, in order to give them keys and tools to apprehend their time. They learn to participate in a conversation and express an opinion, observe, question and think critically.

3 Opening module

This module Soft skills (50h), is composed of a first part, which is dedicated to the personal development and Professional Project of the student. It is a program in the form of workshops assisted by Moocs, to develop confidence, self-esteem and acquisition of the tools necessary to confront situations of written control, interview for internship or employment and small group workshop animation.

Its content is based on the knowledge of one's own skills in the identification of one's personal and professional interests, the documentary research and the desired trades by proposing methodologies of surveys or interviews that facilitate the contact with others.

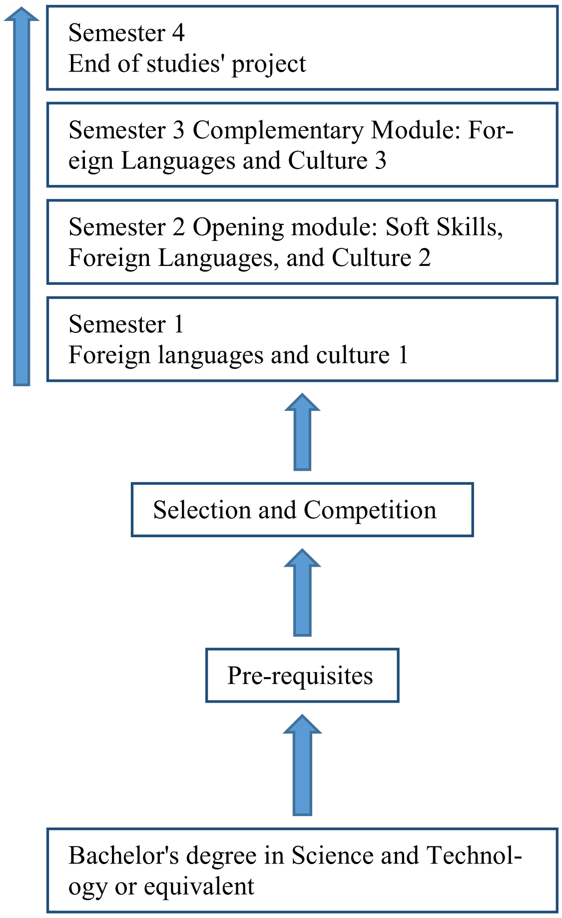

Figure 1. Sequence of modules

The second part of this module proposes to the student the choice among several activities of groups like Sport, Associative Activities, supervision, team work, manager a project for its development and blooming within the university

In the 2nd year of the Master's degree, the complementary and soft skills modules taught previously will help to reinforce linguistic skills in a logic of continuity, to improve the communicative skills of the student.

The modalities of the course are essentially oral, proposing topics of discussion around an aspect of the daily life. Students must make a presentation of 15 minutes around the same themes.

As an example, students will be asked to present a ritual in their culture and that of others, compared with cultures of neighboring countries; the student can also present events activities of his region or the country: International or national holidays, cultural meetings, Music, theatrical plays and major sporting events

The study of traditions, tangible or intangible cultural heritage in Morocco and elsewhere for a comparative study of environmental problems may be subject to more complex workshops. Students should be able to discuss the evolution of scientific concepts and theories. They will have an opinion on the study of the laws of nature, the stages of the experimental method, as well as the evolution of technologies and sciences and their impact on human history.

3 Conclusion

The UCA University, in the face of universal technological change, wanted by its new strategy to meet the expectations of its winners on the national and international level, by offering them teaching tools necessary complementary, open or soft skills to cope with a new educational system that takes into account the means of communication and innovation.

Acknowledgements

My thanks go mainly to the presidency of Cadi Ayyad University for informations gathered from University documents. Also, to have used university statistics documents not cited in reference.

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MENTAL MAPS OF THE AMAZONIAN SATERÉ-MAWÉ INDIGENOUS COMMUNITIES

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Abstract— The aim of this article is to present the developed methodology for the geography didactic material preparation, specifically and especially designed to attend the needs of indigenous schools. Our objective was to provide tools to the indigenous teachers, enabling them to make their own didactic material and share to the academic community their achievements, so that we can enhance the use of mental maps as a didactic resource in the teaching of Geography, in the indigenous teacher training course.

Keywords— Indigenous teacher training course, teaching of Geography, mental maps.

Thematic Line— Educação, Ensino de Geociências e Formação de Professores.

1 Introduction

The Indigenous Teacher Training Course is an intercultural bachelor's degree implemented by the Faculdade de Educação of the Universidade Federal do Amazonas in 2008, due to a demand of the indigenous people Mura, from Altazes – AM, for a graduation course that would enable them to teach in primary and secondary education in indigenous schools. Until few decades ago, teaching in indigenous schools was mainly carried out by non-native teachers, which caused high teachers' turnover, communication difficulty between teachers and students and the study of contents other than the ones proper to their culture and to their own processes of learning. Nowadays this course is attended by seven groups of diverse ethnicities.

This course curricular matrix presents the Geography teaching through four disciplines that aim teaching-learning geography contents, without a strong distinction between Physical and Human Geography, and the discussion of important themes for the indigenous struggle for better living conditions, such as ownership and management of their territory.

The didactics material presented here, entitled Sataré-Mawé Class Geography Booklet, was designed during the Planejamento e Gestão Territorial discipline having as differential the purposes of Indigenous School Education (Brazil ,1988) of promoting the inter culturality, matching the traditional native Knowledge to the scientific one; bilingual, written in Portuguese, as well as, in the native language Sataré-Mawé; differentiated, because it brings relevant contents to this ethnicity; and specific, because it deals with the native Sataré-Mawé land - Terra Indígena do Andirá-Marau (located in the towns of Maués, Barreirinha and Parintins in the Amazonas state), and the political, social and economic reality experienced by that people.

Indigenous teachers, as leaders in their communities don't have just the responsibility and commitment to promote in the indigenous school the teaching learning scientific knowledge necessary to the survival of indigenous people in contact situation, but also to rescue and value of the indigenous knowledge about the world. In this process, they faced all the difficulties of indigenous formal education, together with the lack of Geography books adequate to the reality of indigenous peoples.

In this context, the objective of this article is to present a methodology that seeks to instruct the indigenous teachers in order to it make possible for them to create didactic material based on the mental maps of their communities.

The phenomenological approach has been discussed in Geography since early century XX (Claval 1974) considering the perception and experience of one in relation to the comprehension of one's space.

Studies of Kevin Lynch (1988) open a psychologist explanation of perception when advocates that it is from the spatial perception that the individuals start creating mental images of places.

James Blaut was the first to suggest the design of maps in children teaching as a way to evaluate their perception as well as to solve problems related to space. Thus, he contributed to the analyses of places through maps in geography teaching.

In studies of Eric Dardel (2015) concepts such as inter subjectivity and geographicity became part of the geographic discussion.

Phenomenology proposes to base the geographic investigation since the experienced world and the perception of those who inhabit it. Perception while place knowledge resulted from the interface man-world has started to be strengthened in the1960s.

Tuan (2012) brought to the discussion a humanist bias emphasizing the human perception and knowledge role over the world.

In Brazil, Simielli (2003), Nogueira (1994, 2002), Kozel (1996) raised the discussion to the teaching of geography in the fundamental and secondary study levels.

It was based on the above authors' studies that we considered relevant to take the design of mental maps as the main didactic resource for the preparation of Sateré-Mawé Geography Class Booklet.

2 Methods and material

The analysis of mental maps from Satará-Mawé Geography Booklet was performed under the phenomenological approach, considering the imagetic reading associated to the content of the student's speech as they explained their maps and the geography knowledge literature review about the use of mental maps in geography teaching.

The preparation of Satará-Mawé Geography Class Booklet was held at Fazenda Experimental of UFAM, KM 37 in BR 174, in the capital city of Manaus/AM from October 12 to 20, 2016, as an assignment of the discipline Planejamento e Gestão Territorial. This subject aims to analyze the geographic concepts of land, territory and territoriality, socio cultural relations that are established in the space, the definition of territories while spaces where power is exercised, defining territoriality as identity territory, indicating the importance of geography and other Geosciences in territory planning and management.

The basic bibliography of the discipline was offered to the students, as a research tool and with the objective of presenting aspects of scientific knowledge over the matter. In order to increase comprehension, power –point presentations were developed with the main concepts worked in the discipline: place, territory and territoriality. As additional reading, the principles of Convention 169 from International Labor Organization (ILO) which establishes the right of indigenous peoples' prior consultation on any activity to be carried out on indigenous land and Art. 4. Item III of the Brazilian Constitution which assures indigenous peoples autonomy and self-determination about the management of their territories, have been presented and discussed.

During the lessons, we sought to establish reflections on Planning and Territorial Management by discussing the legal situation of the Andirá-Marau Indigenous Land (TI) where Sataré-Mawé students live.

In general, Sateré-Mawé students long to understand non-indigenous society and take advantage of scientific knowledge, being mostly assiduous and applied students.

As their native language is Sateré-Mawé some lack fully comprehension of Portuguese Language reading and understanding, so when they have difficulty understanding some more abstract concept, we rely on the translation of a leadership, but in general the scientific text reading is time consumer and dictionary use is constant. The strategy to overcome this difficulty is to promote constant dialogue, seeking to bring our speech closer to that of the community itself. In spite of difficulties with the Portuguese Language, the students of this course who are mostly teachers and leaders in their communities have an empirical knowledge about the geography of their territory.

Five strategies were used to promote reflection on the subject and to execute the work. Those strategies will be presented next.

2.1 Conversation Circle

Sitting in a circle, teacher and students discussed the case of indigenous land demarcation, emphasizing its relevance, challenges involving the maintenance of the land, its management, etc. At that moment, each participant in the circle expressed his/her thoughts on the theme, sharing information and experiences. Cases were told narrating facts experienced either by themselves or their relatives. During the conversation, students talked about the importance of land to Sateré-Mawé people and about the demarcation process that some witnessed as residents and indigenous leaders. At that moment the most relevant issues for the formation of indigenous students were considered, information raised and definition of the summary, since it is the role of indigenous teachers to preserve the memory of land conquest and to raise awareness about the need for planning with the community involvement the management of the territory.

At the end of the Geography Booklet developed process a collective review of the information and its translation into Sateré-Mawé language was performed by the students.

To the booklet cover and edges, traditional artwork of Sateré-Mawé people made by the students of this course was used, which is a reference to the Tucandeira Ant glove, alluding to Tucandeira Ant Ritual, traditional of Sateré-Mawé ethnicity. In this rite of passage ceremony from child to adulthood, boys who want to be accepted as adults in the community should insert their hands in a straw glove where dozens of Tucandeira Ants were trapped, these ants bit the gloved hand during the ritual – that can last all night long – causing great pain, swelling and even fever. It is considered to be a courage and endurance test, when the boy proves he's already become a warrior gaining the respect of the community, and, perhaps the most important, that he is now able to get married and raise a family. The choice of this graphism symbolizes the respect for the teaching job taken by indigenous teachers, valuing the indigenous identity and culture.

To prepare the booklet, students shared tasks and helped each other, according to the collective work tradition which is a characteristic of indigenous peoples. As a result of the reflections over the territory, a script of the Sateré-Mawé Geography Class Booklet was defined.

2.2 Work Groups – The Ajuri

To write the texts of Sateré-Mawé Geography Class Booklet, all nine students of this group worked together, not only getting information but also writing the texts on Andirá-Marau Indigenous Land in both Portuguese and Sateré-Mawé languages, which should include information about the importance of the land to Sateré-Mawé people, their characteristics, land situation, land tenure problems, highlighting the main challenges related to the territorial planning and management of the indigenous land.

At that moment, students reported the management projects that had already been implemented at Andirá-Marau, pointing out those that worked out as well as the ones that did not continue. They assumed at that time that some projects didn't work out because, according to them, such proposals had neither meaning nor practical utility for the people. Indigenous people were engaged in those projects that proposed work and improvement to their communities (construction of the flour house, animal breeding, etc.) and later gave up on them because they didn't consider it interesting to continue the projects management for several reasons: they didn't agree to the new location chosen for the flour house (in disagreement to the culture and tradition of the Sateré-Mawé people), to the animal breeding (the animals raised ate the crop), etc. Those reports showed how important it is to listen to the Indians, and to know the place through the impressions of those who inhabit it (Dardel 2015), because they imply that what the researchers considered useful or practical did not always correspond to what the residents wanted or considered important.

The mutual aid process in conducting activities, with collective tasks implementation that includes all the community – locally known as "Ajuri" – is another of the characteristics of the indigenous culture that we used as strategy in Geography teaching-learning, in contents such as territory, hydrography, social problems of the community and environmental education.

Thus, students cooperate with each other, discussed ideas to write the texts and produced the mental maps of the Andirá-Marau Indigenous Land, their communities and rivers that bathe them.

2.3 Workshops

The preparation of the Geography Booklets was preceded by a presentation and discussion of principles of working out the didactic material provided by a federal law office (MEC) in power point arranged by Professor Thelma Marreiro (IFAM – Manaus), highlighting the importance of the research and register of indigenous traditional knowledge on the land. This workshop helped us to realize how important it is to produce the material in native language translated into Portuguese, since Sateré-Mawé are speakers of that language, once it is essential that school teaches reading and writing first in Sateré-Mawé language and then in Portuguese.

Students received colored pencils, black pencils, rulers and A4 sheets of paper, where they made mental maps, drawings and texts while exchanging information, laughing, playing with each other and assigning tasks according to the abilities of each. It was not required that they represented anything specific because direction to the activity as done in the ethno mapping activity was not wanted. It was preferred that the students freely manifested their perceptions.

Texts, mental maps and design made by the students were typed and organized into book layout by the staff.

2.4 Lectures

The course ended with a lecture given by Professor Dr. Gersem José dos Santos Luciano, Indian from Baniwa ethnicity (Alto Rio Negro) and professor doctor of the Universidade Federal do Amazonas about the relevance of indigenous land to the Brazilian traditional peoples and land management for the sustainability of life in the indigenous land.

On the occasion there was a reflection on the indigenous cosmology when the difference between Indians and non-indigenous people worldview was highlighted. Students appreciated Dr. Lucianos's lecture who is an admired and recognized Indian leader all over Brazil.

2.5 Film Session

At the very end of the course, the film Xingu, directed by Cao Hamburguer (2011) was played. This movie tells of the saga of Villas-Boas brothers, indigenists involved in Roncador-Xingu Expedition and the creation of Xingu National Park in the 1960's.

Later, the movie was commented and the differences and similarities with Andirá-Marau indigenous land demarcation process noted.

3 Results

The Sateré-Mawé Geography Class Booklet presents on the cover the mental map of the Marau and Urupadi rivers that bathe the communities where the indigenous students of the course live. (Fig. 1) Rivers have fundamental importance to the Amazonian peoples, especially to the indigenous peoples. Thus, staff considered this mental map a quite significant mean to think about the geography of the place.

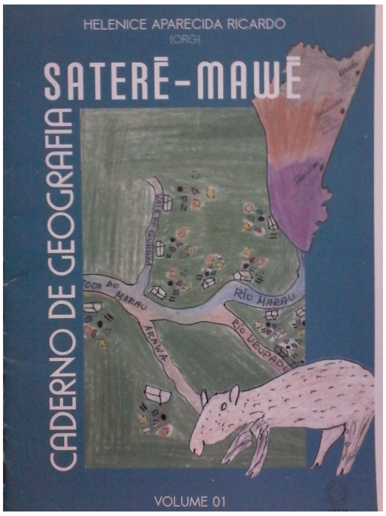

Fig 1. Sateré-Mawé Geography Class Booklet

The booklet contains 24 pages and has the following script: 1. What is the Indigenous Land; 2. The Importance of the Indigenous Land to Sateré-Mawé People; 3. Mental Maps of the Indigenous Communities; 4. Main Characteristics of Andirá-Marau Communities; 5. The Importance of the Traditional Knowledge to the Study of the Place; 6. Environmental Management Plan; 7. Calendar of Economic Activities.

Indigenous students wrote texts about the importance of indigenous land for the survival of Sateré-Mawé people, showing how deep is the Indians relationship with their land, highlighting man and world inter subjectivity, and their territorial and environmental management concern as a mean of assuring future generations survival. Besides, they provided mental maps containing information about the geographic position of their communities. (Fig. 2)

Review of the texts in Sateré-Mawé language was done by José Bota, this course student and an Andirá-Marau Indigenous Land leader as well. Review of the same texts in Portuguese Language was done by the staff, trying to preserve the authors' very "way of speaking", without distorting the text comprehension.

A importância da Terra Indígena para o Povo Sateré-Mawé

A Terra Indígena Sateré-Mawé é considerada uma terra mãe, porque percebemos bem claro, sem confusão, que a gente demonstra os ecossistemas artificiais principalmente na construção de moradias, campos cultivados e plantio nos roçados. Nesse caso, a Terra Indígena Sateré-Mawé é importantíssima para a sobreviver nela, por isso devemos manter sempre um cuidado especial ao utilizar aquela terra para não acontecer um grande prejuízo ao nosso futuro Sateré-Mawé e sempre procurando lutar a favor dos nossos direitos descritos na Constituição Federal.

Kat hamo waku yi Satere-Mawe ywania pe?

Satere-Mawe ywania e'yi ti toine'en aikotã ny ewywuat , kat pote watikuap kahato hot'ok wo sẽse ti ra'yn ipuopyi ne'i torania mĩt minuğ kuap ko'i wata'akasa te'en-te'en mesuwat yi ewa tote, po'oğ ni mẽwat ahepiat waku rakaria: aheine'en hamuat ama'ãm hap mi'i hawyi torania ğo puopywiat koi ehap ko'i ehap ko'i mi'i tupono aitoria ahe'yi wywo watoine'en aiwemikuap ewỹ aiwepiat motpãp nuğ turãn, mi'i pote aru ywã pakuptia ho'opot hap yt kat'i i'atuepe meswat yi tote, mi'ite muesaika po'oğ saikãp iwato rakat to'e hap upĩ.

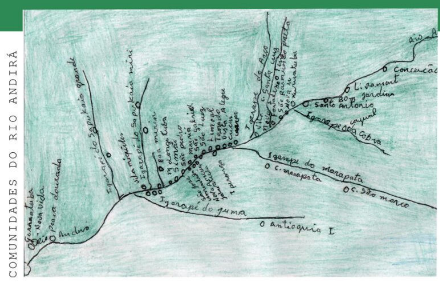

Fig 2. The importance of Indigenous Land to Andirá-Marau People

A total of nine mental maps of the communities where the students live were made. (Fig.3)

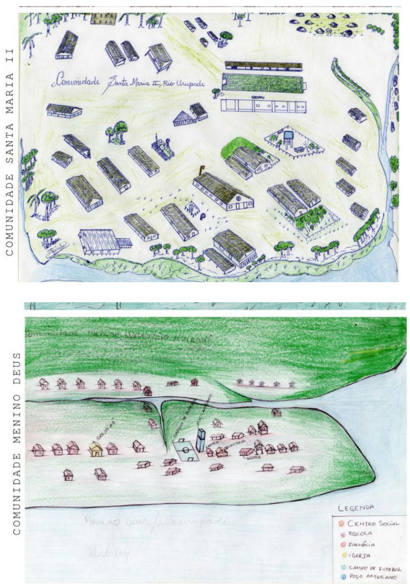

Fig 3. Santa Maria and Menino Deus Communities in Urupadi river

Other mental maps featured the community economical activities, the cultural events schedule in every community, main diseases occurrence area, location of the health care points, medicinal herbs site and the Pajé's house, as well as the main social and environmental problems that affect the life of those who live in the community such as fire, erosion, pollution, gangs, drugs traffic and religion. (Fig.4)

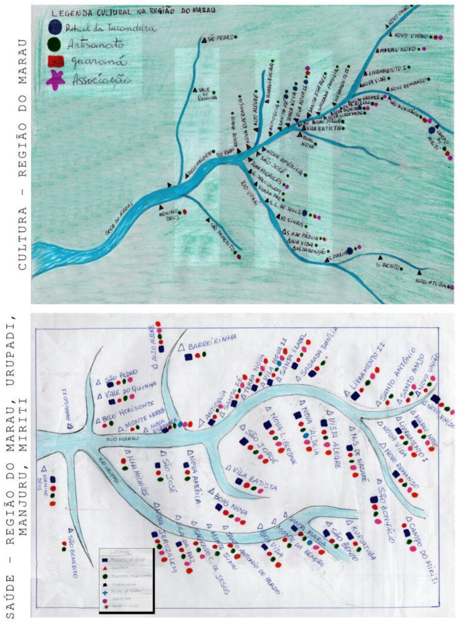

Fig 4. Mental maps of Indigenous rituals occurrence area and health care points location

When it comes to management plan, students considered yellow-spotted river turtle management plan to be important once it is a very appreciated dish in the indigenous cuisine. (Fig.5)

Plano de Gestão TI Andirá-Marau

Quelônios

Devido estar extinta as espécies de quelônios (tracajás, cabeçudo e tartaruga) nas áreas indígenas acima citado, as comunidades locais em prol de preservar as espécies na natureza, organizaram-se e promoveram-se para que as espécies de quelônios voltem atender como alimento muito apreciada por nós indígenas Sateré-Mawé, por isso, para ter o resultado proveitoso buscamos ajuda e acordo das instituições por meio de projetos para termos acompanhamento de técnicos especialistas para ensinar também como iniciar a coleta dos quelônios, saber o local e como conservar os ovos até nascer e o período de devolver aos rios.

Fig 5. Yellow-spotted river turtle management plan

They also highlighted the hunting management by noting the animal reduction in the area, and the territory management plan which proposes ideas for territory border monitoring and references of demarcation to alert in case of invasion. The relevance of rescue and register of traditional knowledge of Sateré-Mawé people was highlighted in another text, reinforcing the indigenous scholar education relevant role in the process of strengthening indigenous identity and the elderly people, as tradition masters.

At last, a calendar relating the months of the year to the cycle of activities that conduct the social and economic life of Sateré-Mawé people from Marau and Urupadi rivers was created: Piracema Season (spawning season), Planting Season, Açaí and Buriti Harvest Season, Indian Week Celebration, Tapecum Season, Start of the time to clear the plantation, Drying the Plantation Season, Guaraná flowering Season, burning of the Plantation Season, Hunting Season, Banana Planting Season, Yellow-spotted river Turtle spawning Season, Corn Plantation Season, Guaraná Crop Season and Saúva (leaf-cutter) Ants Season. (Fig. 6)

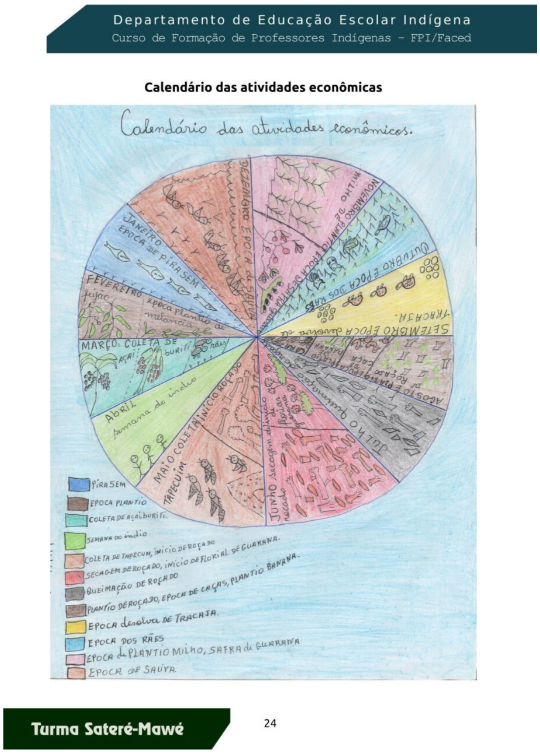

Fig 6. Sateré-Mawé people’s Activity Calendar

In the analysis of the mental maps produced by Sateré-Mawé students we considered that the highlighted figures were the ones showing Marau and Urupadi rivers and their tributaries for being the main access via to the students’ communities. Instead of roads, as in the other regions of Brazil Amazon regions has rivers, mostly navigable, and it is through those rivers that one can reach the most distant places within the zone.

Rivers are essential to the indigenous peoples’ lives. The depth of this relationship Indian people-river was identified in the students’ speech: “I am from Marau river, Master.” It is common, particularly in the inland Amazon, that people are located from the rivers and indicate the river as their birthplace. They refer the river as their address and demonstrate their identity relationship to the river system, once the river is life, path, food and fun.

Through mental maps it was possible to infer that their perspectives in relation to the direction and location systems, the river is the most important benchmark, highlighting this river basin most significant elements according to their own perceptions. According to the students, rivers Marau, Miriti, Manjuru, Igarapé-Açu, Urupadi are the most fishy.

The mental map of Mués-Açu hydrographic basin, a tributary river of the Amazon River (Fig.2), presented the exact disposal of all the communities along the Marau and Urupadi rivers. The Simão Community is the only located in Andirá river and, therefore, another mental map was created to display it. Another relevant fact is that all the communities indistinctively were represented in mental maps of this hydrographic basin, not only the ones where the students live, which shows the strongest commitment to the idea that this indigenous land belongs to all and every Sateré-Mawé people.

In Menino Deus Community, the representation highlights the artesian well (Fig.3), as the most visible element even from distance, and a conquest of the community.

In Andirá-Marau Indigenous Land region, malaria is an endemic disease, as in the whole Amazon region, thus, although there are just a few cases reported nowadays, it appears highlighted in the health map. (Fig.4)

Social problems were highlighted in Nossa Senhora de Nazaré and Santa Maria Communities probably because they are considered to be “poles” where health centers and/or administrative centers of the City Hall are located which draws people from all over the region. It is believed that using those mental maps indigenous teachers will be able to discuss the main problems of the region with their students.

In the economic activity calendar (Fig.6) the most important activities for Sateré-Mawé people were displayed over the months of the year. Not only the ones that could be classified as “economic”, in the meaning of survival warranty – in its most strict sense such as buriti crop, tapecum (a kind of eatable termite), start cleaning the plantation and so, but the ones that represent the nature cycle (e.g. guaraná flowering season, guaraná crop).

The word “season”, quite often used in the calendar, also refers to the cycle of the species cultivated or gathered by Sateré people, as showed in October, “Rães Season” (kind of frog very appreciated by Saterés and quite common in Marau region) and “Saúva Season” (there are at least two leaf-cutter ant eatable species).

Yet, it is worth of mention that april highlights the “Indian Week”. Perhaps, indicating the poor attainment to civil rights that should be equal to every Brazilian citizen.

4 Discussion

In agreement to the numberless authors that pointed de dependence of teachers to the textbooks and the ideological content of the publishing to which the teachers have access (Oliveira 2003, Spósito 2002, Straforini 2004, Vesentini 1987), a methodology that could instrumentalize the indigenous teachers, enabling them to create their own didactic material in which the traditional indigenous people's knowledge could be researched and valued, and the place expertise could be associated to the scientific knowledge, in a cognitive approach where learning starts from local to the global context was sought.

According to Bergamaschi (2008, p.7) Brazilian cultural diversity is not only an anthropological concept, since Brazil has about 230 indigenous people, with over 700 thousand individuals, speaking 180 different languages, spread in 612 Indigenous Lands (TI) but, considers that the indigenous peoples contribute "decisively so that Brazil presents this ethnic-cultural diversity that constitutes impair unique wealth in the planet". This cultural diversity justifies the relevance of the theme for the Brazilian Geography and other Geosciences, as well.

It is of fundamental importance to make indigenous people access to geography scientific knowledge possible and to make it in an intercultural perspective (Cecchetti & Pozzer, 2014, Candau 2014) that assumes cultural exchange between indigenous and non-indigenous peoples, composing a cultural mosaic that just adds to the human knowledge. Thus, the preparation of Sateré-Mawé Geography Class Booklet was mapped out by inter cultural effort promotion.

It is believed that the concept of place could and should be the starting point to Geography learning in the indigenous communities, once it approximates reality and empiric knowledge to scientific knowledge and contributes to increase the students' motivation and interest (Matsumoto et al, 2014).

We agree with Tuan (2012, 2013) and Dardel (2015) and other Humanist Geography authors (Holzer 1992, Kozel 2000, Nogueira 2002, Nogueira 2014) who consider that no one has better knowledge about their place than the ones who inhabit it and get the experience of the lived world. Besides, the benefit of place study, the holistic view of the world and its cultural landscape as motivating factor that brings indigenous people to geoscience is known (Apple et al 2014).

The oral tradition is recognizably important in the educational process of the Amazon indigenous people (Luciano 2006), once it promotes the oral and cultural transmission of the people's traditions; reason why the talking circles were the starting and ending point of this work. Encouraging activities which indigenous students could cooperate with their own knowledge is a stimulus to these indigenous teachers' autonomy and brings through oral history, geologic events and geographic phenomena descript in indigenous myths and legends the opportunity of oral history register (Johnson et al. 2014).

5 Conclusion

The effort to develop a Geoscience didactic material, specific for the Sateré-Mawé ethnicity of Andirá and Marau rivers, both in Sateré-Mawé and Portuguese language texts, which values traditional knowledge originated from self-experience of indigenous space, seeks to promote validation and recognition of knowledge and culture of indigenous people., in accordance to the current education policy for indigenous people, that, according to Santos (1995, p.87) assured the indigenous peoples recognition and "respect to the cultural and linguistic diversity, as well as the mandatory consultation of those peoples' interests".

We emphasize mental maps potential, while spatial representation plenty of local specific knowledge, which benefits learn process, as well as, retrieve the knowledge about the place. This proposal was presented by Nogueira (1994) who also pointed out the possibility of working the spatial representation through mental maps, thus, initiating the main cartographic concept learning, a thesis also supported by Simielli (2003). Those authors added to the debate the possibility of using mental maps as a tool in map teaching. Therefore, we agree with the author's statement "mental maps contain the knowledge about the place that only the ones who inhabit it could ever have and reveal." Statement that reinforced our idea that those mental maps would be for us, geographers and geography teachers, a didactic material of extreme importance to the comprehension of places, because the data that are there represented, regardless of accuracy, reveal the place exactly as it is." (Nogueira 2002, p.130)

Thus, we consider it was a very positive collective material preparation process, counting with students' engagement, group decisions, even in the process of content edition performed by the students themselves with the staff support.

It was of fundamental importance to make this work, especially at this moment when the indigenous cause, fearing indigenous land demarcation and recognition of Brazilian cultural diversity setback, struggle to keep the rights already attained.

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PALEONTOLOGY EXPERIENCE IN THE KINDERGARDEN

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Abstract— Despite its complexity, because it contemplates several forms of scientific knowledge, Paleontology is important in basic education, since it helps to understand the temporal perspective of the changes that affect our planet and the living beings that inhabited it. Through this, Paleontology collaborates to form citizens with environmental responsibility and care. To that end, playful activities for 4-year old children in Unicamp's Center for Partial Coexistence were developed, with themes chosen in meetings with its teachers. Teaching material was developed and employed in activities with the students, showing that it is possible to work with Paleontology in Children's Education with low cost materials, like cardboard box, fabric and buttons.

Keywords— Paleontology, dinosaur, children's education.

Thematic Line— Educação, Ensino de Geociências e Formação de Professores.

1 Introduction

According to Carneiro et al (2004), the study of Earth Sciences in basic education helps to build a planet-wide perspective, forming a responsible and caring citizen as it introduces environmental concerns and other concepts.

Thus, the National Curriculum Guide states that science teaching should cover topics of Physics, Chemistry, Biology, Geology and Paleontology (PCN Brasil 1998).

Despite the current availability of information in publications or digital platforms the popular knowledge of geosciences is still very superficial. (Mello, Mello e Torello 2005, Neves, Campos & Simões 2008, Perez et a.l 2011). The approach of Geoscience subjects in the teaching of preschool children can increase the interest and future knowledge of them on the subject.

One way to raise interest in geosciences in students is to use a topic that generates spontaneous curiosity and allows for discussion and introduction of other related topics.

In this age group the interest of children by dinosaurs and prehistoric animals is undeniable. These have long since become extinct, characteristic as singular morphological aspects and the great corporeal size make them the dinosaurs, among all groups of organisms, current or fossil, the most frequent inhabitants of the children's imagination. As proof of this it is possible to check the large number of toys, publications and even children's clothing produced with the theme dinosaurs.

In this way, using the multidisciplinarity of Paleontology, from the theme of dinosaurs, which naturally attracts children's attention, it is possible to introduce and discuss other subjects related to geology, geography, biology and Environmental Education.

2 Themes and activities

Using the temporal perspective of the changes that affect our planet and the living beings that inhabit it, the theme "dinosaurs" was chosen to work with the Coexistence 2 class, in Unicamp's CECI Children's Partial Coexistence Center, with 4-year old children. The theme completely attracts the children's attention, developing interest and curiosity in students about dinosaurs and the evolution of life on the planet.

Since classroom practice allows the student to live through the experience, it was decided that they should work with material-enriched activities. Plays and games facilitate children's learning making learning happen in a pleasant way and developing interest and curiosity. Thus, games can be used to promote learning in school practice, since playful activities considered facilitators in learning and development processes.

The methodology employed aimed to initially list the teachers' doubts, which were gathered in several meetings with them. Next, topics that could be developed with the students were chosen, and the activities that could be most effective in order to work with these themes were selected. All support material was developed in this line, and during the meetings with students photographic records were taken.

The selected themes are in the list below, and they guided the development of the activities.

- Did dinosaurs coexist with men?
- Did all dinosaurs disappear? Are there still some living?
- What did dinosaurs feed off?
- What sizes were dinosaurs?
- How was the environment where dinosaurs lived?

Activities were developed in the classroom, kitchen, playground and main hall in the Earth Sciences Institute, State University of Campinas (IG-UNICAMP).

2.1 Discovering Diversity and Evolution - Timeline

Even for adults, understanding geological time is rather difficult. As a teaching resource, images illustrating life during the twelve (12) periods in the Phanerozoic Eon (540 My to present) were selected, printed, laminated, and attached with a cord, so that they could be hung on a cloth panel 5.40 m long. In each period a button was sewn in the panel, so that children could hang the plaques with the corresponding images in chronological order. Each image is composed of an illustration that reconstructs the landscape and the typical organisms from each period, from different parts of the world, with emphasis on the Brazilian paleoenvironments.

During the activity, children suggested and argued about what could have appeared in each, while they hung the pieces, one by one. In this way, they learned that organisms appeared, evolved and even disappeared along the ages. This activity answered the first two questions listed in the meetings with the teachers, besides addressing the development of multicellular organisms in the planet and extinctions.


Figure 1. Panel on Geological Time (Photo by Fresia Ricardi-Branco)


Figure 2. Children discussing with Ariel one of the images of the Panel with Geological Time (Photo by Fresia Ricardi-Branco)

2.2 Fun meal - Cookies modeling activity

To address the third question listed, a culinary activity was developed in the kitchen, for baking biscuits in the shapes of dinosaurs (*Tyrannosaurus rex, Ankylosaurus ragnarok, Apatosaurus*) and other extinct giant reptiles (*Pteranodon*, theropod footprint).

During the making, it was explained that dinosaurs with large, pointed and slightly curved teeth were carnivorous like T. rex and used such teeth to rip and lacerate. While herbivorous dinosaurs might both have small, fragile, pencil-shaped teeth, such as Apatosaurus, which use them to pull out shoots of ferns and pines. As well as having teeth and complexes like the ankylosaurus adapted to crush harder vegetables like cycads. And that there were also omnivorous animals like man as well as other prehistoric and black animals that did not even have teeth like the Pteranodon, a winged reptile contemporary with the dinosaurs that used its long beak to catch fish, thus being a piscivorous.

During the confection, the different kinds of teeth and their functions were explained, highlighting which types of animals would have each kind of teeth

Children also discussed the feeding habits of each animal represented in the cookies baked during the activity comparing them with the eating habits of current animals and their behaviors.


Figure 3. Preparing the cookie dough (Photo by Fresia Ricardi-Branco)


Figure 4. Molded biscuits prepared to be baked (Photo by Fresia Ricardi-Branco)

2.3 Size of Dinosaurs - Activity Giant vertebrae

In the playground, an exploratory activity was performed that compared the size of the children's cervical vertebra with the vertebra of the great creature dinosaur cretaceous argentinosaurus, which was one of the largest dinosaurs that existed and lived in Argentina in the Cretaceous period. The vertebra were drawn and cut into cardboard in real size and painted white. The students could see the vertebrae and compare with the size of their cervical vertebra, touching the back of their necks. This resource was used to have children measure the size of some dinosaurs, using their own bodies as a scale.

Figure 5. Children with fóssil replicas and real size dinosaur vertebrae cardboard shapes (Photo by Fresia Ricardi-Branco)

Figure 6. Children with fóssil replicas and real size dinosaur vertebrae cardboard shapes (Photo by Fresia Ricardi-Branco)

2.4 Discussing paleoenvironments - Activity Giant puzzle

Finally, an activity was carried out in IG/UNICAMP, using a 1.8 x 2 m picture pasted in plywood and cut in the shapes of puzzle pieces.

Working as a group, children assembled the puzzle, that showed a paleozoic environment from Brazilian Cretaceous. It was possible, while assembling, to discuss how and where the pictured animals lived, and what did they feed off, while the children tried to assemble pieces that contained water, pieces that contained soil and vegetation. The habitats of two groups of Brazilian dinosaurs pictured were discussed, one carnivorous (*Oxalaia quilombensis*), and one herbivorous (*Rayososaurus*). In addition to discussing the process of fossilization and extinctions.

The interaction of the students was so satisfactory that the teachers requested the repetition of the activity in the classroom.

Figure 7. Giant puzzle assembly, with an image from a Brazilian Paleozoic environment. (Photo by Fresia Ricardi-Branco)

Figure 8. Giant puzzle assembly, with an image from a Brazilian Paleozoic environment. (Photo by Fresia Ricardi-Branco)

Figure 9. Giant puzzle assembly, with an image from a Brazilian Paleozoic environment. (Photo by Fresia Ricardi-Branco)

Figure 10. Giant puzzle assembly, with an image from a Brazilian Paleozoic environment in classroon (Photo by Fresia Ricardi-Branco)

3 Conclusions

It was evident, during the activities, that it is possible to work with Paleontology in Children's Education, even though it is a complex discipline that integrates distinct, interacting types of scientific knowledge, and the importance of the support material used in the activities. Regarding those, it is important to highlight that low-cost, easily procured materials were used in their making.

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THE GEOSCIENCES AS PROPOSAL IN CONTINUED TRAINING TO TEACHERS IN MACEIÓ-AL

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Abstract— This article is based on a reflection on the importance and necessity of continuous training education teacher in schools. Highlighting the relevance of Geosciences in a proposal of continuous training for teachers. The objectives 1 - To find out in the National Education Plan, and in the teaching plans of the state network of Alagoas and municipal of Maceió, what there is of continuous formation of teachers. 2-Highlighting the teaching of Geology as a proposal for change in the continuing education of teachers, specifically for professionals in Science and Geography. 3-Present the conception of teachers of Science and Geography in exercise in the municipal network of education of Maceió-AL on the importance of the continued formation considering the contributions of Geological science. To obtain data, a documentary analysis was carried out in the National Education Plan (NEP) and in the teaching plans that were in force in the municipal network of Maceió and through an online questionnaire answered by the teachers of Science and Geography active in the classroom in classes of the 6th grade of the Maceió municipal school system. It was verified at the end of the research that the NPE seeks to guarantee all the professionals of basic education the continued formation in their respective areas of activity, and that the teaching plans of the state and Alagoas municipal network of Maceió aim at fulfilling with what is established in law, supplying with local needs. It was verified that although there are proposals for the continuous training of teachers linked to the knowledge of Geosciences / Geology, there is much to be done considering the national reality, specifically Maceió-AL.

Keywords— Continous Training, Geosciences, Geology, Teacher.

Thematic line— Education, Teaching of Geosciences and Teacher Training.

1 Introduction

According to Gatti et al. (2011) was from the 1990s that issues related to Continuos Training of Teachers (CTT) had impact on international and national levels, which influenced the development of vocational training policies in various countries of Eu-rope and America. For the authors, the origin of the de-bate on the formation is interconnected to the movements of the epoch that questioned the dissatisfaction and concern with the quality of education.

We describe a reflection on the importance and necessity of the CTT, irrespective of the area of knowledge, since the works of Behrens (1996); Cadau (1996) e Libâneo (2009). This allows us to interpret and understand the theme from the Law nº 13.005/2014 (National Education Plan - NEP).

Still, we highlight the role of the Geosciences in a proposal of CTT, basing in studies of Compiani et al. (2002 and 2005); Piranha & Carneiro (2009); Gonçalves et al. (2012); Almeida, Araujo & Mello (2015) and Silva (2016) who present proposals that aim to disseminate the geological knowledge in the public school network.
Whereas that the Geology/Geosciences when raised, you must understand

> "[...] as the area of knowledge that studies natural phenomena under a physical look, historical and epistemological, making use of the inter-disciplinary perspective (interaction between the disciplines) (Teixeira et al. 2017:291).

The objectives of this work are:

1 To analyze if the continued formation of teachers is present in the National Plan of Education, and in the teaching plans that govern the municipal network of Maceió;
2 To highlight the importance of Geology in the continuing training of teachers;
3 To verify the opinion of the professors of Sciences and Geography on the relevance of the continuous formation and about the Geological Science.

1.1 Importance of continuous training of teachers in the perception of some educators

According to Behrens (1996) knowledge is transitory, renovate itself and builds, being always in motion, so the process of knowledge and the training of the teacher should be something dynamic and continuous. In this case, only the initial training will never meet all the needs of knowledge and training of teachers, since each new change in society faces new problems and recoveries.

For Libâneo (2009), in addition to the initial training of teachers regarding their academic training, it is necessary that the same keep a continuous training, which increase and systematize the critical knowledge and a holistic vision in relation to their own teaching practice.

According to the authors cited all the transformations that occur in the sectors of economic, social, political, cultural and scientific affect scholastic and the formation of the student, requires that the teacher develop their professional identity throughout his career.

Prada et al. (2010, p. 369) describe that

> "learning is more than receiving or obtaining information and know them or understand them is to make learning part of being, implying develop with him [...]".

Thus, it is a process that occurs throughout the human life and professional of the teachers.

Therefore, the continuous training of teachers, must involve in seeking answers to the challenges of education, through a quality education, based on the principles in a critical and reflexive training, integrating theory and practice.

It is important to point out that according to Candau (1996) the continuous training cannot be designed as a process of accumulation of officers, courses, lectures, seminars of knowledge or techniques, but as a craft that involves reflexivity and critical about the practices, contributing to the (re)construction of permanent teacher in both personal and professional level of reciprocal way.

In this way, the continuous training must be understood and planned aiming at the teacher as agent of his own practice, in which produces knowledge, whereas the reflective process and critical.

2 Methodology

An investigative analysis was developed in the National Education Plan (PNE) and in the teaching plans that are in force in the Municipal Network of Maceió / AL, regarding the continuous formation of teachers. In the same period 1996-2016, there were proposals for continuing education offered to teachers in the public elementary school system, based on the knowledge of Geosciences / Geology.

Later, an online questionnaire was sent to the teachers of Science and Geography who have activities in the classroom in the elementary school classes II of Maceió's teaching network. It is noteworthy that the contact of these professionals was obtained through the Municipal Secretariat of Education-MSE in the year 2017.

3 Results and Discussion

3.1 NEP (2014-2024)

The current NEP presents constitutional requirements that have been approved by Law nº. 13.005 of June 2014 laying down guidelines and goals with their respective strategies focused on quality of teaching and teacher training.

The document aims to guarantee the right of basic education and the quality of teaching at universal level and the expansion of opportunities in the educational sector.

It is important to note between among the targets the number 16, by ensuring the continued training of teachers working in basic education, considering as something of great importance for improving the professional growth of teachers and education itself, responsible for the Federal District, states and municipalities to assume the commitment to provide the means for the development of a quality training and accessible to all teachers.

This target seeks to ensure all professionals of basic education to continuous training in their respective areas considering the needs of the education system. While as strategy aims to achieve in collaboration develop and offer courses at public institutions of higher education, equitably and articulated with training policies of states, municipalities and the Federal District.

The law says bases for the elaboration of public policies directed to continuous training, blaming the public offices of education federal, state and municipal governments in capacitation vacancies to education professionals. This, in fact, contributes to offers of courses in the area of continuous training of teachers in the classroom or distance learning modality (Gatti & Barretto 2009).

3.2 The continuous training of teachers in the plans of the network of teaching in Alagoas state and in the municipal network in Maceió.

There are two plans that govern the teaching in Maceió. The first is the Education Plan of Alagoas State - EPAS (2015-2025), is composed of three chapters: 1) Diagnosis of educational reality in the period from 2009 to 2013; 2) Goals and strategies of the EPAS in line with the NEP: This chapter presents proposals for the continuous training of teachers; and 3) Monitoring and monitoring of the development of the EPAS.

We confirmed that in the document there is an interest in fulfilling the goal of number 16 displayed on the EPAS of 2014, whereas in this case the reality of their own state in the face of existing needs in the educational sector.

However, with the respective strategies, the Alagoas State will seek the cooperation between college school and the secretariats of education in state and municipal level, articulating the public policies of both that include actions for continues training.

The second plan is the Municipal Plan of Edu-cation of Maceió - MPE (2010-2020): It is organized into five chapters:

1) Basic tages of education;
2) Methods of Teaching;
3) Training and exploitation of workers in education: refers to exactly the issues related to continuous training of teachers;
4) Financing and management,
5) Monitoring and evaluation.

All chapters are organized into (a) Diagnoses; (b) (c) guidelines and goals.

With the MPE document which exists since 2010 seek to achieve results from the guidelines, goals and objectives that results in the search for improvements to the educational sector in Maceió.

It was possible to verify that the goal of number 22 aims to contribute to the continuous training of teachers of basic education in the form of specialization courses attending, semi-attending and non attending. In addition to deploying policies of recovery and viability of continuous training, recognizing the school as a locus of development and learning.

3.3 The Geosciences as proposed in the continuous training of teachers

According to Compiani (2005) the geology has importance among the other sciences in the process of training of students of basic education, because it enables a holistic and a critical knowledge about the natural and historical reality in which society organizes itself.

Piranha & Carneiro (2009) believe that the geological knowledge contribute to changes of thoughts and attitudes of students, in the face of the teaching-learning process, and that the geological knowledge covered during the training of students, to contribute to the integral formation of the same as a citizen.

According to Carneiro, Toledo & Almeida (2004, p. 559) "the knowledge of Geology provides minimum understanding of the functioning of the planet and lays the foundations for the effective exercise of citizenship". Thus, forming ordinary people more aware of their rights and responsabilities.

Thus, at the same time that the Geology contributes to the human being to take ownership of natural resources of planet Earth, also contributes to the discussions about values (ideological, moral, ethical, cultural, etc.), as it is addressed in the work of Compiani (2005).

It should be noted that the Geology highlighted by the authors is not limited to the concepts and historical aspects and physical nature. Shows a Geology human, at the same time it also informs form in its fullness, the student in the process of teaching and learning.

Therefore, consider the teacher as a professional involved in the formation of students is to believe that the same has overall responsibility for articulating the content with the historical reality of educating, and make the plan of contextualized education, allowing the student to analyze and transform the reality.

Finally, the role of the teacher in the teaching-learning process of the student is essential in seeking to provide an education based on knowledge geoscientific, with simple language, accurate and accessible.

3.4. The Geosciences Programs developed in a proposal for Continuous Training for teachers from public schools in Brazil

We identified the existence of programs that seek to highlight the geological science in basic education in Brazil, from the continuous training of the teacher.

The first project developed in Brazil had as its title: Geosciences and the continuous training of teachers in Basic Education, and was developed by Compiani et al. (2002) in 1997 in conjunction with other teachers from Department of Geosciences Applied to Education of the Institute of Geosciences (UNICAMP)

Participated in this project from 1997 until 2000 Thirty-six schools of Campinas and fifty and five teachers from different areas of training (Science, Geography, History, English and Mathematics).

The second project was centered on the teacher training in exercise in public education, prioritizing the activity by the teacher in the classroom involving the continued education. The title "*Geology General for Basic Education and rocks and minerals for Basic Education*" developed by the Department of Geology (IGEO) of the Federal Rio de Janeiro University of responsibility by Almeida, Araujo &-Mello (2015).

In this article the proposals developed in the years 2010 and 2011 were offered in the form of training course aimed at teachers of public schools in Rio de Janeiro.

The objectives were the issues related to lack of didactic resources for work subject of Geosciences, specifically the contents of Geology and arouse interest of professionals involved seeking to contribute to the spread of themes and practices related to geology can be worked in primary and secondary education.

The third project has been in development since 2003, involving teachers in the areas of Education, education and history of Geosciences, teaching of geography and the teaching of the Sciences of the Unicamp, and professionals in the areas of teaching of Biology, Physics, Geography, Mathematics and Chemistry of a school of the state network, located in a city in the interior of São Paulo. The project has as title: Earth System Science and Teacher Training.

It is a collaborative project, which aims at the professional development of teachers, through reflective cycles in a proposal for innovation curricular. Each teacher involved in the group of research tends to from their knowledge and contribute to the resolution of the problem together

In the area of research for this article was found to lack of jobs for the continuous training of teachers supported in geological knowledge, but we found the existence of a project that had as its title: Pedagogical Workshop: a methodological proposal for the continuous training of teachers of geography, developed by Silva (2016) in the city of São Sebastião, located in Agreste region of Alagoas.

As the work of Silva (2016) sought to propose in the pedagogical workshops, used the geological content, practical activities viable to be reapplied in the classroom by professor of geography, contributing significantly in the process of teacher education, as soon as well, in the construction of knowledge of the student.

In addition, we found that education plans developed at state and municipal level, which are in force in the public school of Maceió, seek to accomplish what is established in the Law No. 13.005/2014 the NEP, articulating actions that benefit the quality of teaching at the initial and continuous training of teachers.

In relation to the programs of continuous training developed from the Geosciences/Geology, we observed that has not occurred simultaneously and organic in Brazilian territory. Despite the three works found in the southeastern region and one in the Northeast region, specifically in one of the municipalities of Alagoas. These are levels of ranges and differentiates it from, generating an inequality of opportunity and spread of knowledge.

Although the contributions that the geological science has to offer in the formation of the human being as a citizen, the bibliographical research, there is a gap in the Geosciences/Geology in continued training faculty, in relation to the professionals in the public schools.

Noting the lack of jobs directed the formation of the teacher in office in the capital of Alagoas, we applied a questionnaire, seeking to observe how the debate about the continuous education is reflected in the reality of these professionals significantly and authority.

3.5 Data about teachers of Science and Geography in office in the municipal teaching network of Maceió-AL

In Fig.1 we can observe the interest in whether the teachers in activity in the 6th grade classes have some kind of post-graduation. It was found that only 17% of teachers have no course of post graduate (stricto or lato sensu), a relatively low number compared to approximately 83% of professionals holds some kind of continuous training.

In this case, the majority of the professionals involved in the research have interest in maintaining their permanent formation.

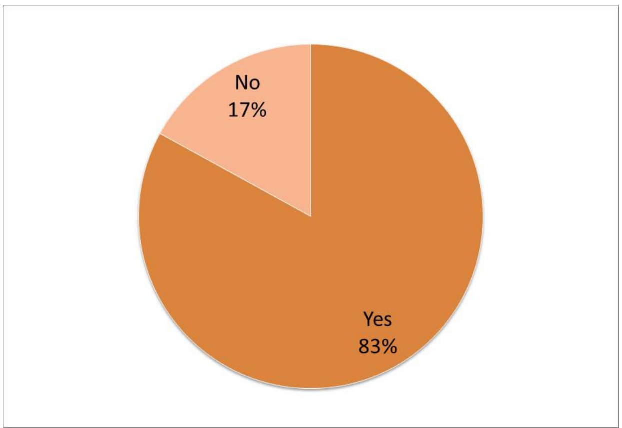

Figure 1. Have you postgraduate course?

In Fig.2 the teachers who answered the first question has postgraduate, informed the levels. We observed that most features of specialization (lato sensu) and the other masters (stricto sensu), while the same 17% from the previous question, reaffirmed does not possess any graduate course.

Considers that the choice by the specialization course may be related with the flexibility of time, the duration and the amount of investment.

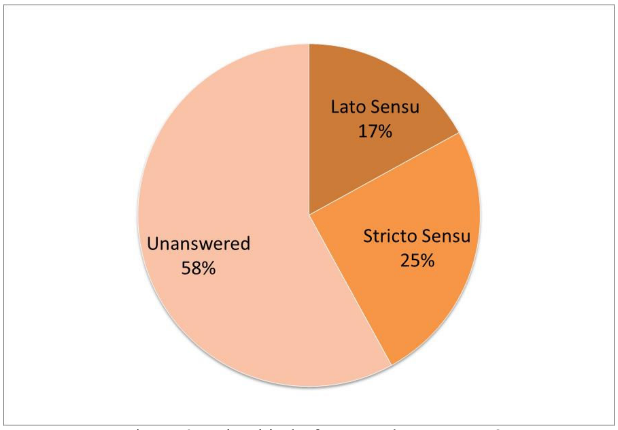

Figure 2. What kind of postgraduate course?

After checking the level of training of teachers, we seek to see if you really for the teacher in the classroom there are important in maintaining a continous training and as we observed in the graph of Fig.3 Approximately 92% said they would be necessary to continuous training.

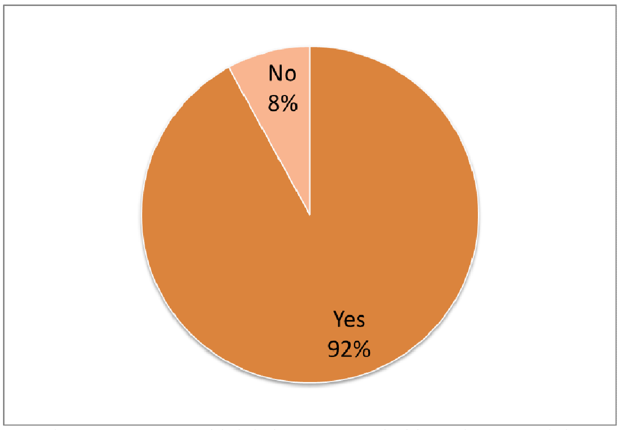

Figure 3. Dou you think is important to hold continuous training?

In the graph of Fig.4 we found that 7% of teachers have participated workshop about the Geosciences/Geology.

However, approximately 83% stated that until now have not participated in any activity linked to the theme. Thus, there are a significant number who possessed no contact with the subject generating a concern about the importance of knowledge for the development of each student.

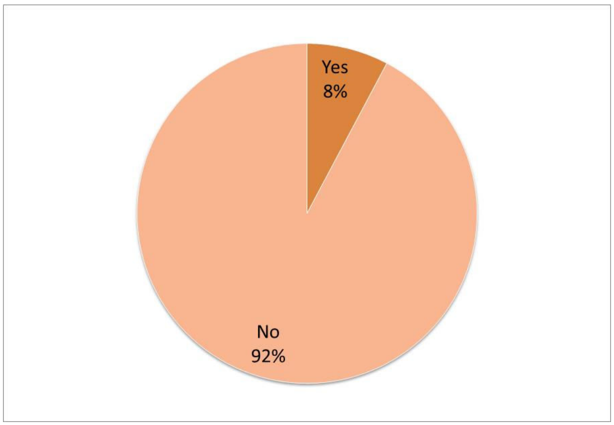

Figure 4. Have you ever participated workshop about the Geosciences/Geology?

Finally, the Fig 5 shows how many of those involved in research have interest in attending a course in Geosciences/Geology. We found that about 75% of the members of the research would like to participate in a proposal on Geosciences/Geology, aiming to learn and improve themselves in their respective areas.

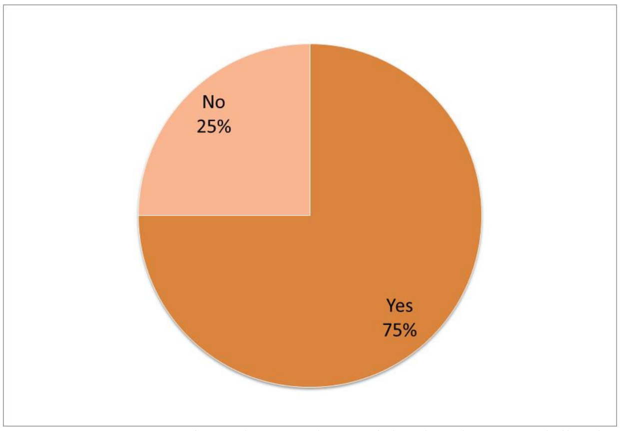

Figure 5. Do you have interest in participating in a specialization course about Geosciences/Geology for basic education?

With the data obtained through the responses of teachers, we see that there is an interest of the majority of teachers in maintaining a continous training, seeking to enhance their knowledge and recognizing the need to be active in their own process of formation.

We also note that the knowledge of Geosciences/Geology do not form part of the continuing education of teachers, generating a concern, since the contents that come with these sciences are part of the curriculum of the 6th grade.

The data corroborate Piranha & Carneiro (2009) when they claim that the absence of geological knowledge in the formation of a society contributes to the generation of serious problems related to the way of the individual thinking, questioning, give their opinion and decide on issues involving its own development in society.

4 Conclusion

The research showed the importance and necessity of continous training of teachers in basic education and confirm the existence of legal devices such as the NEP (Law No. 13.005 of June 2014) which aims to ensure the recovery and quality of permanent formation of the teacher.

In relation to the proposals of continous training for teachers based on knowledge of the Geosciences/Geology, verified that, in spite of various efforts by parties of professionals who recognize such knowledge are essential in the process of formation of the teacher and the student.

It is necessary to develop strategies that seek to disseminate in an organic manner the concepts and aspects of geological science, especially in the area of study. A viable strategy is to continue seeking the teacher as agent who contribute to the development and expansive of knowledge, and in the process of teaching and learning of students.

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THE INTERNATIONAL VERSION OF THE FREE-TO DOWNLOAD GEOSCIENCE TEXTBOOK FOR 16 YEAR OLDS: NOW REGIONAL VERSIONS?

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Abstract— The development of an international geoscience textbook for 16-year olds was proposed, following the development and publication of the IGEO International Geoscience Education Syllabus. The proposal for a textbook to address the syllabus, was taken forward at a workshop in 2016. Following the development and approval of a project brief after this workshop, writing began in earnest. The first draft was completed and then circulated to geoscience and geoscience experts for comment and amendment. A modified version was developed in the light of these comments and sent to a proof-reader for final comment. Meanwhile the diagrams are currently (February 2018) being drawn and professionally redrawn. The 70,000-word, 55-diagram, 500-photograph textbook is on track for free-to-download online publication in June 2018. Following publication, a companion volume will be developed containing hands-on and minds-on teaching ideas and questions to test understanding and geoscience thinking skills. At that stage, colleagues around the world will be encouraged to use this ‘international version’ to prepare a version for their own region, by replacing the photos with photos from their own region, adding regional ‘interest boxes’ and translating the book into their own language, where applicable. These versions will then also be made available for free download. In this way, new geoscience textbooks will be developed for regions, teachers and pupils that have never had such a textbook, and textbook-writers across the world will have an authoritative version to use in their own writing.

Keywords— Geoscience textbook, 16-year olds, international version, regional versions, international syllabus.

Thematic line— Teaching of Geosciences and Natural Sciences for School-Level Education and Teacher Training.

1 Introduction

The International Geoscience Education Organisation (IGEO) considered in 2012 that a helpful way to support the school-level teaching of geoscience globally, would be to publish an international syllabus of the geoscience that should be taught to all students by the age of 16.

1.1 The initial development of the International Geoscience Education Syllabus

The syllabus was developed by reviewing all the national syllabuses containing geoscience that could be accessed at the time (from Australia, England, Japan, New Zealand, Norway, Portugal, Scotland, South Africa, and the United States) and then basing the new syllabus on this content. The syllabus was developed on these principles:

- based on existing curricula around the world since a syllabus using existing curricula would be most likely to be globally accepted;
- with a clearly apparent structure, even though such structure is not readily apparent in many existing curricula;
- concisely presented on just one page, since a concise syllabus is more likely to be acceptable to non-Earth science educators and teachers; more detail to be provided through exemplification on the following pages to indicate the extent of coverage, although it was anticipated that detail would vary from country to country
- should not aim to indicate progression.

In addition to these principles, the syllabus used as its basic structure an Earth systems approach, using the following chapter headings:

- Earth as a changing system
- Earth is a system within the solar system, within the universe
- Earth is a system which has changed over time
- Earth’s system comprises interacting spheres – geosphere, hydrosphere, atmosphere and biosphere
- Earth’s system produces resources
- Human/Earth system interactions
- Earth’s system is explored through fieldwork and practical work

The syllabus was developed by Chris King, with key contributions by Ian Clark – Australia, Rosely Imbernon – Brazil, Luis Marques – Portugal, Ian McKay – South Africa, Bronte Nichols – Australia, Glenn Vallender – New Zealand, Clara Vasconcelos – Portugal, Ashvin Wickramasooriya – Sri Lanka, Michael Wysession – United States of America.

The syllabus was presented at the international conference of the IGEO, GeoSciEd VIII, in Hyderabad, India in 2014 and was subsequently published on the IGEO website at:

http://www.igeoscied.org/?page_id=269

During discussions in India following the presentation of the syllabus, Gillian Drennen suggested that the IGEO should follow up the development of the syllabus by publishing a textbook to support the syllabus. Further discussion proposed that a workshop should be convened at the International Geological Congress due to be held in South Africa in 2016, to take the textbook idea forward.

2 The IGEO international geoscience textbook workshop, Cape Town, 2016

The workshop ran as part of the International Geological Congress in August 2016, was well attended and provoked positive and supportive discussion. The brief prepared following the workshop and further electronic discussion and subsequently approved by IGEO Council was as follows:

Brief for International Geoscience Education Textbook to be devised by the International Geoscience Education Organisation (IGEO)

A geoscience textbook should be devised to provide a scientifically accurate and accessible resource to reach as wide an audience as possible. The textbook should be made available in a range of different versions (prepared as below) and be published online and made widely available through the IGEO website and other linked websites.

A first version should be written in English, using photographs drawn from across the globe and examples of interesting geoscience phenomena (presented in separate boxes) – this will be the 'international version'. This version should be taken by colleagues around the world and 'regionalised' by adding photographs and examples from their own region. It should also be translated into different languages. In this way, versions appropriate for different countries, regions, states and even cities will be developed.

The textbook:

- Should cover the IGEO International syllabus, which addresses what a student should know by the age of 16
- So, it will be aimed at an able 16-year-old student
- However, it is regarded as a textbook and reference book aimed primarily at teachers
- Practical activities and extension questions relating to the text will be published in a companion volume, which can readily be updated
- The text will be written using language as accessible and jargon-free as possible
- Advice will be taken on making the ebook format as attractive and engaging as possible, including appropriate font, layout, diagrams, etc. – which will also allow ready translation
- A glossary of important terms will be incorporated
- The text will be checked by experts
- The photographs used should be copyright-free, fully acknowledged, cropped and sharpened to show the geological features most clearly, and should preferably have a scale, locality and geological age information
- 'Regionalisers' and translators will be free to change, add to or delete text in any way – subject to checking by regional experts.

It was further agreed that:

- Chris King would write the first version of the text
- Tanja Reinhardt would redraw the diagrams
- Several colleagues, both at the Congress in South Africa and beyond, offered help to 'regionalise' and translate the textbook
- Many other colleagues asked to be kept informed of progress

It was further agreed that the textbook should be prepared largely by voluntary effort, to encourage others to contribute to regional versions of the textbook on a voluntary basis, once the 'international version' had been published.

3 Development of the textbook

Over the following eighteen months, a first draft of the textbook has been written. The contents are as follows:

Contents

4.1.1.7. Soil
4.1.2. Earth processes and preserved characteristics
4.1.2.1. Surface processes
4.1.2.2. Sedimentary processes
4.1.2.3. Igneous processes
4.1.2.4. Metamorphic processes
4.1.2.5. Deformation processes
4.1.3. Structure of the Earth and evidence
4.1.3.1. Evidence
4.1.3.2. Crust
4.1.3.3. Mantle
4.1.3.4. Core
4.1.3.5. Lithosphere
4.1.4. Plate tectonics and evidence
4.1.4.1. Unifying theory
4.1.4.2. Plate construction and subduction
4.1.4.3. Characteristics of plate margins
4.1.4.4. Mechanism and rates of movement
4.1.4.5. Evidence

4.2 Hydrosphere
4.2.1. Continental water
4.2.2.1. Continental water sources
4.2.1.2. Water supplies
4.2.1.3. Water contamination
4.2.2. Oceanic water
4.2.2.1. Water composition
4.2.2.2. Tides
4.2.2.3. Waves
4.2.2.4. Large-scale circulations of fluids on Earth

4.3. Atmosphere
4.3.1. Atmospheric composition
4.3.2. Atmospheric flow
4.3.3. Atmospheric change

4.4. Biosphere
4.4.1. Evolution
4.4.2. Impact on other systems

5. Earth's system produces resources
5.1. Raw materials and fossil fuels
5.1.1. Bulk raw materials for construction
5.1.2. Bulk raw materials for industry
5.1.3. Metal ores
5.1.4 Industrial minerals
5.1.5. Fossil fuels
5.1.5.1. Peat and coal
5.1.5.2. Oil and natural gas
5.1.6. Prospecting
5.1.7. Environmental protection and remediation

5.2. Power supplies
5.2.1. Energy from fossil fuels
5.2.2. Renewable energy

6. Human/earth system interactions
6.1. Natural hazards
6.1.1. Eruption
6.1.2. Earthquake
6.1.3. Tsunami
6.1.4. Landslide

6.2. Environmental issues
6.2.1. Erosion
6.2.2. Drainage-changes
6.2.3. Waste disposal
6.2.4. Pollution
6.2.5. Mining/quarrying
6.2.6. Burning fossil fuels and the greenhouse effect

6.3. Impact on human history
6.3.1. Resource wars
6.3.2. Migration due to climate change

7. Earth's system is explored through fieldwork and practical work
7.1. Observation, measurement and recording
7.2. Synthesis of observations
7.3. Investigation and hypothesis-testing

Glossary

The first draft was circulated to nine geoscience and geoscience educational experts for comment, and their amendments were gratefully received and mostly implemented.

At the time of writing (February 2018):

- the text of the corrected draft is being proof-read and corrected;
- the diagrams are being drawn;
- once prepared, the diagrams are being re-drawn professionally by Tanja Reinhardt;
- the geoscience communicator Iain Stewart has agreed to write a preface;
- formal endorsement/ approval of or support for, the textbook is being sought from the IGEO, the International Union of Geological Sciences (IUGS) and the European Geosciences Union (EGU);
- the textbook is on track for online publication by June 2018.

The draft has the following approximate 'vital statistics:

- 230 A4 pages;
- 70,000 words;
- 55 diagrams;
- 500 photographs;
- 62 'interest boxes' of interesting information, going beyond the syllabus;
- a glossary of 160 terms.

4 A flavour of the text

The textbook has the following introductory chapter, designed to ease readers into the textbook and to encourage them to read on.

4.1 Why explore geoscience?

Geoscience is the scientific study of our whole planet. Nowadays, it is even more than that because it includes planetary geology too. It involves the many elements of geology, such as geochemistry, geophysics, palaeontology, hydrogeology and engineering geology, but is wider, because it also includes meteorology, oceanography, environmental science, soil science and study of the solar system. Geoscience uses evidence from the planet's past and present to predict the future, but also uses evidence from the present to 'predict' what happened in the past. It focuses elements of biology, chemistry, physics, Maths, geography and engineering into a study of the Earth and the planets.

One of the joys of studying geoscience is that everyone can do it. When children pick up interesting pebbles on a beach and begin to think why they are interesting, they are starting to ask the questions that geoscientists ask. When they collect several interesting pebbles, or different colours of sand, or different fossils, they are beginning to sort things out, or to classify Earth materials, as geoscientists do. When they ask why the sand forms interesting shapes, they are beginning to investigate Earth processes, just like geoscientists.

If you want to study geoscience further, you might be able to do this at school or college or by taking a university degree. Many people study geology just because they enjoy asking and answering questions about how the Earth works or because they enjoy collecting interesting things. But others become professional geologists, spending their whole lives asking and answering geoscience questions. They investigate the Earth, from the tropics to the poles, from the highest mountains to the deepest seas or by searching for new Earth resources, better ways of disposing of waste or the best places to build new buildings safely.

This is what this book is about. It begins by looking at the whole Earth system, the Earth within the solar system and how all this has changed over time. It brings together studies of the Earth's geosphere, hydrosphere, atmosphere and biosphere and looks at where the resources and power supplies we need are found. It focuses on Earth hazards and environmental issues and how these change human history, and it looks at what geoscientists do and how.

So, if all this interests you, read on – you will already be starting to think like a geoscientist.

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- Sand shapes – published by vastateparksstaff under the Creative Commons Attribution 2.0 Generic license.]

5 The next steps

When the diagrams have been completed, incorporated, and checked and the 'international version has been published as a pdf document ready for online download, work will begin on the companion volume. This will be keyed into the chapter headings, suggesting 'hands-on' and 'minds-on' teaching ideas and strategies (for example, the activities at www.earthlearningidea.com), with questions for students to consolidate and extend their understanding. This companion volume has deliberately been developed separately, so that the text of the textbook is not broken up by the materials in the companion volume, and the companion can readily be updated without disturbing the pagination or the formatting of the textbook. This will allow new teaching ideas and questioning to be easily added at any stage. The companion volume can also readily be linked to the translations of the textbook that are developed.

Figure 1. Interesting pebbles and sand shapes

Then those colleagues who have shown interest in using the 'international version' as a means of developing a geoscience textbook for their own country, language, state, city or region, will be encouraged to do so. They will be asked to replace the photos with local ones and replace or add to the 'interest boxes' with local examples, and also to translate the text into their own language, if necessary. In this way they will be able to develop a geoscience textbook for regions that may never previously have had such a textbook. Meanwhile textbook-writers across the world will have an authoritative source to refer to when developing their own textbooks and teaching materials.

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THE 'MY EARTH SCIENCE EDUCATOR STORY' INITIATIVE

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Abstract — Many Earth science educators are doing excellent and sometimes truly amazing jobs across the world, but not only is this not generally known, but eventually all this good work, wisdom and enthusiasm will be lost, if we can't find a way of passing these on to the next generation. The 'My Earth science educator story' project has been instigated to encourage experienced Earth science educators to write up their stories specifically to inform and inspire the next generation. In this context, anybody who feels that they have contributed something to Earth science education is regarded as an 'Earth science educator'. The stories are published at intervals on the International Geoscience Education Organisation (IGEO) website, and have built up over time into a compendium of wisdom, advice and experience providing fascinating insights into our world of Earth science education. The sixty seven educators who have contributed stories so far are two thirds male, one third female and have a mean age of 57 years. They have a wide range of backgrounds, with some people having several roles. They included 47% school teachers, 64% lecturers, 36% educational researchers, 27% professional geologists, 23% writers and 26% public communicators. 35% of the contributors had spearheaded one of more specific geoscience educational innovations across the world. The main stimulus to become a geoscientist was reported through the stories as a school teacher for 23% of the contributors, a lecturer by 38%, a family member by 18%, the surroundings they grew up in by 27% and fieldwork by 18%. Nearly half the contributors (44%) commented on the importance of a national or international organisation (such as AEPECT in Spain, ESTA in the UK, IGEO or IUGS-COGE) in supporting their endeavours.

Keywords— Earth Science, educator, teacher, lecturer, researcher, communicator, story.

Thematic line— Teaching of Geosciences and Natural Sciences for School-Level Education and Teacher Training.

1 The initiative

Many Earth science educators are doing excellent and sometimes truly amazing work across the world, but not only is this not generally known, but eventually all this endeavour, wisdom and enthusiasm will be lost, if we can't find a way of passing their experience on to the next generation.

The 'My Earth science educator story' project was instigated to encourage experienced Earth science educators to write up their stories specifically to inform and inspire the next generation. It was launched in 2016 by the International Geoscience Education Organisation (IGEO) and the IUGS Commission on Geoscience Education (IUGS-COGE). Each story is less than 1000 words in length, with two to six photographs; anyone who feels that they have contributed something to Earth science education is regarded as an 'Earth science educator'.

The stories are published at intervals on the International Geoscience Education Organisation (IGEO) website (IGEO website). Sixty seven stories have been published so far from 24 countries: Argentina, Australia, Bangladesh, Brazil, Canada, Egypt, Germany, Hungary, Ireland, Iran, India, Italy, Japan, Namibia, New Zealand, Norway, Portugal, South Korea, Spain, Sri Lanka, Switzerland, Taiwan, the UK and the USA.

The contributors are two thirds male, one third female and have a mean age of 57 years. They have a wide range of backgrounds, with some people having several roles. They included 47% school teachers, 64% lecturers, 36% educational researchers, 27% professional geologists, 23% writers and 26% public communicators. 35% of the contributors had spearheaded one of more specific geoscience educational innovations across the world.

The main stimulus to become a geoscientist was reported through the stories as a school teacher for 23% of the contributors, a lecturer by 38%, a family member by 18%, the surroundings they grew up in by 27% and fieldwork by 18%. Three people (5%) commented that a lecturer had put them off becoming a geoscientist, and one (2%) said the same for a school teacher! Some commented on the influence of textbooks (5%), museums (3%) and movies (3%) on their decision to study geoscience.

Nearly half the contributors (44%) commented on the importance of a national or international organisation (such as AEPECT in Spain, ESTA in the UK, IGEO or IUGS-COGE) in supporting their endeavours.

2 Examples of the stories

It was very difficult to choose the most appropriate examples to illustrate the variety of approaches taken and the variety of life-paths experienced by our story-writers, but hopefully, the following will give a flavour of the very rich reservoir of advice and inspiration provided by the stories.

Each story begins:

My Earth science educator story – *Name*
What I did, why I did it and what happened

The examples continue, as below:

2.1. Rosely A. L. Imbernon

Figure 1. Rosely in a Brazilian Airforce plane taking part in the RONDON Brazilian Army Project, helping to educate university teachers and students in areas of social risk

2.1.1. Without (geo)chemistry the Earth does not react...

The choices I have made throughout my professional life have always focused on trying to understand the dynamics of everything around me, in trying to (re)write a story to explain what I saw, felt and lived.

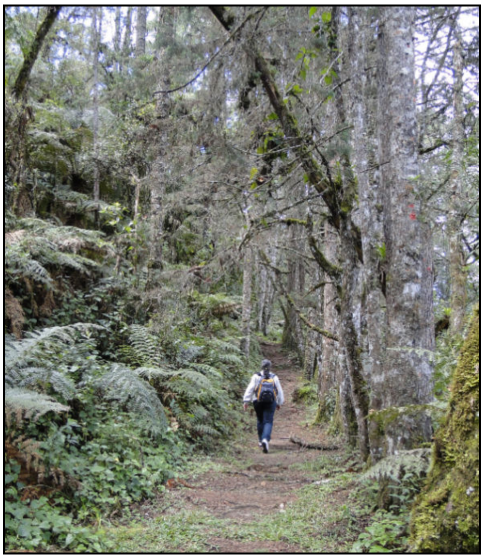

Figure 2. Campos do Jordão State Parks, São Paulo state, Brazil, Atlantic Forest, Serra da Mantiqueira, At 1600m (Chris Bourotte)

I studied Chemical Engineering to become the engineer 'son' my father always dreamed of. But, after his death in August 1983, when I was in the second to last year of my course, I decided to change my life. I left a job in an industrial research laboratory, concluded the engineering course, and joined the geology course in the University of São Paulo. To abandon a career in chemical engineering, with all the research that I had carried out in the industry, and to begin a new undergraduate degree, was an easy decision for me, but a difficult one for my family.

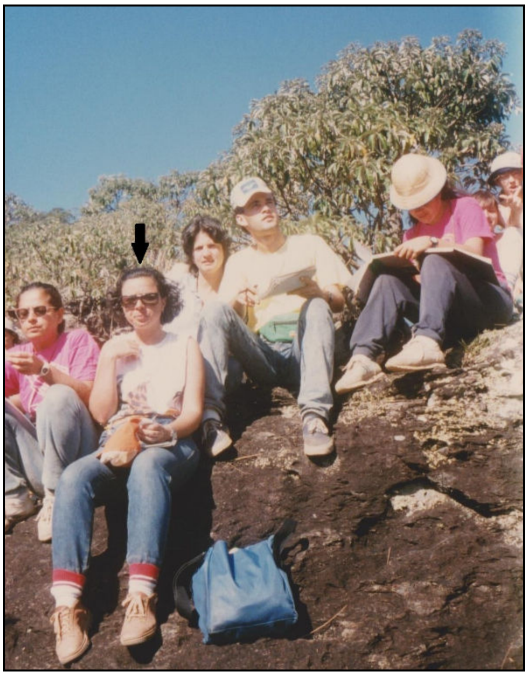

Figure 3. My first field trip with my study group during my geology graduation course, in the Carrancas region, Minas Gerais, Brazil, south of the São Francisco Craton. (Rosely Imbernon)

After three years of undergraduate studies in Geology, my master and doctoral researches culminated in the coming together of Chemistry and Geology: through the study of geochemical weathering processes in a tropical country.

The carbonatite rocks of Catalan, Goiás (Brazil), rich in rare earth elements (REEs); the ultramafic rocks of Fortaleza de Minas, Minas Gerais, mineralized in elements of the platinum group (EPG?); and the volcanic-sedimentary sequence of Canoas, State of Parana, mineralized in zinc, lead and silver, led me to a universe in which the chemical elements danced between weathering solutions and the neogenesis of secondary mineral phases.

The zinc from sphalerite broke free and was imprisoned again during the chloritization of phlogopite; lead from galena, released during weathering, found a flexible trap in jarosite formed from iron released by pyrite, and sulfate, formed by the oxidation of primary sulphides.

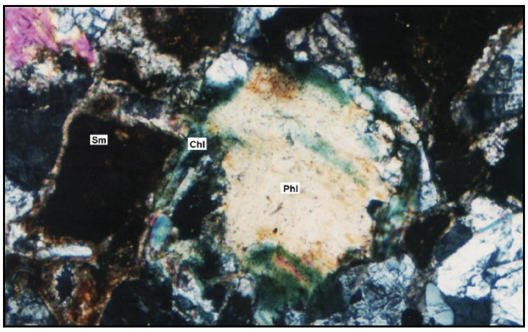

Figure 4. Phogopite choritization, with Zn incorporated, in the ore mineral from Canoas 1 mine, Adrianópolis, Paraná State, Brazil. (Rosely Imbernon)

This dance was part of my commentary, both in the field and in the laboratory, and made me happy to see that in the Earth nothing is created, nothing is lost, but everything transforms...

2.1.2. The path of education ...

The option of teaching in high school arose from the need to work for my living during my postgraduate geochemistry period. What should have been a temporary job became a passion that lasted more than ten years, and enabled me to develop research in education, in parallel with my doctorate.

From that moment on, my scientific life has taken two routes: one focused on studying the behavior of heavy metals in the environment; and another on the methodology for teaching geoscience in the public school primary education system of Sao Paulo.

Over this time, I have been able to move between the two, at times focusing solely on geochemistry, at other times, only on education. However, in environmental education I've found a confluence through which I have been able to establish a single path for my research.

Be it in the classroom or on the field classes with my students or during teacher training, I have investigated ways to teach the Earth science content from an environmental education perspective.

Thus, I've found in the epistemological and methodological challenges of environmental education, my research field of education in Earth sciences.

Figure 5. Soil classes with indigenous students from Amazonian Forest, Acre, Brazil (Rosely Imbernon)

Figure 6. Indigenous school, in the protected indigenous lands of the Puyanawa people, Amazonian Forest, Acre, Brazil

Rosely Imbernon, São Paulo, Brazil,
April 2016, imbernon@usp.br

2.2. Betty Trummel

Figure 7. At the edge of the Barne Glacier in November, 2006, during the ANDRILL Project

2.2.1. Becoming a teacher…first choice; science educator…not so much

I always wanted to be a teacher, but my early days as a student and training to be an educator did not fill me with a love of science. Any science training I had was basic and rather uninspiring. Despite this, I entered the teaching profession in 1978…with a huge amount of enthusiasm.

A shift to focus on science in my elementary classroom began three years into my career, when I attended a weeklong, summer environmental conference. I met other educators who led field trips teaching about wildlife, plants, geology, and other aspects of the environment. I thought back to my life growing up on a small farm, and how I spent the vast majority of my time outdoors. I was hooked on science! Most critical, I found the camaraderie of educators and friends with similar science interests. That became a catalyst in both my professional and personal life.

2.2.2. Fast-forward about 12 years

While continuing to teach elementary school, I worked for several weeks each summer at the very conference that had inspired me. Making personal connections was a highlight and provided me with a form of professional development and mentorship. I looked outside the box, and outside my school district to enhance my science education skills. Science simply wasn't viewed as an important subject area for professional development, but I was hungry to learn more and to implement new projects to incorporate science into my classroom and expose children to hands-on, experiential learning.

I found I had the ability to expose students to careers related to science and change their perception of what a scientist actually does. Possible science careers opened up before our eyes!

Meanwhile, I earned a Master's Degree in Science/Outdoor Education in 1991. And, the stage was set for an exciting new chapter in my life when I was awarded the *Presidential Award for Excellence in Elementary Science Teaching* in 1996.

2.2.3.The beginning of the "Antarctic era" in my teaching…a true earth science teacher was born!

While attending the Presidential Science Award ceremony, a representative from the National Science Foundation (NSF) in the USA told me about a unique teaching opportunity. I applied and was chosen for the Teachers Experiencing Antarctica and the Arctic (TEA) program. Soon I was headed to McMurdo Station, Antarctica to work alongside geologists drilling into the sea floor to retrieve sediment cores: the Cape Roberts Project. It took my science learning and enthusiasm to a whole new level…working as part of an earth science team, following real-life scientific research in action and sharing it with a broader educational audience through daily journals, emails, and photographs.
TEA was set up to immerse teachers in a research experience as a component of their continuing professional development, and to bring polar research into classrooms in innovative ways. It was an incredibly motivating opportunity for me, and I forever will be grateful to NSF for selecting me for this experience.

The Cape Roberts/TEA experience was key; even more important it fired me up to share the work of scientists with students, teachers, and general public long after the actual time in Antarctica. Presentations, teacher workshops, the National Science Teachers' Association annual conference, and networking with educators around the world were all now part of the fabric of my everyday life and teaching.

Figure 8. Helping out as a core technician in ANDRILL's drill site laboratory, 2006.

2.2.4. Beyond textbook science

In 2005 a new international collaboration of earth scientists planned the ANDRILL (Antarctic Drilling) Project. Following the work of the Cape Roberts Project, ANDRILL's goal was to obtain sediment cores for multidisciplinary study. I applied for a spot to be one of six educators on the education outreach team. This collaboration of scientists and educators was several steps beyond my first geology research experience, mainly due to the fact that this time I was part of a team of educators from four countries. We would all be instrumental in sharing ANDRILL's work and developing curriculum materials. During the three-month ANDRILL project, I was totally immersed in the science. With improved technology, I was able to share our work with an even broader educational audience. This innovative type of program infused learners with excitement.

ANDRILL

I made an important connection with Italian educator Matteo Cattadori. We continue to collaborate on projects, long after the ANDRILL experience. It's inspiring to work with an educator who shares a similar commitment to science. It makes us strive to be better teachers!

Figure 9. At the ANDRILL drill site with Matteo Cattadori (educator) and Tamsin Falconer (drill site logistics), 2006

2.2.5. The Polar community keeps growing…

An ever-expanding community of Polar educators is a direct result of programs like TEA and ANDRILL. This network led me to a third Antarctic experience with a new geoscience project named WISSARD. Similar in scope in terms of education outreach, I spent ten weeks in Antarctica with a team of scientists. WISSARD used a hot water drilling system to penetrate through the Ross Ice Shelf into subglacial Lake Whillans for sampling of water and sediments.

With each project, I've learned more about earth science and how to transfer information to learners of all ages. My students have hosted an annual science event called the "Flexhibit" (flexible exhibit); written by ANDRILL educator, Luann Dahlman. Watching my ten-year old students teach their parents and peers has been a highlight. Knowing that I've encouraged future scientists is rewarding.

My varied experiences have provided a unique window to the world of earth science, and have shaped my teaching and how I've delivered earth science information during presentations around the world. For an elementary teacher to have an Antarctic geoscience opportunity is incredible. Having the privilege to represent three science teams and the NSF on so many levels is monumental. I've touched thousands of lives, and they have touched me as well. What an honor to be an earth science educator!

Figure 10. Presenting to students in 2006, just before leaving for the ANDRILL Project

2.2.6.The next chapter

After thirty-five years, I retired from classroom teaching in June, 2015. The next chapter includes starting my own small business *The Science Roadshow*, which is dedicated to promoting lifelong learning in science and technology. Goals: keep teaching, be part of new projects and adventures, and stay involved in education. I have a responsibility to keep earth science alive in classrooms; to open new doors to learning. And, professional development doesn't stop…it's a lifelong goal.

Visit my blog at: www.scienceroadshow.wordpress.com

2.2.6. Publications

- The Delta Kappa Gamma Bulletin: International Journal for Professional Educators; *"International Partnerships for Professional Development."* Fall 2012

- Illinois Science Teachers Association Journal *Spectrum; April 2009; "International Cooperation and Educational Outreach Efforts During the International Polar Year (IPY)"* with Matteo Cattadori, Trento, Italy.

- *Praxis Geographie;* January 2008; German publication; article and lesson/activity related to the ANDRILL geological drilling science.

- International Earth Sciences Symposium; 2008; *The ANDRILL ARISE Educational Outreach Program: Educators Immersed in Science Research in Antarctica (paper and presentation at the symposium);* with LuAnn Dahlman

- *Betty Trummel, December 2015, aged 59, Crystal Lake, Illinois, USA, thescienceroad-show@gmail.com*

2.3. John Carpenter

In Junior High School, I saw a film about archaeology and something clicked. I could have a career where I could study the earth and be able to work outside. Unfortunately there was no opportunity in either Junior High or High School to study earth science, but I loved chemistry and entered Rice University as a chemistry major. In my second year at Rice University, I took my first geology course and realized that as a geologist or geochemist, I could work outside part of the time and in a laboratory part of the time. In 1958 I married Charlie.

Figure 11. John and Charlie Carpenter, 2008

In Graduate School I focused on geochemical studies for both my masters and PhD studies. Upon completion of my PhD, I took a temporary job and while working there, I was contacted about a teaching position in geology at the University of South Carolina. I took that job but expected to stay at USC for about three years. That was in 1966. I retired from USC in June of 2000.

I enjoyed teaching geology and geochemistry to college students and doing geochemistry research. However, in 1967, South Carolina mandated that earth science was to be taught in the 8th grade. Teachers, however had virtually no subject matter background in that area. Along with a colleague, I received my first grant in teacher education from the National Science Foundation. That program was very successful and we were funded for three additional years. I discovered the joy in working with teachers. Eventually, with the encouragement of my Dean, I dropped my geochemistry research, to work almost exclusively with teachers at all pre-college levels. In 1973, I was granted a sabbatical leave to work with the Earth Science Teacher Preparation Project (ESTPP), in Boulder, Colorado, which was a career-changing event in my life.

When I returned to USC, in the summer of 1973, I began teaching an undergraduate course in Environmental Geology to two cohorts – undergraduate students and pre-college teachers. As a result, I began to realize the severity of the environmental problems affecting the Earth. Because of the ESTPP experience, I completely revised all of my courses. Introductory science courses at USC were typically taught by lecture with some laboratory work and were failing for many reasons. I decided to focus on the environmental earth science course. I restructured my 200+ student course into a 3-hour block, once a week; not just lecturing but also utilizing small-group discussions and service projects and other learning activities. The restructured course was an instant success and I taught several thousand students using this approach until my retirement in 2000.

Figure 12. Undergraduate fieldwork, 1975

With the assistance of several graduate students, I developed and implemented a doctoral program more appropriate for people who wanted to teach geoscience courses at the college level, but not in a research-driven institution like USC. That alternative doctoral program still exists at USC.

With assistance from some faculty and graduate students, we also developed a master's degree program for pre-college science teachers that included more course work in the sciences and less in traditional education courses. This program has been revised but continues to exist. During this time, I decided to change my career from being a science research professor to a science professor engaged in geoscience education research. Surprisingly, my Dean supported this change. He counted all grants received and papers published on par with grants and papers from my geochemical research.

In 1983, I proposed establishing a specific unit within the university designed to develop scientifically literate and compassionate prospective and practicing teachers of science. I approached the same Dean who had previously supported my non-traditional activities with a plan to establish a Center for Science Education, in the College of Science and Mathematics. Once again he agreed with the concept and together we managed to have the Center officially established in late 1983. In January of 1984, I was named Director of the Center, a position I held until 1999. Almost immediately, the Center began to expand and I needed to add some people. Undoubtedly the most important hire was Phil Astwood. Phil had been my student while working on his masters and his doctorate. He left for about ten years to teach at Winthrop University in Rock Hill, SC. In 1986, I asked the Dean to bring Phil aboard full-time. He said yes, Phil said yes and the rest, as they say, is history. There were problems, of course. But for the most part, I had about fifteen golden years as Center Director. During that time we accomplished more than any of us could have imagined. The Center still exists at USC.

Figure 13. With elementary students, 1995

In 1993, I participated in an international Geoscience Education and Training conference in Southampton, England. In 1997, I was a co-convener of the Second International Conference on Geoscience Education, in Hilo, Hawaii. The third geoscience education conference was held in Sydney, Australia in 2000, where the International Geoscience Education Organization came into formal existence and where I was presented an award "for Distinguished Contributions in Earth Science Education."

In 2000, I retired as a Distinguished Professor Emeritus. For about 10 years thereafter, Charlie and I continued to work as consultants in science and mathematics education. I could not have accomplished any of the above without Charlie.

Figure 14. Retirement with the University of South Carolina, provost, 2000

I also thank the University of South Carolina and especially my past Dean, Dr. Jim Durig, now retired. I don't think many institutions whose goals were and are still to be considered a major research institution, would have given me the opportunities that USC did. My geology colleagues accepted and rewarded my teacher-education activities. I will never forget and will always cherish the ESTPP work environment I experienced in Boulder. Without the support of several tens of graduate students and faculty from other departments, the Center could not have taken off as it did. Special thanks go to my closest professional colleague Phil Astwood. I have also had the great privilege to work with several hundred colleagues from all over the world. Two, however, have had a great influence on me - Ian Clark and Chris King. The people who have my greatest respect are the pre-college classroom teachers of science, but more importantly of students, with whom I've been privileged to work with.

Figure 15. With middle school teachers, 2000

John Carpenter, aged 77, Irmo, South Carolina, USA, November 2015, jcarpentersc@aol.com

3. Future contributions

The 'My Earth Science Educator Story' stories are building up over time into a compendium of wisdom, advice and experience that provide fascinating insights into the world of Earth science education. So, please contribute your own story, and don't be shy. Many people have initially been reticent to write their own stories, but when they realised that this was for the good of future generations, they persevered and have told some fascinating tales. Please access: http://www.igeoscied.org/wp-content/uploads/2015/11/guidance.pdf, for guidance on how to write your own story. All submitted stories are published after minor editing.

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The initiative is very grateful to all the following for submitting such wonderful and stimulating stories:
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Mike Passow, USA
Jorge Bonito, Portugal
Betty Trummel, USA
Dirk Felzmann, Germany
Maggie Williams, UK
Sibylle Reinfried, Switzerland
Bill Hoyt, USA
Richard Edmunds, UK
Wilson Teixeira, Brazil
Ben Mapani, Namibia
Kari Beate Remmen, Norway
Ashvin Wickramasooriya, Sri Lanka
Young-Shin Park, Korea
Glenn Vallender, New Zealand
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Rualdo Menegat, Brazil
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Afia Akhtar, Bangladesh
Elizabeth Devon, UK
Steve Anderson, USA
Peter Bitschene, Germany
Amelia Calonge, Spain
José Sellés-Martínez (Pepe), Argentina
Rosely Imbernon, Brazil
Roberto Greco, Brazil/Italy
Godfrey Nowlan, Canada
Federico Pasquarè, Italy
Missy Holzer, USA
Silvia Figueirôa, Brazil
Yoshisuke Kumano, Japan
John Clague, Canada
Chan-Jong Kim, Korea
Rosanne Fortner, USA
Beverly Ross, USA
Paul Ruscher, USA
Volker Kaminske, Germany
Peter Craig, UK
Anish Warrier, India
Kholoud Mohamed Ali, Egypt
Greg McNamara, Australia
Eileen van der Flier-Keller, Canada
Takashi Sawaguchi, Japan
Seungho Maeng, Korea
Nick Eyles, Canada
Michael Streifinger, Germany
Chun-Yen Chang, Taiwan
Gordon Neighbour, UK
Denise Bacci, Brazil
Don Huggan-Has, USA
Pete Suchman, USA
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Eamonn Grennan, Ireland
Glenn Dolphin, Canada
Bahram Nekouie-Sadry, Iran
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THE SHELL IN THE STONE: WHAT CHILDREN SEE AND EXPLAIN

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Abstract— The described research activity aimed to investigate how mental models form and are used on topics of Earth sciences. A particular experiment was carried out in two classes of nursery school on a sample of 40 five-year-old children, as first step in a research that will subsequently involve also students of primary and secondary school. The research question of this first step was: "If the children are placed in front of a rock with fossil shells, found in the mountains, are they able to distinguish the shells (remains of living organisms) from the rock? If so: do they explain their presence in the rock, and how? Subsequently, the children are involved in an educational sequence on the formation of sedimentary rocks. Do the pupils use this experience to explain the presence of shells in the rock?" The children were interviewed one at a time before and after the learning sequence and both times they were asked to do a drawing of the rock in front of them. The results show that not all children have seen fossils in the rock. In the explanations of the children about the way in which the "rock with the shells" was formed, it seems to exist a hierarchy of complexity. It starts from no answers or seemingly meaningless answers to move on to explanations related to an anthropomorphic activity of the shells, up to invoke external causes capable of forming the rock (among the external causes we include human activity). Some children have indicated catastrophic natural events such as earthquakes or floods, which caused the formation of rocks containing shells. Someone has suggested the transport of the sea. Children's thoughts seem to retrace the path made by humanity to explain geological phenomena. The collected data indicate that, even for children of the same age, there are different degrees of complexity in the answers. The analysis of the answers and of the drawings shows that the learning activity influenced the children's thoughts. In this specific case, the disappearance of anthropomorphic ideas and the entry of catastrophic natural events could be evidence of an evolution of children's thinking, abandoning a naive idea to face a more complex thought. Some children seem to have discovered that the Earth and its rocks are not immutable, but they presuppose an internal or superficial movement.

Keywords— Earth Sciences, nursery school, rocks, fossils, children.

Thematic line— Teaching of Geosciences and Natural Sciences for School-Level Education and Teacher Training.

1 Introduction

The Italian curriculum for nursery school (3-5 years old children) states that: "Pupils continuously explore the reality and learn to reflect on their own experiences by describing, representing, reorganizing them through different criteria." (M.I.U.R. 2012, p. 28). This statement is the basis of the present research, which investigates the reactions of 5 years old children when they are put in front of a rock with fossilized shells; namely, if they recognize shells in that unusual occurrence, during their exploration; how they describe the rock and how they represent it with a drawing. We chose a rock with shells because children usually have already met shells in familiar contexts, and their occurrence within a rock may rise curiosity. We guess that, if they recognize shells as objects associated to the sea environment, they possibly could ask themselves why shells occur within a rock collected far from the sea, e.g. in the mountain. Children "have a range of knowledge schemes that are drawn on to interpret the phenomena they encounter in their daily lives." (Driver et al. 1994, p.7) and the research aims to explore how children interpret natural unusual things. It is worth noting that the age 3-5 curriculum is based on "fields of experience" and not on disciplines. Therefore, we did not look for precision of descriptions or correctness in explanations; our idea is to record and, if possible, to understand their lines of reasoning about a natural process. Our expectations are not on the children performance but on a possible progression of their thinking. The children explore and describe the rock with the shells before and after a learning sequence about the transformations of rocks from the mountain to the sea, i.e. the first part of the sedimentary cycle. Fossils and the fossilization process are not mentioned in the learning sequence. Collecting the data before and after allows us to investigate if and how that learning sequence influences the children ideas. To know how ideas change after a learning sequence can give some hints on how alternative conceptions or misconceptions about rocks and their processes of formation can arise (King 2008).

2 Theoretical framework

Children's concepts about geologic phenomena arise from their daily experience (Libarkin & Schneps 2012). They build their own idea about the origin of rocks, for example, even if these are the products of processes far from their life. Which can these ideas be? The daily experience of children is connected with the reality but also with the play, the imagination, the fiction (Piaget 1964). We expected that their ideas on rocks may be connected with their concrete experience and also with freaks and fantasies closer to their imaginations, as stated in the essay "The Child's Conception of the World" (Piaget 1926). Fantasies are produced not only by children but also by adults. For example, "freaks and fantasies of an industrious Earth and of a nature that relaxes" (Godard 2017, p.124) were the ideas of some natural historians of '600 that "denied the organic origin of fossils, and attributed them to spontaneous generation in the ground" (Godard 2017, p.124). The scientific thought of the Mankind developed in time. Equally, it would be interesting to observe if also in the Child there is a similar development of the scientific thought.

Children have got representations of natural processes independently from, and often in contradiction with, physical or chemical models (Georgantopoulou et al. 2016); this research focuses in observing the evolution of their thoughts and representations. In fact, "although early childhood children have not yet developed their scientific thinking and understanding they do have initial representations of the concepts and the phenomena of physical world and they are also able to articulate composed reasoning in order to express their ideas about the natural environment." (Georgantopoulou et al. 2016, p.115). The research is based on existing works showing the capability of children to have a progressive reasoning (see Zimmerman 2000).

3 Research question

The purpose of this research is to recognize the first germs of the concept of sedimentary rock in the reasoning of children. This is a first phase of a research aimed at understanding the build-up of the concepts of transformations of the natural environment in time, fossils and sedimentary rock formation in children. Rocks with fossils (Fig. 1), in this case shells, are presented to children and the research interest is to observe their behaviour and to understand their ideas, built on their own experiences and fantasies, about the formation of rocks and the origin of "rocks with shells".

If a child is in front of a rock taken in the mountain with marine fossils, is he/she able to recognize shells as objects commonly found at the sea? If yes: how does the child explain the formation of this rock? Later, it faces a learning sequence about the sedimentary process. Can the learning sequence change his/her idea?

4 Methodological framework

The research involves forty-five-year-old children (19 females and 21 males), enrolled in two nursery schools of Pontedera, a town in the countryside of Tuscany, in Italy. The instruments of the research are the interviews and the drawings of pupils. Teachers carry out the interviews, following a protocol designed by the researchers. The data collection is carried out in two phases: a first interview about the characteristics of the rock (Fig. 1) and a second interview, about the same rock, after a learning sequence about selected sedimentary processes. Thirty-eight children were present at the interview before the learning sequence and thirty-six were present at the interview after the learning sequence.

Before starting interviews, the teacher completed a form to assign to each child a serial number to safeguard the identity of the children during data processing by the researchers. At the beginning of the audio recorded interview, the teacher says the serial number of the child. The interviews are performed in a place isolated from the classroom and not used by other people to not disturb the child. The child can touch, handle, move etc. the rock during the interview. The teacher asks the child to draw the rock at the end of the interview.

The interview begins making comfortable the pupil:

> "Hello, do you see this beautiful rock that my friend found in mountain? He asked me how it is made but I thought to bring it to school to be helped by you. What do you see in this rock got from mountain?".

The protocol highlights that it is important to insist on the words "rock, stone, pebble, etc." to make it clear that it is a natural element not made by men and that it gets from mountain and not from seaside or countryside. If the child says to see shells in the rock, then the teacher asks: "In your opinion, given that the rock comes from mountain, why are shells in this rock, that they live in the sea?". After the answer, the teacher asks the pupil to draw the rock. On the contrary, if the child doesn't say to see shells in the rock, then the teacher asks right away the pupil to draw the rock without further questions. After the learning sequence on the formation of sedimentary rocks (described in the following), the teacher repeat the same questions.

Figure 1. The rock examined by the children

4.1 The learning sequence

Between the two interviews, children are involved in a scientific learning sequence performed both in the Natural History Museum and in their class. The whole learning sequence lasts approximately three months. In the first part, they listen to the story of a character ("Chicco, the sand grain"), a very big piece of rock that departs from the top of the mountain and then arrives in front of the sea as a small grain of sand. During the travel Chicco meets different environments: mountain, glacier, a landslide, stream, river and beach. The character changes, becomes smaller, smoother, more rounded, moving from one environment to the other. During and after the story, the children observe rocks and sand, figuratively go to the beach, see a river and so on. They note that the sand, seen under a lens, resembles a bunch of pebbles, and that the pebbles can be obtained by breaking the bigger rocks. They focus on the similarity of objects that look like very different from each other, and on the transformations from one to the other. In the second part, always following Chicco's story, they are invited to observe the differences among what they call "stones". They realize that there are minerals which are very heavy, transparent, glittering ..., as well as minerals that stick to magnets, minerals that you can use to write on the paper, and so on. This second part is done at the museum, with minerals that children can weight, scratch, draw, "fish" with a magnet etc.

The anthropomorphism makes transformations nearer to children and the animism gives the idea of change and movement in natural processes. If anthropomorphism and animism are well used, they can be used to explain scientific issues (Kallery & Psillos 2004). Teachers use the storytelling as starting point to talk about transformations and changes of environments that occur in time.

4.2 The data elaboration

Later, recordings of pupils' interviews were listened and transcribed. The answer were synthesized and inserted in a form to have an overview and a better summarizing picture of children ideas. The form is divided in three parts: before and after the learning sequence and a comparison part. The first two parts comprehend: types and colors of draws; if children saw shells and tried to explain why they are in a rock coming from mountain. The third part gathers comparisons of draws and answers before and after the learning sequence.

Answers about why a rock with shells was in mountain, were assembled in nine items:

1. the pupil didn't see shells
2. without or no-sense answers
3. action of men
4. previous rock with attached shells
5. anthropomorphism: rocks and shells can move
6. connection of the rock with water
7. transport by sea
8. catastrophic natural events
9. others

Items were counted before and after the learning sequence to see possible differences.

5 Results

The first important datum is that 16% of the children didn't "see" shells in the rock, before the learning sequence. Before the learning sequence, about one third of pupils didn't explain or gave a nonsense answer about the presence of shells in a rock collected in mountain. The percentage reduces to nearly 20% after the learning sequence. Some children invoke a human action on the collocation of shells in rock of mountain. For example ('them' are shells in the sentences): "Because you took them" or "Because someone took this rock" or "Because someone caught and put them in the mountains". The percentage reduced from 18% to 8% with respect to the learning sequence.

Some children thought shells were attached to the rock by an external entity: "Because they are stuck on", "Because this rock was at sea and the shells went on this rock". The percentage increased from 8% to 14% with respect to the learning sequence. Other children explained the shells in a rock coming from mountain in connection to the presence of water: "Because in the mountains there is always a waterfall", "Because it came from the water". A pupil answered "Water .... it floats.... fallen" after the learning sequence, whereas he had given before a nonsense answer. These answers give the idea of a static action of water. Instead, another group of children thought the water like a means of transport of matter (shells, rock or both): "Because the sea went up into the mountain and brought all the shells" or "The waves made the shells go to the mountain", "They came from the ocean". The percentage decreases from 13% to 8%. Some answers are "The stream has transported them from the sea to the mountain" or "Under the water .... they went with the ocean. They jumped and .... They came to the mountain" or more simply "It's a rock of the sea ... waves". Before, the first child answered "The sea has dragged them", the second pupil supposed anthropomorphic shells and the third invoked a human action. An idea of anthropomorphic shells was put forward by two pupils before the learning sequence "Because they swim", "Maybe they didn't find any family". Nobody got idea of anthropomorphic shells after the learning activity. The 36% of children attributed the presence of shells in the rock to natural catastrophic events such as earthquakes or landslides. This idea developed only after the learning sequence. Sentences were such as: "Because an earthquake happens. It made the earth move. The water has gone up until the mountain", "Because the earthquake made them come to the mountain. He broke everything up. The sea has risen", "Because there may be an earthquake, and the water goes up. It gets up and finds the shells over the mountain", "Because the rocks have fallen into the mountain and then a landslide has made the rocks go to sea. And then the shells all stick to the rock. Because ... because there was an earthquake, it made to jump the stone and got to the mountain.", "Because there were earthquakes. The land went up".

The comparison of interviews' answers before and after the learning sequence shows a change of thought for nearly 40% of children, while if you consider their draws then the percentage increases at 76%. The percentage of children influenced by "The story of Chicco" both in answers and in draws is the 39%. Instead, pupils not changing idea after the learning sequence are 33%.

6 Conclusions

The research was carried out with a limited number of pupils, but results can be considered indicative to open the way for new questions about the approach of Earth Sciences in the school and especially in the nursery school.

Not all pupils have noted (or have stated to note) the presence of the shells in the rock. That may suggest that some facts - evident for adults - are not always evident for children. It underlines the possible disagreement between what teachers imagine that pupils see, and what children actually see in didactic contexts. Another hypothesis could be the fact that everyone – both children and adults - seeks and notices what already knows, allowing to give a meaning to an unknown object. Children facing the unexpected can be embarrassed and miss a suitable name for that object and so they do not mention it at all. In both cases, the gap between teaching and learning becomes wider until to get to the misunderstanding. To promote an active discovery environment, teacher has to be aware of what pupil already know about the proposed topic. Initial pre-knowledges, right or wrong, or ignorance of a topic imply distinct approaches for facing it.

As expected, children watch the rock focusing on its surface, as if it was a bidimensional object; they do not image what there is inside (Benciolini et al. 2012). In accordance with it, some children reported that the shells are stuck on the rock.

Obviously, no age 5 pupil is able to give a scientifically correct explanation for the formation of rock and the presence of shells. It is possible to notice however a scale of answers. You start from not answers or non-sense answers, then pupils give answers of magic kind such as anthropomorphic, or invoke the action of man to bring shells in mountain. You get to attempt to explain the formation of rock by motion of sea or by catastrophic natural event such as earthquakes and landslides. The naive thoughts of children seem to emerge when pupils fail to articulate a more complex reasoning.

As a final remark, it seems that children thoughts retrace the path realized by the mankind to explain geological phenomena.

The analysis of answers and drawings together shows that the learning sequence has contributed to the changing of children thoughts. In this specific case, the disappearance of animistic ideas and the entrance of catastrophic natural events could represent the evidence of an evolution of the children mindset. They left a naive idea to face with a more complex thinking. Some children seem to have discovered that the Earth is not at rest, casting a glance at the dynamics of geological processes.

Acknowledgements

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THE TEACHING OF GEOSCIENCES IN A FREE UNIVERSITY PREPARATION COURSE

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Abstract— In Brazil the Exame Nacional do Ensino Médio (ENEM) is the most common way to sign up in a free public university. The ENEM consists in a 180-question-exam that covers the entire high school knowledge acquired by the student. As the country faces problems with its low quality public education, the college entrance exam is especially difficult for those who studied in public high schools, who are mostly teenagers from poor families. Considering this situation, some students of the Federal University of Ouro Preto created a free college preparatory course in which the aim is to prepare the low-income youth of Ouro Preto to the ENEM. At this course, geology students teach geography and geology and the teachers link what they have learned at the university graduation course with the ENEM content. The classes are composed of thirty students at maximum, this way, personal attention can be given to any student who has trouble with the subject that is being taught. The lectures are dynamic, using instruments like geological scale models and maps, so that students remain interested in the class from the beginning to the end. Also, the course focus on solving exercises from previous ENEM's so that students can familiarize with the exam. The teachers are also constantly evaluated by the students, in this way, they get to know what they need to correct in order for to be a better teacher. The students of the preparatory course gave a very positive feedback about the lectures and some of them got good grades in ENEM and will start to go to university in 2018.

Keywords— University, teaching, geosciences

Thematic line— Education, Teaching of Geosciences and Teacher Training.

1 Introduction

In Brazil the *Exame Nacional do Ensino Médio* (ENEM) is the most common way to sign up in a free public university, also, the exam is necessary if one wants to apply to a funding program or to a full scholarship in a private university.

The ENEM is a 180-question-exam that covers the entire content of high school. Additionally, one who is taking ENEM has to write a dissertation on a topic that has been discussed by Brazilian society lately. The exam usually happens on two consecutives Sundays of November, and the students have to answer 90 questions on the first Sunday and 90 questions plus a dissertation on the second Sunday.

As Brazil faces problems with its low quality public education, the college entrance exam is especially difficult for those who studied in public high schools, who are mostly teenagers from poor families.

Although these students had geography lessons in high school, their educational background in geoscience was not good.

Considering this situation, some students of the Federal University of Ouro Preto (UFOP) created in 2017 a free college preparatory course (EducaPET) in which the aim is to prepare the low-income youth of Ouro Preto to the ENEM. At this course, geology students teach geography and geology and the teachers link what they have learned at the university graduation course with the ENEM content.

2 Methodology

The geology/geography classes last 90 minutes and they take place on Tuesday nights, from 20:00 to 22:40 p.m. It is essential that the classes happen at night because many students still have to attend the regular high school lectures during daytime. There are at maximum thirty students in the class, to guarantee that each student will receive personal attention if it is needed. The teachers of geosciences of the free college preparation course are undergraduate students of geological engineering at UFOP, and they are all volunteers. The undergraduates, a group of 12, take turns, and each week one is the teacher (Fig. 1). The topics that are taught in the lectures are related to the high school content, but the teachers also go deep in some subjects, as they have a large knowledge on some of them, based on what they have learned at university. Some of the topics that are taught in EducaPET are Brazilian hydrology, pedology, climatology, geomorphology, cartography, energy resources and Earth dynamics.

EducaPET teachers compensate for the gaps in the basic education of public school students using like audiovisual resources, maps, minerals and geological scale models in the lectures, and as Dale (1969) stated, a dynamic approach of the subjects leads the student to not easily forget what has been taught to him. Also, Apple (2014) writes that when one is teaching geosciences, it is important to link the content of the lecture with the cultural reality of the student. Therefore, EducaPET teachers constantly relate the geology and the ancient mining history of Ouro Preto with discipline. Every two months is an exam simulating the ENEM, so students can test how much they are prepared for the actual exam. Based on the results of this simulated test, teachers can know what the students' biggest problems are with the discipline and discuss them later in class.

Figure 1. The teachers of geosciences and other disciplines of EducaPet

The other subjects of the preparatory course were Portuguese, chemistry, mathematics, English, Spanish, physics and biology, and the teachers were all undergraduate students of courses related do the themes above. By the end of the preparatory course, the students filled out a form evaluating the performance of the teachers and answered questions about their social background.

4 Results

The results of the questionnaires about the performance of the teachers of geoscience and the social background of the students were answered by 26 pupils. Based on the answers given, it is perceivable that EducaPET achieved its goal to support mainly poor teenagers. In figure 2 the graph states the household income of the students, and 64% of their families receive monthly less than R$ 1874,00, which is equivalent to 580 U.S. dollars.

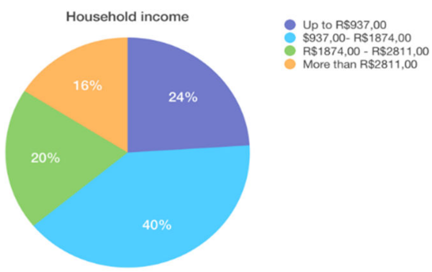

Figure 2. Household income of the students

In the matters of the education quality, only 8% of the students reported that not having a single and fixed teacher was a problem (Fig. 3). Most of them 54% alleged that the rotation of teachers was not a hindrance for their learning.

Finally, students agreed that the methodology used by the teachers was good (Fig. 4), but they also suggested that classes should be more interactive.

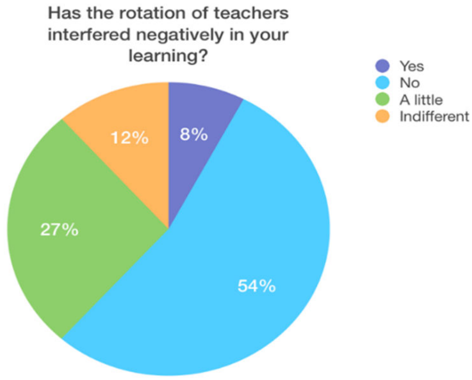

Figure 3. Graph representing the answer to the question “Has the rotation of teachers interfered in your learning?”

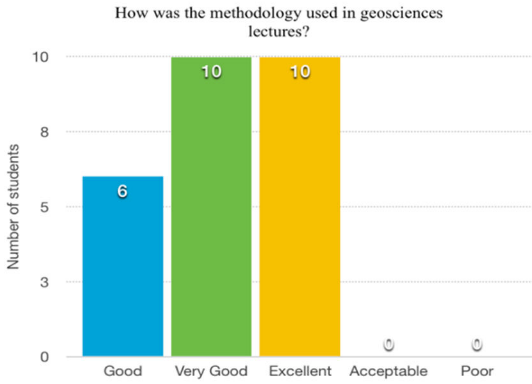

Figure 4. Graph representing the answer to the question “How was the methodology used in geosciences lectures?”

In the last exam simulation, that happened two weeks before ENEM, the students answered correctly 46% of the geoscience questions. However, it is important to remark that some students did not manage to answer the questions on time. Since the average time the student has to spare in each question is only three minutes, some of them, who could not manage time very well, tend to fail at completing the exam. Indeed, in a long and exhausting exam like ENEM, training the rhythm that one answers the questions is important as studying the content of the subjects.

5 Conclusion

EducaPET comes as an alternative for young people who cannot afford a private high school or a paid college preparatory course. Some students that enrolled in the course manage to get a good grade in ENEM and will start college in 2018. Actually, the best grades to get to Chemistry and Production Engineering graduation courses at UFOP were from EducaPET students. This data was obtained by talking to the former students after the exam. Since the project is new, it has many points that needs to be improved, like the methodology and didacticism of the teachers.

Anyway, EducaPET was a very positive initiative, and helped socially vulnerable young people from Ouro

Preto to be closer to their dream to enter in a public university. When it comes to geosciences, the teachers not only taught, but also tried to stimulate the curiosity of the high scholars about the Earth and its systems. Somehow this approach worked, because one of the students decided that he wanted to pursuit a geologist degree. EducaPET will continue during 2018, and the project's creators hopes that each year, more poor teenagers from Ouro Preto manage to get to university.

6 Acknowledgements

The authors of this paper would like to thank the Federal University of Ouro Preto for all the support, the students of EducaPET in 2017 for the interest and dedication on lectures and the undergraduate students who took a little of their time to teach in this project.

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THE TEACHING OF GEOSCIENCES IN CURRICULA OF SCIENCE COURSES OF THE NATURE IN THE CENTRAL-WEST REGION, BRAZIL

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Abstract— The interest in the study of Geosciences in Basic Education has been increase in the last years, motivated by the geological, environmental and social changes in the planet, in attention teacher training courses, more precisely, those that aim to train educators in the area of Nature Sciences. This paper has as general objective to identify disciplines that present aspects of Geosciences in the college courses in Natural Sciences of the Central-West Brazil region. The researched had three stages: 1) Identification of Universities; 2) Identification of courses and curricula; 3) Analyzes of the menus of significant disciplines. There were 26 disciplines distributed through the courses, the one of biology being one that presents a greater concern with the teaching of contents of Geology and Biogeography, Evolution and Paleontology. It was noticed that the curricular matrices of these courses are not extremely disciplinary, not contemplating interdisciplinary concepts for Geosciences, which is configured as a deficiency in the area.

Keywords— Teaching of Geosciences, Teacher training course, Natural Sciences.

Thematic Line — Education, Geosciences Education and Teacher training.

1 Introdução

Interest in the study of Geosciences in Basic Education has grown in recent decades, motivated by geological, environmental and social research on the planet. It has been perceived the need to understand and explain such events to the students, so that they can seek solutions to the natural and historical phenomena.

According to National Curriculum Parameters student you must have the opportunity to meet and discuss their daily events be it local or global extension. Concepts can be worked in a contextualized way by one or more disciplines in order to enable the student to reflect and propose changes in the various situations observed daily.

It is the objective of the school disciplines to allow discussion moments, as well as activities that seek critical posture of the students. Thus, the concepts of Geosciences can to contribute significantly in this discussion about this area of knowledge and the result of a articulation in a Geography and as Natural Sciences (Almeida; Araújo; Mello 2015).

It is worth noting that for Galvão & Finco (2009) the concepts of Geosciences are physical, chemical and biological, and develop a wide range of time and space. These processes, by itself in nature and not in laboratories where variables can be controlled, are characterized by forming open systems, in which you can see that a large number of variables relates, over time and space.

However, what is observed is some resistance from educators and researchers from the Teaching of the Nature Sciences (TNS) in exploring and discussing issues related to the Geosciences in their classes. For Teixeira, Machado and Silva (2017) there is a lack of didactic proposals which would allow the insertion of the concepts of Geology (classified as Geosciences) in the classes of the disciplines of Natural Sciences, even if the contents are part of the program menu for Biology, Chemistry and Physics.

Thus, it becomes possible to think what are the reasons for this resistance from educators of the TNS working concepts of Geosciences, more precisely of Geology, during the basic education lessons. This leads us to look for initial training of science teacher, once it is in this period that the educator meets with the main content that will be work after passing through a transposition didactics in the classes of Primary and Secondary Education. For Maldaner (2000) is in initial formation that the teacher is faced with major scientific concepts to be worked in future lessons in basic education. So, when this formation is well structured the teacher can work more thoroughly the contents of the Natural Sciences, which includes the Basic Geology.

If we unite the ideas put forward by the three papers cited (Fig. 1), we can understand the need to analyze the resume of graduate courses in Biology, Chemistry and Physics. Figure 1 shows directions for initial formation of teachers, as based on the curricular structure of Major courses which, in this case, include Chemistry, Physics and Biology.

In this sense, this article has as general objective to identify disciplines that present aspects of Geosciences in the courses of Sciences of Nature Major in the Brazil central-west region. This analysis is part of a PhD research which has been developed in Goiás state.

2 Methodology

This research is a survey of the curricular menus of Majors courses in Chemistry, Physics and Biology of public universities of states that comprise the central-west region (Goiás, Mato Grosso, Mato Grosso do Sul and Distrito Federal).

There were three steps:

1) Identification of Universities;
2) Identification of courses and curricula;
3) Analyzes of significant menus of disciplines.

In the first step we researched the public universities that had the graduate courses in chemistry, physics and/or biology.

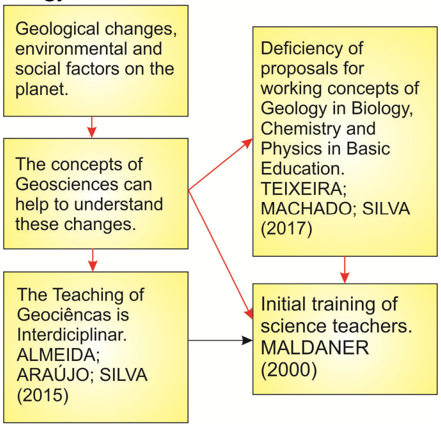

Figure 1. Linkage between the ideas of three papers, pointing to the initial formation of science teachers

The second step consisted in identifying the disciplines that had some relationship with Geosciences. This step was the most thorough, because the minimum approximation that discipline had the concepts of our interest led us to select it for analysis.

In step three were analyzed the disciplines identified in the second step, seeking to emphasize the concepts of Geosciences who beheld and in which courses were more common. Besides were investigated:

1) The number of subjects per course;
2) Interdisciplinarity;
3) Approximation with the basic education.

All articles were recorded and analyzed by the factors mentioned above.

3 Results and Discussion

In the first step of the research were identified ten public universities in central-west region of the country. Of these, 04 belonged to Goiás State, 02 to Federal District, 02 to Mato Grosso state and 02 to Mato Grosso do Sul.

Were added 32 graduate in chemistry, physics and biology courses, distributed by the diversify Universities identified. It is worth noting that some universities presented themselves in campus courses in different cities, they were counted individually.

The courses identified are 10 degree in Physics, Chemistry 13 and 09 of Biological Sciences. The majority of graduate courses in Chemistry are from Federal Institutes of Education.

After the process of identification of the curriculum matrices of the courses analyzed were found 26 disciplines linked to the Geosciences. Figure 2 presents the distribution of the disciplines per state in the central-west region.

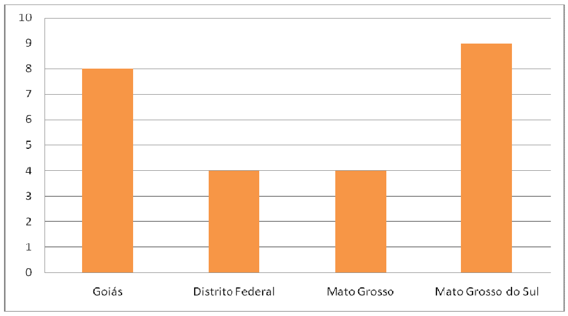

Figure 2. Graph that represents the number of disciplines related to Geosciences and their distribution in the states in the central-west region

Mato Grosso do Sul state presents a greater number of disciplines which are distributed in the courses analyzed. This number corresponds, in its greater part, the disciplines found in the curriculum matrices of Biological Sciences courses.

We observe in Figure 2 that Geosciences, despite being an area of interdisciplinary knowledge, have a little discussion in undergraduate courses in the Natural Sciences. For more that have been identified disciplines in these courses what we can say is that the number is still small.

This is because, in part, to the interdisciplinary character that is poorly addressed by some educators. Each knowledge area is concerned to focus on the concepts "own" your domain and end up forgetting that nature is a set of pleadings and interdisciplinary knowledge.

To deal with such broad concepts and characterized by the dynamism, the future teachers should be trained with a look more complete (interdisciplinary), and this can happen from a change of posture facing the curriculum matrices of Majors Courses.

However, what we perceive is a disciplinary vision of processes, vision that begins even in training courses, as observed in the graph of Figure 2. We identified 32 courses, those that come with concepts of Geosciences, bring one or two disciplines for this purpose, being that, many times, these disciplines are optional.

Biological Sciences courses are those who submit to sit greater concern with this issue totaling 14 disciplines distributed in 09 courses identified. Subjects like "Geology and Biogeography", "Paleontology" and "Evolution" come with concepts of Geosciences and make an approach to interdisciplinary character interesting, from the point of view of scientific and pedagogical.

The disciplines found are presented in the graph of Figure 3. We realize that Geology and Biogeography is the discipline present in the courses identified, mainly major in Biological Sciences, where they were identified 08 disciplines with this title. Already in the course of Bachelor in Chemistry just 01 discipline with this focus was identified.

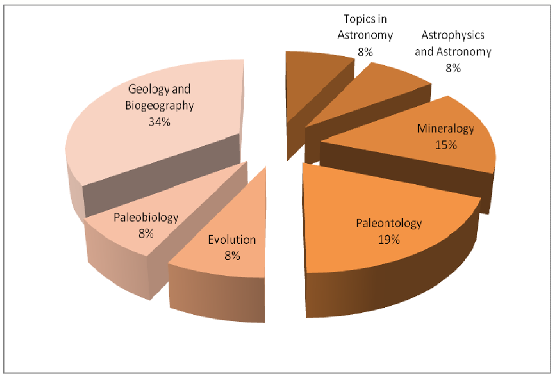

Figure 3. Graph of disciplines identified in courses in the Natural Sciences, which have approach of concepts of Geosciences

It is also possible to observe that the disciplines of Astronomy and Astrophysics and Astronomy topics appear in the analysis. Are disciplines from majors courses in Physics, which represents the training of teachers with greater shortage in concepts of Geosciences.

What we observed in majors courses in Physics is a great curriculum based on disciplines of calculation, highly individualistic and with little contextualization. This has repercussions in classrooms of Basic Education, especially in Secondary Education, as highlighted by Ricardo & Freire stating that:

> "Although it is essential to the ability ma-theme in physics, is not unique, and either, it reduces it. Thus, it appears that these pupils had access to a physical education too stuck to math and application of formulas". (Ricardo & Freire 2007, p.253)

Thus, according to the references cited, the interdisciplinary look loses space for the complex mathematical formulas and calculations. The concepts of Geosciences to Physics, such as formation of planet Earth, Geophysics, Electromagnetism, among others, are avoided by teachers in this area, precisely because they have not had contact with these contents in their initial training.

The majors courses in Chemistry feature disciplines more focused on Mineralogy. We believed that this can be justified on account of the rapprochement between the study of minerals with the chemical bonds that part of its structure. In addition, it is easy to contextualize the formation of soil with the oxidation of different metals like iron, copper, nickel and cobalt.

The knowledge of soils enables the interconnection of knowledge from different disciplines, which makes it more rich (Antunes et al. 2009). The authors also state:

> "The fragmentation of knowledge in isolated disciplines produces, in students, the false impression that the knowledge and the world itself are segregate (Lee et al., 2009, p. 283).

The authors also emphasize the importance of a broader discussion of concepts and suggests the theme soil as to contextualize. It is possible to realize the importance of working contents of Geosciences in training courses to provide theoretical support to future teachers of Natural Sciences.

There is a need to break this disciplinary paradigm that is seen in the natural sciences, which often prevents the development of curriculum matrices incorporating the study of nature as a whole, or through the vision of more than one discipline.

All disciplines identified have interdisciplinary nature, but still represent a small number before the need for discussion of Geosciences. This hinders the integration of these concepts in Basic Education, once that teachers may not feel safe in mediating the study of concepts that they were not presented in the initial training.

Finally, even though the number of disciplines identified is small, we emphasize that there are creators of major courses that verify the importance of Geosciences in the training of teachers and that this number may increase for the next decade, through the reforms in the curriculum matrices of these courses.

4 Conclusion

By means of the data presented, it was possible to identify that there are few subjects linked to the Geosciences in major courses in Chemistry, Physics and Biology of the Central-West region. Were found 26 disciplines distributed by courses, Biology is the one that presents a greater concern with the teaching of evolution and Biogeography, geology and paleontology.

This makes us reflect that the training of teachers in the Nature Sciences need of a gaze turned to that question, so that the future teachers to work in their classrooms, the contents by means of an interdisciplinary look and contextualized.

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UNESCO-IGEO EXPERTS SURVEY ON GEOSCIENCE EDUCATION: EARTH SCIENCE IN PRIMARY AND SECONDARY EDUCATION

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Abstract- This UNESCO-IGEO Experts Survey on school-level geoscience education includes data from 37 non-Latin American countries, but is provisional since it is based only on a draft report, which has yet to be commented upon and ratified by UNESCO. The data does not include information on Latin American countries, which form the subject of a separate report. This is the fourth international survey undertaken by IGEO and has the widest worldwide coverage. The comments on the previous third survey concluded, ‘, ‘there is fairly good coverage of Earth science in the school curriculum globally – particularly for 7 – 16 year olds’ and, ‘… global development is very patchy. Nevertheless, a general improvement is probably discernible.’ The current survey comprised 139 questions in a SurveyMonkey™ online questionnaire focused on science education and Earth science education. Only the Earth science elements of the survey are discussed here. These provided data on the topics of Earth science study at primary, lower secondary and upper secondary level, showing that the atmosphere forms a key component of study at all levels, whilst space and planetary sciences also have a high profile. Earth science, geology and geoscience as subject areas, form important components of the curriculum above primary level, as does geography. The data also showed that specific geoscience support for teachers is only available in less than half the countries surveyed. The main finding is that only between half and two thirds of countries have geoscience in their curriculum at primary and lower secondary levels, much lower figures than the 84% found in the third IGEO survey. The upper secondary level data indicated that in only 30% of countries was the amount of Earth science to be taught prescribed, compared with the 2013 survey finding that 74% of countries had compulsory Earth science at upper secondary level. The current survey also asked how closely the guidelines for Earth science teaching were followed, finding that they are not closely followed or are ignored in around a third of countries. The current survey findings can be summarised as, ‘the Earth science coverage of curricula across the world is variable, with significant numbers of countries having no reported Earth science curriculum; for those countries that do have Earth science curriculum guidance, the guidance is not closely followed in a significant number of countries.’ The state of Earth science education across the world therefore shows scope for major improvement in a number of areas and regions. It is hoped that this survey will provoke the development of geoscience education in all the areas which the current survey has shown the situation to need improvement.

Keywords— International survey, global survey, Geoscience education, Earth science education, primary, secondary.

Thematic line— Teaching of Geosciences and Natural Sciences for School-Level Education and Teacher Training.

1 The status of the information provided below

The survey was carried out in mid-2017 and a report was drafted on the response of the 37 non-Latin American countries worldwide that provided questionnaire data. The analysis given below is provisional and is based on that draft report, which has yet to be commented upon and ratified by UNESCO. The information gathered for the Latin American countries has not yet been analysed, and so is not included below.

2 Background to the UNESCO-IGEO Experts Survey on Geoscience Education

When the International Geoscience Education Organisation (IGEO) was first formed in the year 2000, one of its priorities was to establish the distribution and scope of Earth science education across the world.

A second survey was undertaken in 2006 jointly by IGEO and the International Union of Geological Sciences Commission on Geoscience Education and Technology Transfer (IUGS-COGE).

In 2012, the IUGS hierarchy invited IGEO/IUGS-COGE to write up the results of the 2006 survey for publication. It seemed sensible at that stage to invite all those countries that had provided data for the second survey to update their data for 2012. The opportunity was also taken to invite new countries to participate, through both IGEO and IUGS. The third survey therefore included all the 2012 data together with data from the 2006 survey from countries that were not able to update their data. Each of the first three IGEO surveys sought a response to the overarching question of, ‘How does school-level Earth science education compare across the globe?’ through a series of sub-questions. The first survey acquired data from 21 countries, the second from 27 countries, and the third from 32 countries. Analysis of the data from the third international survey was published on the IGEO website in 2013 and is available there (IGEO website). The results were summarised by King (2013).

The 2013 survey concluded: ‘The data from the ... sample of the 32 counties included in the survey can be summarised as follows.

- **Curricula** - across the world, Earth science is included in science and geography curricula in a variety of different ways
- **Standards** - most countries have national standards for Earth science
- **Global coverage** – there is fairly good coverage of Earth science in the school curriculum globally – particularly for 7 – 16 year olds
- **Textbooks** – more than half the textbooks for elementary students and more than a third of textbooks for high school students are of poor quality or are not available …

Overall, the data indicates that most global developments in Earth science education at school level have been driven by enthusiastic individuals and groups. This being the case, it is not surprising that global development is very patchy. Nevertheless, a general improvement is probably discernible.' (King, 2013, 26).

The current survey, entitled, *'Experts survey on geoscience education: approaching Earth Sciences in primary and secondary education'* is the fourth international survey of geoscience education. It was jointly conducted by IPGG/UNESCO and the International Geoscience Education Organisation (IGEO) with the support of the International Union of Geological Sciences Commission on Geoscience Education and Technology Transfer (IUGS-COGE). The survey was undertaken between the months of May and September 2017.

3 Methodology for the Experts Survey on Geoscience Education

The particular focus of IPGG/UNESCO was to survey school-level geoscience education in as many Latin American countries as possible, whilst IGEO with IUGS-COGE support was able to expand the survey to include 37 more countries across the globe.

The results from the Latin American countries will be reported in a separate UNESCO report, and so are not covered in what follows.

Representatives across the world were invited by IGEO and IUGS-COGE to participate in the survey by submitting a brief Curriculum Vitae and providing their institutional backgrounds. Some countries had an individual contributor whereas small teams of contributors were involved for some countries. Contributors were invited to complete an online Surveymonkey™ questionnaire comprising 139 questions in blocks (Fig. 1).

Identification of respondent
Country profile
Science education in general
Primary education
  General science curriculum
  Earth sciences curriculum
  Student's assessment
  Teaching
Lower secondary education
  General science curriculum
  Earth sciences curriculum
  Student's assessment
  Teaching
Upper secondary education
  Multiple branching system
  No Multiple branching system
  Promotion of Earth sciences vocations
  Student's assessment
  Teaching
Informal learning and extra curricula activities
Educational innovations
Social innovations

Figure 1. Blocks of questions in the 'Experts survey on geoscience education: approaching Earth Sciences in primary and secondary education' online questionnaire

The questionnaire included a glossary of terms used, to help to standardise responses from across the world.

4 Initial findings across the 37 non-Latin American countries which responded to the Experts Survey

The list of countries which responded to the survey is shown in Table 1.

Table 1. The list of countries covered by the survey, excluding Latin American countries.

Australia	Mauritius
Bulgaria	Mongolia
Canada	Namibia
China	New Zealand
Denmark	Norway
Egypt	Pakistan
Finland	Philippines
France	Portugal
Germany	Russia
Greece	South Africa
Hong Kong	South Korea
India	Spain
Indonesia	Sri Lanka
Iran	Taiwan
Israel	Turkey
Italy	United Kingdom
Japan	United States
Kyrgyzstan	Zambia
Malawi	

Of those responding to the survey:

- 81% of the contributors held Doctorates;
- an additional 19% held Masters degrees;
- 51% were male;
- 49% were female;
- 62% were from universities;
- 14% were from research centres;
- 11% were from National Ministries;
- 8% were from schools;
- 5% were from private organisations;
- 76% were members of the International Geoscience Education Organisation (IGEO);
- 22% were Commissioners of the International Union of Geological Sciences Commission on Geoscience Education (IUGS-COGE);
- some were members of both organisations.

The data provided below focusses on Earth science education and does not include the broader science education aspects of the Experts Survey.

4.1. Primary education in Earth Sciences

27 respondents provided data for the primary-focussed part of the questionnaire, indicating that 22 of the countries surveyed (81%) have Earth science in their primary curriculum, whilst five countries do not. The primary science topics covered by the 22 countries are shown in Figure 2.

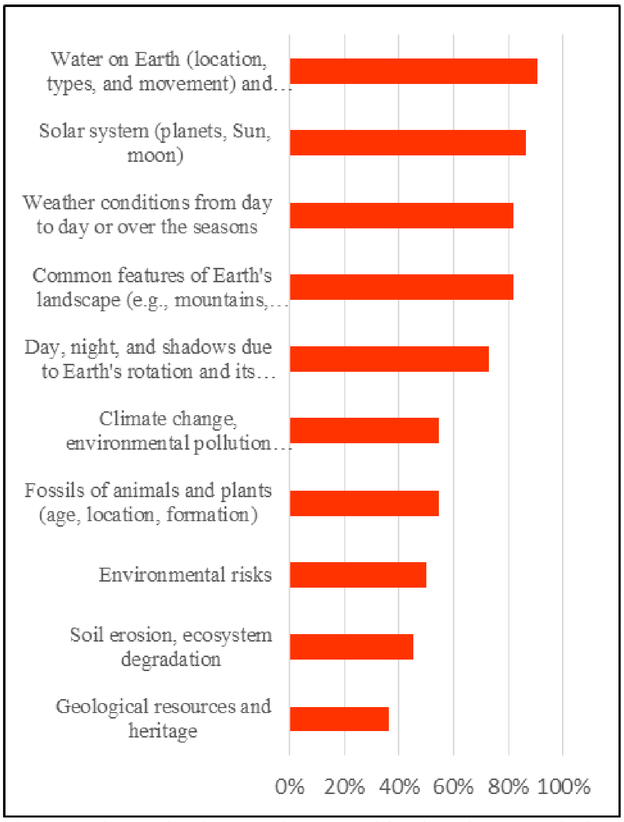

Figure 2. The Earth science topics covered by the primary curriculum (n=22).

The support available to primary teachers for their teaching of Earth science across all 37 countries is shown in Figure 3.

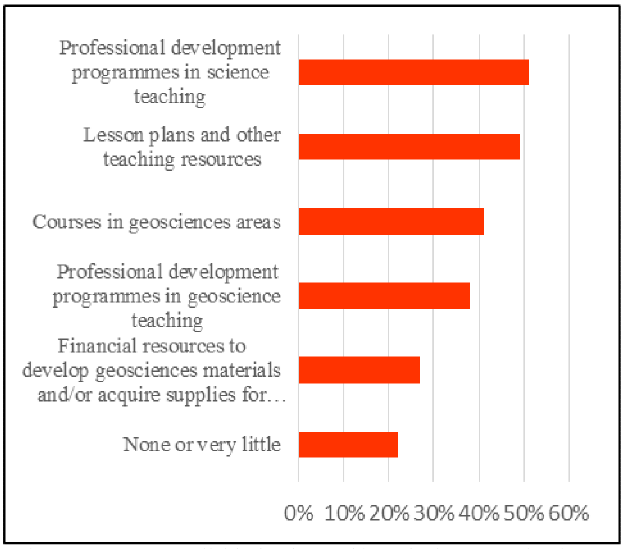

Figure 3. Support available for the teaching of primary Earth science (n=37).

In 76% of the countries (n=37) teaching materials are available for the teaching of Earth sciences at primary level (but in 24% of countries – 9 countries, they are not). However, the general view of the reviewers is that the quality of the teaching material provided, where available, is only moderate and 14% is poor, with only 8% (3 countries) having high quality Earth science-teaching material available.

4.2. Lower secondary education in Earth sciences

Thirty of the responses show that 77% include Earth science in the lower secondary curriculum (23 countries), whilst 7 countries do not. Across the 23 countries Earth science is taught in a variety of subject areas with a number of titles including, geography (57%), geology 35%, biology 35%, Earth and space sciences 31%, geosciences 31%, environmental sciences 31%, physical geography 36%, Earth sciences 26%, Earth science 26%, chemistry 26%; a range of other areas had lower percentages. Most of the teachers of these subject areas were general science teachers (51%); Earth science specialists comprised only 24%. The 23 countries gave information on the topic areas covered by lower secondary Earth science shown in Figure 4. The support provided for teachers of Earth science is shown in Figure 5.

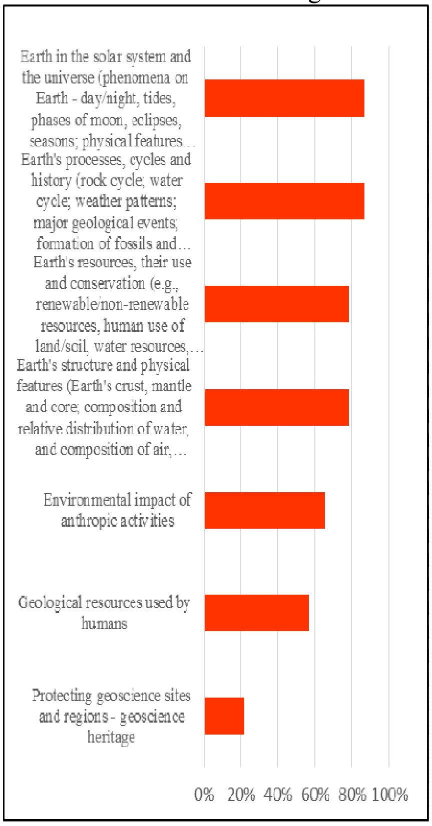

Figure 4. The Earth science topics covered by the lower secondary curriculum (n=23).

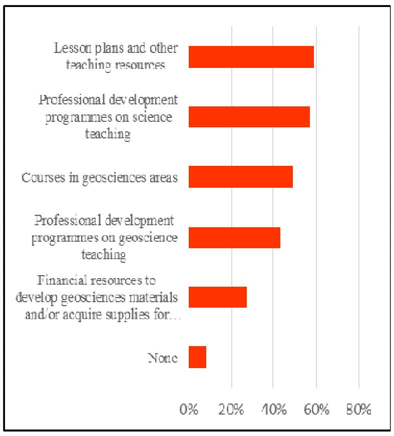

Figure 5. Support available for the teaching of lower secondary Earth science (n=37).

Lower secondary level Earth science teaching materials at are available in 84% of countries (n = 37), but six countries do not have access to these materials. As at primary level, only in three quarters of countries are the resources of moderate or high quality; six countries have only poor-quality materials.

4.3. Upper secondary education in Earth sciences

In only 42% of the countries surveyed (n=26) is the amount of curriculum time to be given over to Earth science specified.

Respondents were provided with a list of Earth-science related sub-disciplines and asked to indicate which of these formed a major part of the Earth science curriculum. The responses are shown in Figure 6.

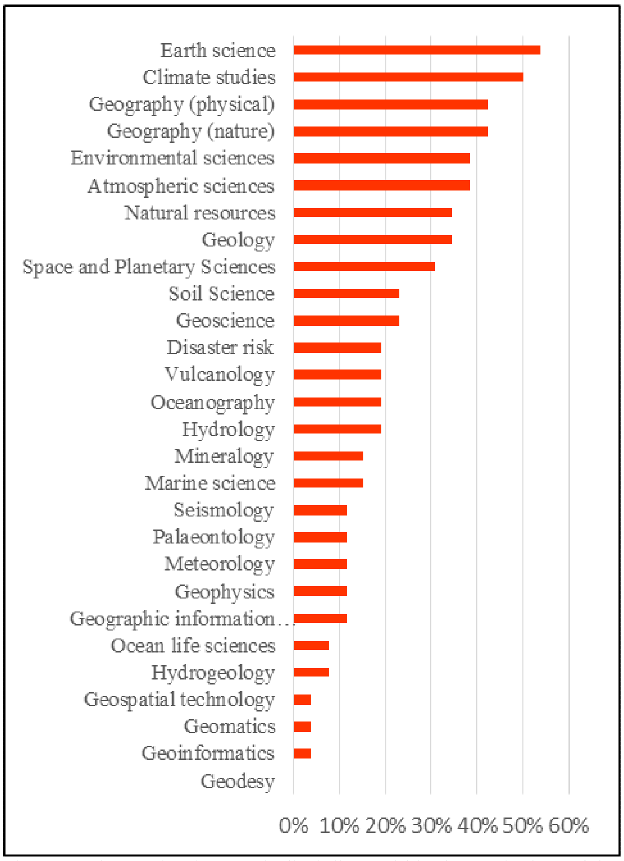

Figure 6. The Earth science sub-disciplines within the curriculum of the students who choose science (n=26).

However, the respondents gave their opinion that the curriculum guidance in Earth science at upper secondary level is followed closely in only three countries (12%). It is followed quite closely in 38% of countries, not very closely in 35% of countries, and it is largely ignored in 15% of countries – four countries.

The support available to upper secondary teachers for their Earth science teaching is shown in Figure 7.

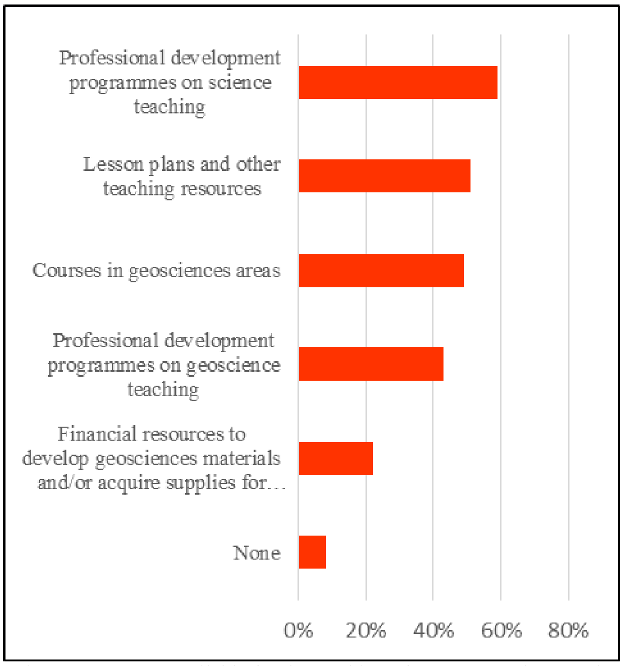

Figure 7. Support available for the teaching of upper secondary Earth science (n=37).

Teaching materials for the Earth science content of the upper secondary curriculum are available in more than 80% of countries, but seven countries (19%) have no such resources. In most countries the quality of these teaching materials is moderate or high, with only three countries reporting poor quality (8%, n=37), this is an improvement of the quality of resources available at lower secondary level.

4.4. Innovations in Earth science teaching

65% of the countries surveyed reported innovations in the teaching of Earth science in the past ten years. In their free responses, seven of the countries that reported innovations (29%, n=24) indicated that this was in response to curriculum change, whilst three countries (13%) reported the development of new curriculum materials for Earth science teaching.

More than half of the countries surveyed (54%) reported the presence of research groups in their counties focussed on Earth science education.

5 Discussion of the Geoscience education findings

The data appears to show that only 59% of the countries surveyed at primary level (only 22 of the 37 countries indicated that they do teach Earth science) and only 62% at lower secondary level, contain geoscience in their curriculum. These are much lower figures than those in the 2013 survey (King, 2013, 21, Table 4) where 84% of countries had an upper primary and a lower secondary Earth science curriculum.

The situation at upper secondary level is much more difficult to clarify due to the different option systems in use across the world. However, the data from the current survey indicated that in only 11 countries (30%) is the amount of Earth science to be taught prescribed, compared with the finding of the 2013 survey that 74% of countries had compulsory Earth science at upper secondary level.

In addition, the current survey asked how closely the guidelines for Earth science teaching were followed, finding that they are not closely followed or are ignored in around a third of countries.

The current survey, therefore, paints a significantly worse picture than that found by the 2013 survey, which concluded, 'there is fairly good coverage of Earth science in the school curriculum globally – particularly for 7 – 16 year olds', King, 2013, 26). A more accurate statement for the current survey might be: that the Earth science coverage of curricula across the world is variable, with significant numbers of countries having no reported Earth science curriculum; for those countries that do have Earth science curriculum guidance, the guidance is not closely followed in a significant number of countries.

Figures 1, 3 and 5 show that the atmosphere forms a key component of study at all levels, whilst space and planetary sciences also have a high profile. Earth science, geology and geoscience as subject areas, form important components of the curriculum above primary level, as does geography.

Meanwhile, Figures 2, 4 and 6 show that specific geoscience support for teachers is only available in less than half the countries surveyed, whilst financial support for Earth science teaching is only available in around a quarter of the countries surveyed.

In nearly a fifth of the countries surveyed, no teaching materials are available for the teaching of Earth sciences, these presumably, are the countries with little or no Earth science in their curriculum. However, in the large majority of countries the quality of materials is only moderate or poor. It seems that the quality of textbooks has improved since the 2013 survey (King, 2013), where the situation was summarised as: 'more than half the textbooks for elementary students and more than a third of textbooks for high school students are of poor quality or are not available' (p26), nevertheless it is worrying that the availability of high-quality Earth science teaching material is still so limited across the world.

6 A conclusion

The main finding of this school-level geoscience education survey, in comparison with the 2013 international survey (King) is that the Earth science teaching situation across the world is significantly poorer than in 2013. This could be for the following reasons.

- The situation has become poorer.
- The style of the questionnaire questions is different between the different surveys, prompting different responses.
- The questionnaire medium is different (paper questionnaire in 2013, electronic in this survey).
- The countries included in the survey are different. Of the 34 countries included in the 2013 survey (King, 2013), the countries not included in the current survey were: the Latin American countries Argentina, Brazil and Uruguay, and the other countries, Bangladesh, Belgium, Czech Republic, Estonia, Romania, Saudi Arabia, Scotland, and Trinidad and Tobago (11 countries in all). Meanwhile, the 14 countries which took part in the current survey, which were not represented in the 2013 survey were: Bulgaria, China, Denmark, Egypt, Greece, Hong Kong, Iran, Kyrgyzstan, Mauritius, Mongolia, Namibia, Pakistan, Turkey, and Zambia.

Whichever of these reasons has had most impact, the fact remains that the current situation does appear to be poorer than previously, and can be summarised as above, namely: 'that the Earth science coverage of curricula across the world is variable, with significant numbers of countries having no reported Earth science curriculum; for those countries that do have Earth science curriculum guidance, the guidance is not closely followed in a significant number of countries.'

In conclusion, therefore, the state of Earth science education across the world shows scope for major improvement in a number of areas and regions. By raising awareness of these issues through this survey, it is hoped that more emphasis on, and support for, Earth science education across the world can be provided in the future, by all agencies concerned.

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Iran – Hanieh Bakhshaee
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Russia – Evgeny Nesterov
Spain – Amelia Calonge
Sri Lanka – Ashvin Wickamasooriya
South Africa – Tanja Reinhardt
South Korea – Young-Shin Park
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WHICH ARE MORE SUITABLE TEACHING MATERIALS FOR NEXT GENERATION EARTH SCIENCE CLASS IN JAPANESE THE UPPER SECONDARY SCHOOL?

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Abstract— Occurring in the context of improvement of the national standard of education in Japan, the university entrance exam may change to assess thinking power. To discuss appropriateness of teaching materials for geoscience class in the upper secondary school, the author surveyed "Basic Earth Science" textbooks. Fields of geoscience contents in the textbooks deal with solid-earth geophysics (including seismology), volcanology, petrology, paleontology, geology, meteorology, and oceanology. In the textbooks, the science process skills fewer appear and "interpreting data" is most popular in the textbooks. To improve instructional method for active learning, more development will be required.

Keywords— geoscience, the upper secondary school, active learning, teaching material, textbook analysis.

Thematic line— Education, Teaching of Geosciences and Teacher Training.

1 Introduction

Earth science curriculum for the upper secondary school students in Japan has been changed in it's about 70 year-history. Major reason is that former Ministry of Education changed science curriculum every ten years. Nowadays, the national curriculum for the upper secondary school has two subjects in geoscience field, "Basic earth science" and "Earth science". The proportion of number of the students learning "Earth science" is less than one percent. On the other hand, percentage of "Basic earth science" leaner is around quarter so that the basic subject is more popular subjects of geoscience for the upper secondary school students. Recently, new ministry of education (MEXT: Ministry of Education, Culture, Sports, Science and Technology, Japan) stated that so called "active learning" will be introduced for improvement of the upper secondary school education (Central Education Board 2016). Government officials have paid attention to inquiry-based teaching and learning because that the more general educational benefits will be generated using this approach (e.g. MEXT 2017b).

In practices of modern compulsory education in Japan, teaching materials have been picked up and the "collaborate learning" style has been chosen when teachers instruct by way of active learning. Thus we can find two aspects in the upper secondary school education, teaching materials and collaboration in class. However, the author would like to focus on teaching materials due to limitation of space.

As to teaching materials, the author guesses that earth science teachers will be expected to develop new materials to refine thinking power of their students. So, before discussion of teaching materials improvement, the author analyses modern textbooks by way of classification activities from view of science process skills. The analyzing will show whether Japanese earth science textbooks are suitable for active learning or not.

This research also aims to help teachers who want to focus on the powerful ideas of earth science rather than teaching a series of facts. Those ideas may lead students to a deep understanding of the earth.

2 Recent School Curriculum Revision in Japan

Firstly, the author will describe the background of curriculum revision in Japan. In 2017, MEXT publicly notified new "The Course of Study" as the national curriculum and standard of Japan, which contains study of geoscience and astronomy in science class at elementary and the lower secondary schools (MEXT 2017a, 2017b). The point is MEXT mentions not only curriculum but also instructional method in the standard. That is, the ministry focuses more on developing key competencies for all learners. To change instructional method in class, MEXT recommends to introduce so called "active learning" in science class. In addition, a new national standard for the upper secondary school (MEXT 2018) appeared in 2018. Considering the recent report on school education by the Central Council for Education, such policy will be also addressed for the upper secondary school curriculum by MEXT immediate future.

3 How Can We Instruct by Way of Active Learning?

When the students study some event-related objects regarding to volcano eruption and seismic activity, teachers can show some samples and/or images to make the students gain knowledges. After knowing scientific concepts of the Earth, the students can understand modeled workings and/or schematic structure about our planet. However, as to some fields, such as marine topography and subsurface geology, students never experienced or seen in daily life. The author supposes they have almost no conception of such idea. For example, in Japan, the lower secondary school students have to study basic concept of plate tectonics. A questionnaire research to the students revealed that they have no idea about movement of ocean sea floor (Kawamura 2018). Therefore, learning plate tectonics may be only to get knowledge from their teacher. As mentioned above, Japanese teacher ought to teach plate tectonics by way of active learning. But, how should they do?

4 Objective of This Study

Being faced with the revolution in teaching methodology for science class, the author attempts to reveal actual situation of teaching materials of "Basic Earth Science" textbooks. By finding characteristics of materials, we can discuss Japanese teaching methods using such materials are suitable for active learning or not. The author will report results of textbook analysis and discuss some issues on science concepts related to geoscience.

5 Materials and Research Method

5.1 Materials

A survey was done to five "Basic Earth Science" textbooks for the upper secondary school students which were published in 2016 and 2017. The author classified the contents into science process skills on the basis of the criteria described below.

5.2 Classification

The term "science process skills" has been popularized by the curriculum project, Science - A Process Approach (SAPA). SAPA grouped process skills into two types-basic and integrated. The basic process skills include observation, communication, classification, measurement, inference, and prediction. The integrated skills comprise of controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting, and formulating models. Padilla et al. (1983) found that process skill teaching might influence formal thinking ability. If new curriculum for the upper secondary school in Japan aspire for development thinking power, the integrated skills would be necessary. So the author will focus on the integrated skills that may appears in textbooks.

Criteria for classification is based on definition of the science process skills (e.g. Jinks 1997).

6 Results

Implementing textbook survey, the author found seventy three activity contents in five textbooks. Fields of geoscience contents are solid-earth geophysics (including seismology), volcanology, petrology, paleontology, geology, meteorology, oceanology, and space science.

The skill "interpreting data" marks the highest number and relatively the lower numbers are occupied by skills "controlling variables", "experimenting", and "formulating hypothesis". Skills "defining operationally" and "formulating models" don't appear.

7 Discussion

7.1 Effectiveness of Teaching Materials in Terms of Active Learning

The results show that only one study contents may be useful to promote thinking powers such as interpreting data. Hence, other science process skills rarely appears in the textbooks. Can the students get integrated skills and thinking powers using those textbooks?

Padilla et al. (1983) systematically integrated experimenting lessons into a middle school science curriculum. The results indicate that the more complex process skills cannot be learned via a two week unit in which science content is typically taught. Rather, experimenting abilities need to be practiced over a period of time (Padilla 1990). The research conducted by Padilla et al. (1983) may mean a group of training of integrated process skills will be required to get thinking power. If Japanese teachers aspire that their students get stronger thinking powers, they should conduct active leaning instruction repeatedly in their earth science class.

As showing textbook survey results, the skill "interpreting data" is the most popular in "Basic earth science". So, we may not expect strong effectiveness in terms of thinking power. The author guesses that the textbooks were wrote to get more knowledge about the Earth. In short, Japanese teachers would like to teach in three ways; talking the Earth, illustrating schematic figures, and making charts or graphs using data. Gaining thinking power would not be main purpose of their classes.

7.2 Importance of Teaching Knowledge in Japan: An Issue Related to Entrance Exam

By the way, Japanese teachers have been faced another big issue, instruction for test taking skills. Their students must compete for university entrance examinations so that the upper secondary school teachers have been expected to teach those skills well. The teachers will teach many knowledges because the admissions offices of university are apt to check students' knowledge by the entrance exam. In short, the entrance exams actually control contents taught in secondary schools. The teachers might be caught in with a dilemma between new curriculum and entrance exam. Recently, the improvement of university entrance exam has been undergoing by MEXT. If the exam reform requires more integrated skills, textbooks will deal with more study contents by way of active learning. The author supposes that it depends on the entrance exam reform whether textbooks will be guidebooks for stronger power of thinking or not.

8 Conclusion

The research question is which are more suitable teaching materials for next generation earth science class in Japanese the upper secondary school? The answer is research activity using "interpreting data" skill. The recent improvement of the national standard of education requires change of instructional methods. The national university entrance exam may change to require more thinking power. More teaching materials ought to be developed, which are suitable for other science skills acquisition.

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Thematic Line

Environmental Education, Sustainability Education and Geoethics

CISTERNS FOR SCHOOLS: CONTEXTUALIZED EDUCATION RELATED TO AN EXTENSION PROJECT

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Abstract—The Brazilian semi-arid and its environmental and territorial dynamics in several areas of knowledge have been frequently discussed in conferences, meetings and academic institutions It is a region of dry climate with low pluviometric rates and high evapotranspiration in Brazil. Currently, this region comprises 1262 municipalities, that due to their geographic and socioeconomic characteristics receive projects on public policies, aiming to lower socioeconomic disparities and get a better interaction with regional singularities. Based on that information, it was intended to analyze the execution of the project "Cisternas nas Escolas" (Cisterns for schools), developed by ASA Articulação in Brazilian semi-arid environment, in the municipality of Mucugê, state of Bahia, in 2017.

Keywords—Semi-arid, Public policies, Contextualized Education.

Thematic line—Environmental Education, Education for Sustainability and Geoethics.

1 Introduction

The water is not only a factor of social and economic development, but also an essential element for life on this planet. It plays a vital role in life, as a whole, for it is constituent of living beings, used in many and various manners, for example, supply of the population, power generation, irrigation, seafaring, and is also part of the industrial processes of different products (Couto 2010).

Brazilian semi-arid environment occupies an area of 18,2 % (982,566 km²) of the national territory (ANA 2002).

It comprises the states of Alagoas, Bahia, Ceará, Rio Grande do Norte, Minas Gerais, Paraíba, Pernambuco, Piauí and Sergipe, having a population of approximately 22 million people.

This geographical region has distinctive features, with the semi-arid tropical as its prevalent climate, and irregular rains, since the evapotranspiration is three times higher than the annual rainfall volume (Suassuna 2002). The most important feature of Brazilian semi-arid environment is the Caatinga biome (Ab'Saber 2003). The vegetation is constituted of deciduous and semi-deciduous species, with arboreal and bushy appearance (Ab'Saber 2003).

Facing the socio-economic context of residents and their difficult access to water, was created ASA Articulação Semiárido Brasileiro (Brazilian Semi-arid Articulation), a social organization network, that since its crea-tion in 1999 goals to discuss and take actions on living in that region. Currently, more than 3,000 organizations are part of ASA (ASA 2017).

Since its very beginning, ASA has centered its actions on the right to have access to water, from that perspective was created *Programa de Formação e Mobilização Social para a Convivência com o Semiárido* (Social Formation and Mobilization Program for the interaction with Semi-arid), which comprises *Programa Um Milhão de Cisternas* (P1MC) (Program for 1 million cisterns), Programa Uma Terra Duas Águas (P1+2) (One Earth two waters Program) and currently *Programa Cisternas Nas Escolas*. (Cisterns for schools Program).

Besides discussing the living relations in the Semi-arid, this Project encourages the Contextualized Education, based on sustainability principles and collective building of knowledge, by means of different social factors, such as reflexive action and knowledge rallying. the contextualized education is described as an elaborative process of theoretical and practical knowledge that involves territoriality of subjects, related to living conditions and local reality, valuing their habits and traditions, making them active subjects in the building of knowledge, from their realities. In this point, education is built in dialogues between teachers and students, where both valuate better the knowledge. (SENA, 2014).

This research objectives are analyze the experience of a Contextualized Education, related to an extension Project Cisternas nas Escolas (Cisterns for schools Program) in the municipality of Mucugê - BA, in the year of 2017, focused on educational activities, related to workshops of Gestão de Recursos Hídricos na Escola (GRHE) (Water Resources Management at School).

2 Cisterns for schools Program

Throughout the centuries, the complexity of multiple usage of water by society has made its to be seen as supply of necessary resources to Capitalist production, for their own interests (Silva et al. 2011).

According to a report of *Direito a Aprender* (The right to learn), developed by UNICEF in 2009, a total of 37,600 school located in rural areas of Brazil, 28,300 are not supplied directly from the public network (ASA 2017).

Based on that, *Projeto Cisternas nas Escolas* (Cisterns for schools Program) (Picture 1) was created by the Social Development Ministry as a partnership between the Federal Government and ASA, planning to provide water to schools in the rural areas of the Brazilian Semi-arid environment, in the states of Bahia, Pernambuco, Alagoas, Sergipe, Rio Grande do Norte, Piauí and Minas Gerais.

Picture 1. Cistern building at Benjamim Alencar School, village of Brejo in Mucugê

This Project aims at building cisterns with capacity of 52,000 liters for storage of rainwater. This program provides awareness and training course to the school community on how to manage water and workshops of contextualized education, related to semi-arid context.

2.1 The importance of the implementation of the Contextualized Education in schools in rural areas of the Brazilian semi-arid

The school plays an important role in the construction of knowledge. Although, the Brazilian educational system is still traditional, in which the teacher imparts the knowledge and the students only receive it. According to Freire (2002) authoritarian and conservative teaching does not allow students to have access to collective construction of knowledge through their life experiences.

Thus, the Contextualized Education could be understood as construction of knowledge, valuing regional characteristics. Pedagogically, it integrates the local context with educational themes in the dialogue of knowledge. It favors the valuation of knowledge of the local themes, emphasizing the idea that “teaching is not about transferring knowledge, but respect to the autonomy and identity of the students” (Freire 2002).

In many schools of the rural areas of the Brazilian semi-arid, the knowledge of local themes is neither valuated nor discussed in the construction of Pedagogical Political Projects of the schools and in the preparation of teaching plans, inasmuch those tools aim at defining collective goals and strategies for the effectuation of quality and democratic education (Kuster & Mattos 2007).

In this context, the Cistern for Schools Project expands its works. Besides the construction of alternative technology, it aims at training and developing sensitivity of teachers and school staff on water management and interaction with workshops on School Water Resources Management and Contextualized Education focused on collective construction of knowledge (ASA 2017).

The conceptual, didactic and methodological approaches aim at valuing agriculturists and the popular wisdom, providing better reflection on the relation between society and nature and on how the understanding of natural sciences, history, sociology and other subjects makes possible a better interaction with the environment and its regional peculiarity (Reis & Carvalho 2011).

Thus, the effectuation of the Contextualized Education, especially in schools in rural areas provides collective construction of pedagogical knowledge about the reality of interaction of the students, being a facilitator element of the teaching and learning process resulting in a better interaction with the semi-arid.

3 Material and method

During the production of this work was done a historical and bibliographical review on Brazilian semi-arid environment, ASA and Cisterns for schools Program.

The data of execution about this program were systematized in the municipality of Mucugê, in this year, such as the follow-up of all the procedures of execution of this project in the 19 schools that had cisterns built in them.

The procedures of execution of this Project were: Meetings with the local community; Regional meeting; Workshop on water management at school; and field visits to follow up the cisterns buildings.

The data above mentioned were used to analyze the progress of those actions in the municipality of Mucugê and ASA, and working together with *Cáritas Regional Nordeste* 3, developed actions for living with local community.

4 Results and discussions

Since the beginning of Cisterns for schools Program in 2014 by the end of the current year, 5323 cisterns have been built in schools in Brazil (ASA 2017). In the state of Bahia, 1,211 out of 9,671 schools in rural areas have already received cisterms from the program.

Cáritas Brasileira Regional NE3 is one of social organizations that executes the Cistern for schools program. This organization works in the states of Bahia and Sergipe, nevertheless, the cisterns have been built only in the state of Bahia, where it built 173 school cisterns. Cáritas Regional Nordeste 3 is a non-profitable organization associated with the Catholic Church and develops different social works.

In 2017, this organization executed the third phase of the Project, by building cisterns in schools of the municipalities of Irajuba, Boa Vista do Tupim and Mucugê (Table 1)

Table 1. Municipalities of Bahia that had cisterns built in the 3rd phase of Cisterns for schools program.

Municipality	Built cisterns
Irajuba	10
Boa Vista do Tupim	16
Mucugê	19

Schools and their received materals

I. 1 cistern with storage capacity of 52,000 liters
II. 2 ceramic filters of 15 liters
III. 1 water tank of 1,000 liters;

IV. 1electric pump
V. 1 faucet;
VI. Hydraulic and electric facilities (pipes and wires)

Including all the needed material for building the cisterns and the foundation for water tanks.

4.1 Execution of the Project in the municipality of Mucugê

In March of 2017, the municipality of Mucugê was included in the third phase of the project, for receiving Cistern for schools program in 19 schools in its rural area, installed by *Cáritas Regional NE3*.

In association with the municipality council of Mucugê, and its Education and Sporting departments, all the 22 schools in rural area were subscribed to the program, but only 19 received the cisterns.

Shortly after, there was a regional meeting with representatives of the Project, local public agents and organizations, aiming to present the actions developed by ASA and *Cáritas Brasileira Regional NE3*, where partnerships and agreements were made, between the Project executor and the municipality council, which was represented by the Educational projects coordinator Kezia Andrade dos Santos, responsible by execution of the project. After that, there was a meeting with the local community (Picture 2), aiming to present the program to local residents, those meetings were held from July to November 2017.

Picture 2. Meeting with locals of Brejo, village of Mucugê

4.2 Workshops on Water resources management and Contextualized Education

Besides cistern buildings, ASA also provides training for teachers, school cooks and janitors. The workshop on Water resources management was held on August 23 at the Department of Education, directing to train the staff of 19 schools, dealing directly with water management, cooking and supply of school needs.

During the workshop (Picture 3) conducted by the pedagogue Paula Dantas, representative of *Cáritas Regional*, were discussed the following subjects:

a) Water management and supply of school needs;
b) Maintenance of the water catchment and storage system ;
c) Interaction with Semi-arid;
d) Water and Education as rights and technology as a conquest;
e) Commitment of the local and school community with the water quality from the perspective of a nutritional sovereignty.

Picture 3.Workshop on water resources management

The workshop on contextualized education aimed to involve the teachers in the building of pedagogical knowledge about the interaction with the semi-arid environment and its reality, addressing concepts, didactics and methodologies that value the regional and local knowledge and folk wisdom.

The workshop was conducted in three different modules, with specific dates from September to October 2017, in which were discussed the following subjects:

a) Concepts on semi-arid;
b) Historical and Geographical contextualization; the importance of contextualized Education in the school;
c) Interaction with the semi-arid; The school we have and the school we want;
d) Evaluative memory; Historical process of Education;
e) Analysis on experiences of contextualized education installed by ASA in the municipalities involved in the Project;
f) Cistern as a pedagogical interdisciplinary element based on cross-fuctional activities;

g) Presentation of teamworks developed in the modules by the teachers in the classroom;
h) The importance of networks;
i) Sharing experiences on the school community; Challenges, perspectives and goals;

The subjects a, b and c were explained during the three modules, directly composed of geoscience content, which provided to the educators a better comprehension on the subject discussed in the classroom, stimulating a deep reflection on the relation society-nature and on how the comprehension on the subjects, related to geoscience could lead to a better relation with the environment, in this case, the semi-arid environment.

From that perspective, teachers could know and analyze the importance of the contextualized education to the municipality of Mucugê, for their actively participated in the activities requested by the pedagogue during the workshop (Picture 4).

Picture 4. Workshop on Contextualized Education – Visit to Parque Municipal de Mucugê

The conference of Contextualized Education to interaction with the semi-arid environment, was held in the last phase of the project, comprising the municipalities of Irajuba, Boa Vista do Tupim and Mucugê. It took place in the municipality of Varzea do Poço, the first municipality to implement contextualized education in the curriculum of its schools, it aimed to collect experiences from those municipalities, during the project.

5 Conclusion

The Brazilian semi-arid environment is often seen as a poor region, marked by social inequality. However, this region is rich in natural and economic resources, providing that there is an interaction with its singularities.

Based on this information, The Cistern for schools program was implemented in 2014, in a partnership with the Federal Government and ASA, configured as public policy, aiming to provide access to water in schools of the rural area of the Brazilian semi-arid environment.

The municipality of Mucugê had 19 cisterns with storage capacity of 52,000 liters of rainwater, built in schools of rural area. This social technology has become very important to the school communities, because access to water is still difficult in many of those communities. The workshops on Water resources management and Contextualized Education have expanded horizons to the valuation of regional and local knowledge, which is very important to countrymen.

The financial support was provided by the Federal Government, through the Ministry of Social Development, which invested approximately R$ 161,000 in the municipality of Mucugê. (Cáritas Regional NE3).

The execution of the Cistern for schools program in the municipality of Mucugê demonstrates the importance of the interaction with the semi-arid singularities.

The practice and strategies of contextualized education caused reflections on the teachers about the content related to Science of Earth studied in schools, which have contributed to the spread of geoscience knowledge.

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ENVIRONMENTAL EDUCATION IN THE CONTEXT OF THE TRAINING OF PARTICIPATORY SPACES IN HYDROGRAPHIC BASE COMMITTEES IN THE STATE OF SÃO PAULO, BRAZIL

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Abstract — This paper proposes to analyze the main aspects related to the participation of civil society in the Piracicaba, Capivari and Jundiaí River Basin Committee (CBH-PCJ), from the perspective of environmental education projects. The methodological approach adopted is based on qualitative research, through participation in CBH-PCJ meetings, and application of research tools for data collection, in the form of semi-structured questionnaires. In this way, we will seek to identify the challenges and perspectives that have involved the establishment of the protagonism of civil society, in different segments of representation in the Basin Committee, and formal education institutions (public and/or private). The projects analyzed presented as proposals the development of new values related to water resources. In this sense, we note the importance of participatory spaces in river basin committees, through Environmental Education projects, which present as characteristics a factor of replicability and sustainability of the actions, in order to reach the proposals of Agenda 2030.

Keywords — Environmental education, watershed committee.

Thematic line — Environmental Education, Education for Susstainability and Geoethics.

1 Introduction

The current scenario shows a constant concern, by the various public and private agencies, in the search for a more adequate way to achieve social and environmental balance and well-being.

The present study seeks to corroborate with an integrated view of the various areas of knowledge, necessary for interdisciplinarity and inherent to the investigative studies of Environmental Sciences.

According to Rebouças (2015), one of the limiting factors for sustainable development is water. And this reality must be addressed by minimizing the effects of water scarcity (seasonal or otherwise), waste and pollution, especially by rapidly evolving nations.

The socio-environmental issues that involve the use and occupation of the environment, especially in watershed areas, involve the definition of a management and planning unit, which occurs through river basins. This system follows the French management model, which was adapted to the Brazilian reality. This model shows an integrated management, with the participation of several entities, including civil society organizations, and there should be no conflicts between the different sectors responsible for achieving these goals, which is not always the case (Parente 2007).

In order to subsidize the management of water resources in Brazil, the National Water Resources Policy was established by Federal Law No. 9,433 of January 8, 1997, which established important management instruments that are in various stages of implementation and consolidation in the various basins in Brazil, some of which are only deployed in some basins (Prota 2011).

In this context, the State Policy of Water Resources, proposed by the government of the state of São Paulo in the 1990s, law nº 7663/91, defines as management units the river basin committees, which are normative and deliberative bodies whose purpose is to promote the management of resources in their respective river basins. They have the power to promote the debate on water issues and arbitrate, in the first administrative instance, conflicts related to water use, through the use of management tools.

Environmental education is recognized more than as a tool to reach an objective, to solve a problem, or to change behaviors, it is also a fundamental part of educational processes and projects transforming society, being possible to verify potentialities and fragilities of activities and actions that have occurred or are occurring in the watersheds (Dorici et al. 2015).

According to Diniz & Maranhão (2013), Environmental Education collaborates with the strengthening of the National System of Water Resources Management - SINGREH, mobilizing the various actors around the innumerable issues associated with the management of water resources. With the educational process, the interface of themes such as the issue of poverty, diseases and health, human settlements, floods, water and soil degradation, climate challenges, among others, is worked on. In this way, the territorial approach of the river basin becomes a good way to transform attitudes, behaviors and values, through permanent and continuous educational processes.

The National Policy of Environmental Education - PNEA, instituted by law n. 9,795 / 1999 and regulated by Decree 4.281 / 2001, determines the creation, maintenance and implementation of environmental education programs integrated with the activities of management of environmental resources, including water resources.

Considering Environmental Education as a continuous and cyclical process, the theoretical and practical foundation of the projects in several instances can occur through the study of generating themes that include lectures, workshops and field trips. This process offers subsidies to teachers and others interested in transferring knowledge to act in a way that encompasses the whole society, contributing to the active involvement of the public, making the education system more relevant and more realistic (Roos et al. 2012).

The population, in general, must be evolved in these management instruments, which leads to the realization of environmental education programs, both formal and non-formal to water resources. In this perspective, EE aims to involve the population in actions to manage water resources, in order to recognize its role.

Based on an EE proposal for water resources management and the application of environmental policy instruments, which play a fundamental role in improving relations between man and nature, it is possible to identify the aspirations of the community, as well as the means, to guarantee the popular participation in the management of the watershed areas, through sustainable local development (Bernal 2012).

In the State of São Paulo, social actors emerge in public debates, which were previously monopolized by the energy and basic sanitation sector. The great innovation that emerged with the promulgation of the State Policy of Water Resources was the opening of the decision-making process and the management of the participation of diverse segments of civil society through the creation of the Watershed Committees, which are advisory and deliberative bodies that promote the management water resources within the limits of the river basins (Eça et al. 2013).

In fact, the Basin Committees, since they are constituted spaces, which aggregate public institutions and civil society, and which has the role of promoting the debate on issues related to water resources, moderating conflicts and approving and monitoring the execution of the Resource Plan In the last two decades, river basin water has become a central instance in the implementation of this public policy, which must be strengthened and improved continuously (Diniz & Maranhão 2013).

The structure of the Basin Committees proposes the establishment of Technical Chambers, which are thematic commissions that can be created through deliberations, with the objective of technically subsidizing the members of a Basin Committee in their decisions in the Plenary. In its scope, the creation of technical chambers of Environmental Education has been fostered, with the function of promoting communication, education, training and mobilization actions.

The Technical Chamber of Environmental Education is of great importance in a Hydrographic Basin Committee, since it contributes to a greater participation of society through several environmental education projects, in addition to increasing the knowledge of the participants about the technical contents addressed, favoring the mediation of conflicts and promotion of sustainability.

Chapter 18 of Agenda 21 emphasizes the protection of the quality and supply of water resources with the application of integrated criteria for the development, management and use of water resources, and thus to meet the water needs of all countries for development sustainable development.

In 2015, heads of state and government and senior representatives gathered at UN headquarters established a set of 17 goals that balance the three dimensions of sustainable development: economic, social and environmental, as well as including 169 universal goals, integrated and transformative, long-range and people-centered, with full implementation of this Agenda in 2030.

In this context, the investigative studies that mitigate this work is to verify how the real participation of the civil society in the CBHs occurs, to legitimize the democratization of the management of the natural resources and the practice of the sustainable development. The analysis of the activities of different Committees throughout their trajectory is important, in order to infer the stage of implementation of society in debates and meetings in a participatory and democratic way. Given this, this work is justified because there are few studies developed on this subject in the area under study, which implies actions that favor the improvement in the quality of management of the natural resources of a basin, through a greater interdisciplinarity between Education and Geosciences.

1.1 Characterization of the study area: Environmental Education in the Piracicaba-Capivari-Jundiaí River Basin Committee (CBH-PCJ)

Regarding the study object, the CBH PCJ (Piracicaba, Capivari and Jundiaí River Basin Committee) was created in 1993 as the first Basin Committee of the State of São Paulo. Thus, it will be sought to verify how the protagonism of civil society, through the environmental education projects within the scope of the Basin Committee, and the effective actions that have resulted from such projects, will be sought.

The Piracicaba, Capivari and Jundiaí River Basin Committee (CBH-PCJ) covers an area of 14,137.79 km2 in the state of São Paulo, Brazil, of which 11,402.84 km2 correspond to the Piracicaba River Basin, 1,620.92 km2 to the Capivari River Basin and 1,114.03 km2 to the Jundiaí River Basin, as shown in figure 1.

This Water Resources Management Unit, located in the eastern region of the State of São Paulo, corresponding to the Piracicaba, Capivari and Jundiaí River Basins, has independent exutaries on the Tietê river, and is called UGRHI PCJ or UGRHI 05 (Xavier 2006).

The watershed region of the Piracicaba, Capivari and Jundiaí rivers has great political and administrative importance, concentrating a population of 5.5 million according to the IBGE census in 2014. In the 60s it was a vector of growth in the interior of the State of São Paulo and began to supply 31 m^3 of water to the Metropolitan Region of São Paulo through the Cantareira System, whose construction began in the same decade.

Currently, this volume supplies 50% of the Alto Tietê basin and continues to be the largest producer of water for the RMSP (Metropolitan Region of São Paulo). The water balance of sub-basins such as the Corumbataí, Jaguari and Capivari rivers has reached 50% of the utilization of their available water resources, which in terms of management security shows that these sources are in a critical situation, since they occur in them conflicts can occur or may occur through the use of water resources (Morgado 2008).

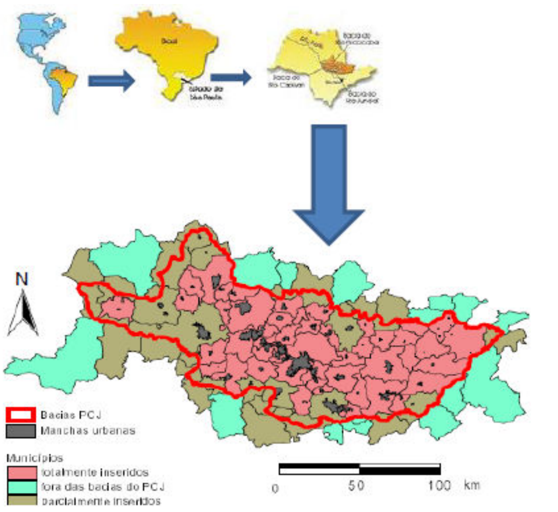

Figure 1. Location of the Piracicaba, Capivari and Jundiaí river basin in the state of São Paulo, Brazil

With the expansion of economic development and population growth there is a greater demand for water resources, which puts the region on the alert and requires planning and resource management to ensure multiple uses. In this scenario, the withdrawal of water through the Cantareira System further aggravates the situation and creates conflicts between municipalities and hydrographic regions, such as Alto Tietê and PCJ basins (Morgado 2008).

Thus, there is a gradual increase in the importance of Environmental Education in maintaining the environmental quality of public water supply sources, considering that the native forests of the region are concentrated mainly along the banks of watercourses and in conservation units, representing 7, 93% of the 15,300 km² area of the Piracicaba, Capivari and Jundiaí rivers basin (Morgado 2008)

The analysis of the participation of civil society in the management of water resources in Brazil has as its starting point the federal legislation that includes the Federal Constitution, the Law of Waters and the National Policy of Water Resources, in which the insertion of this segment in the normative instruments established for the management of water resources. In this context, the maturity of actions and policies in favor of the environmental issue, Basin Committees acquire an important role in society as effectively public and democratic spaces, according to the principles and foundations referred to in Law No. 9,433 of 1997.

The activities in environmental education focused on water resources management in the PCJ Committee began before the collegiate policies were established in 2004. These experiences were evidenced since the creation of the State PCJ Committee in 1993 and the experiences until 2017, have demonstrated a great diversification in the projects that seek to reach different target audiences with different languages and methodologies, but all with a common objective, to facilitate communication for the implementation of the water resources management system in the region.

The study area that constitutes the CBH-PCJ's territory covers 58 municipalities in São Paulo. The basin is inserted in the center-east border of the Paraná Sedimentary Basin, being formed by a great variety of lithologies. In relation to the geomorphological provinces, there is the presence of the Atlantic Plateau, Peripheral Depression and Basaltic Slopes.

The CBH-PCJ region, although widely used for agriculture and experiencing high urban-industrial growth beginning in the mid-1970s, is an important area of biodiversity. It has remnants of the Atlantic Forest and Semi-Deciduous Seasonal Forests of Plateau, with scattered fragments.

The bodies of water belonging to the basin cross regions of the State of São Paulo with high population density and industrial development. According to the 2010-2020 Basin Plan, the quality of the water bodies indicates that there is a 2/3 ratio between the number of scheduled stretches and those that do not comply with the draft proposal, which do not meet the framework.

In this context, the basin committee has an important role to insert projects that involve the regional communities, in order to prevent and mitigate environmental problems, through environmental education.

Environmental management of river basins is a complex task that requires collective practices that have the dissemination of information and the creation of activities in networks that are easy to reach. This process should take into account the socio-environmental context in which the basin is inserted and the activities aim at the joint learning to determine the tasks to be carried out from a common agreement of the society for its management (Jacobi et al. 2011).

In fact, Bernal (2012) points out that in participatory planning the determination of participation levels, or the stages in which it occurs, is an important procedure. When we return to the performance of different segments of society in a basin committee, for example, we realize that there is an internal participation with representatives of civil society and the participation of society in general at other times. However, it is recommended that participation occurs at the highest number of decision and action levels, so the process will be more authentic, integrative and decentralized.

The participation of society in certain important events in the context of which it belongs, such as during the elaboration or fulfillment of goals of a basin plan, is often hampered by the unavailability of systematized information to the community that covers a particular committee. This participation of society should be encouraged in the school environment, which is often unaware of local environmental policies, which indicates an obstacle to educational practice on local committees (Meneghesso 2014).

Several private and public institutions at the municipal, state, federal, and governmental and nongovernmental levels of Brazil are increasingly inscribing in their pedagogical practices actions dedicated to Environmental Education, even though they are local actions, however, they fall short of the principles that which aim to open spaces that can ally the quality of life in the community (Lima et al. 2007).

Within the scope of the CBH-PCJ, the Technical Chambers (TC) are composed of a coordinator, an assistant coordinator and a secretary, elected from among the CBH members, whose bodies or entities are able to provide technical and administrative support to the development of its work (Deliberation of the PCJ Committees no. 115/11, of 06/28/2011).

Currently CBH PCJ has 11 Technical Chambers, being CT of Underground Waters, CT of Environmental Education, CT of Integration of Diffusion of Researches and Technologies, CT of Hydrological Monitoring, CT of Grants and Licenses, CT of Water Use and Conservation in Industry , CT of Basin Plan, CT of Protection and Conservation of Natural Resources, CT of Sanitation, CT of Environmental Health and TC of Use and Conservation of Water in the Rural Environment.

Thus, based on a diagnosis on the production and diffusion of environmental education in the scope of the projects developed by the Committee, and the conservation of natural resources, through spaces brought by the National Water Resources Policy, promulgated with Federal Law n. January 8, 1997, emphasizing the importance of the role of the Hydrographic Basin Committees (Brasil 1997), will analyze how the gradual participation of civil society on the environmental theme, which is addressed mainly through projects, is analyzed. can promote the empowerment of society in preserving the environment in which we live.

In this context, it is essential to present and disseminate the actions and results of these works in participatory spaces such as the Hydrographic Basin Committees, in which they should be regional-minded in an effective water parliament and as an important arena for socio-environmental debate (Martins 2015).

2 Methodology

In this work, the methodological proposal was the case study, which is a procedure used with the objective of understanding and planning the intervention, in which the theoretical knowledge is directed to a specific territorial cut, as a procedure of scientific investigation, with the purpose of evaluating the their possibilities of contributing to the construction of scientific knowledge, since the various systems only acquire a human meaning insofar as they are assumed by action and intervention (Gutierrez 2002).

In order to carry out the present study, meetings were held bimonthly in different municipalities of the CBH-PCJ, through observant research, in which the facts are perceived directly, without any intermediation, reducing the subjectivity of the research (Gill 2008).

Through participation in these committee meetings and documentary analysis (minutes, reports, etc.) it was found that some subjects and projects are treated with a higher priority than others, according to the demand and relevance. It was observed that one of the programs with the greatest repercussion and comprehensiveness is a so-called Water Drop, which carried out preparatory actions for the 8th World Water Forum to be held in 2018, a fact that was verified at the 81st ordinary meeting of the Technical Chamber of Environmental Education in 21 / 02/17.

Thus, a questionnaire was elaborated to the members who coordinate this project, through open questions, for a greater information gathering and understanding of those involved in it, constituting the qualitative research that supported this work (Flick 2009).

3 Results and Discussion

Through participation in the meetings of the Technical Chamber of Environmental Education of the PCJ Committee, as well as analysis of the latest minutes and documents, it was verified that several objectives are fulfilled such as participating in the elaboration, implementation, dissemination, monitoring, of Environmental Education of the PCJ Basin Plan; participate in the drafting and revision processes of the PCJ Basin Plan and the Water Resources Situation Report; propose, guide, evaluate and follow environmental education projects financed by the PCJ Committees; propose the elaboration of educational and communicative materials for the PCJ Committees; map and promote the articulation and integration of environmental education actions in the PCJ Basins; prepare its Work Plan and schedule of activities, at the beginning of each term; to create Working Groups, according to the needs of the committee's demands.

The activities in environmental education focused on the management of water resources in the PCJ Committee began before the collegiate policies were established in 2004. These experiences were evidenced since the creation of the State PCJ Committee in 1993, with the objective of assisting in the implementation of the Water Resources Management System, according to the State Policy of Water Resources of the State of São Paulo, Law 7663/91. In this way, there is a great diversification of the projects, financed by FEHIDRO, that seek to reach different target audiences, with different languages and methodologies, always seeking to facilitate communication for the implementation of the Water Resources Management System.

Table 1 (attached) shows the main projects and environmental programs with interface with existing water resources for the Piracicaba, Capivari and Jundiaí Rivers watershed region.

It is verified that all projects are focused on Water Resources Management, with great diversification and concern to reach different target audiences, with different languages and methodologies, always seeking to facilitate communication for the consolidation of the Water Resources Management System.

A questionnaire was directed to the coordination of the Gota D'água project, to better know a "Non-Formal" project developed in the Committee, which already reached 103,353 educators and 3,238,545 students. The Gota D`Água project is of the PCJ Consortium, which is an intermunicipal consortium formed by municipalities and companies. The PCJ Consortium is a member of the PCJ Committees and the main objective of the project is to involve potential environmental educators / agents to carry out environmental awareness actions aimed at the management of water resources in their municipalities Activities and actions are developed by their programs, among them the Environmental Education and Awareness Program, which has contributed to the understanding and implementation of the water resources management system in the region, with differentiated methodologies and accessible language.

The Gota d'Água Program emerged from a need observed in the Water Week Project, developed by the PCJ Consortium since 1994. Since the Water Week is aimed essentially at the formal public (mostly municipal school an increasing demand from stakeholders from other sectors (companies, NGOs, universities, environmental secretariats) was observed. To achieve a greater involvement in environmental education actions, the project was expanded, thus creating the branching of the Gota d'Água project.

In 2017, the 5 best projects of Education and Environmental Awareness were awarded and guaranteed a place in the entourage for the World Water Forum in Brasília for the year 2018. These actions have been able to reach their objectives, seen that there has been an increase in the number of participants from various sectors of civil society.

4 Final Considerations

It is verified that all projects are focused on Water Resources Management, with great diversification and concern to reach different target audiences, with different languages and methodologies, always seeking to facilitate communication for the consolidation of the Water Resources Management System.

From the evaluation of the projects carried out and / or in progress in the municipalities belonging to the Piracicaba, Capivari and Jundiaí river basins, it was verified that environmental education represents a fundamental instrument for a possible alteration of the current environmental degradation model, acquiring a transforming and conscientizing function for a new paradigm of sustainable development.

It is clear that it is important to make citizens, especially children and adolescents aware, to act responsibly and keep the environment around them healthy in the present, so that in the future they will be able to demand and respect the rights of their own and those of their entire community.

Through the application of the questionnaire, it was verified that the main positive result of the Gota D`Água Project, which already has 27 years of existence and an ampla network of environmental agents, is the increase in the quality of the actions carried out in the municipalities that already participated in the environmental education projects of the PCJ Consortium, which are now achieving a wider range of partnerships and involvement of the various social actors in the municipalities, although there are difficulties in attracting resources, as well as the permanent exchange of municipal actors, since alternations of public managers and changes in their priorities and interests.

Although Environmental Education is guaranteed by article 255 of the Federal Constitution (Brazil 1988), there are many difficulties for its implementation in several places. Although there have been good examples, such as the Gota D 'Água project, there are still some barriers along the way. These difficulties occur when there is a lack of resources and support from management teams or even from some professionals who are not yet prepared to work on environmental issues, or even by not knowing how to do Environmental Education practice activities outside the workplace, contributing to increase disinterest and demotivation.

The case study developed showed that intervention, through Environmental Education projects, allows the transformation of the community and the way it interferes in the environment, seeking to find solutions to the socio-environmental, economic, political, cultural, to which they are subject.

The results obtained in the projects analyzed in the municipalities belonging to CBH-PCJ indicated that it is important that such projects present sustainability of the proposed actions, and that other institutions adopt similar initiatives. In fact, the good examples and attitudes developed enable an improvement in the quality of life for the communities involved and the promotion of the objectives for sustainable development proposed by Agenda 2030.

Thus, the projects developed by the CBH-PCJ show a maturation of this democratic space of management of water resources, in relation to the others. Likewise, the fact of having a basin agency, reflects a greater investment of resources and prioritization of environmental education projects on a recurring basis.

The importance of participatory spaces in river basin committees, with Environmental Education projects with continuous occurrence, allows the construction of a critical and conscious thinking of those involved, protagonists in the management of water resources. Likewise, it is essential that the committees corroborate that these practices occur in a participatory, democratic and pleasurable way.

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Table 1. Main Projects developed in the PCJ Basin

Project title	Period of realization	Influence area	Organization and collaboration	Goals	Contents of Geosciences
Riparian Forest Recovery Program	2005-2017	Micro-Basins de Nazaré Paulista, Cabreúva e Joanópolis	Municipal Secretariats of Environment and Agriculture	Development of instruments, methodologies and strategies to make feasible a program of restoration of long-term riparian forests.	Water sources; Water quality; Hydrological cycle; Erosive processes; Native vegetation; Contamination of waters.
Water and Water Drop Week	1994-2017	40 counties belonging to the PCJ River watershed	PCJ Intermunicipal Consortium	Involve potential educators / environmental agents to carry out environmental awareness actions aimed at the management of the water resources of the watershed.	Contamination of urban rivers and groundwater; Water quality; Vegetation; Basic sanitation; Environmental education
Water Enduro (Enduro Ecológico)	1996-2017	All segments of society in the PCJ River watershed	PCJ Intermunicipal Consortium	Community awareness and awareness about the problem of water resources and environmental degradation.	Vegetation, urbanization; Quality of water resources; Environmental education
Mini-Nurseries	2001-2017	10 counties belonging to the PCJ River watershed	PCJ Intermunicipal Consortium	Provides opportunities for teachers and students to enhance their knowledge of the environment.	Vegetable landscapes; Geodiversity; Pedology; Hidrills.
Training courses	2006-2017	Community in general of the PCJ River watershed	PCJ Intermunicipal Consortium	Elaboration of projects based on the PCJ Watershed Plan	Environmental education; Watersheds; Water quality, socio-environmental impacts; Historical patrimony.

Continued from table 1.

River springs and Micro-Basins	2004-2017	Community in general of the PCJ River watershed	Coordination of Integral Technical Assistance (CITA)	To work together with the rural producers of São Paulo for environmental improvement through the planting of cilia-res forests, adequate soil management and adaptation of rural roads.	Preservation of the rural landscape; Minerals; Vegetation; Use and conservation of soil; Hydrographic microbasins.
Letter from Indaiatuba	2007-2017	Metropolitan Region of Campinas (RMC)	9 counties s belonging to RMC	Improve the quality of life of the population	Environmental sustainability; Basic sanitation; Arborização urbana; Reforestation; Biodiversida-de; Energy sources.
Green Blue County Project	1991-2017	The entire population belonging to the PCJ River watershed	Intermunicipal PCJ consortium, municipalities and public power	Awareness of society on the problem of water resources with water recovery actions.	Water sources; Quality of water; Environmental education; Basic sanitation; Native vegetation; Resource counting
Projeto Município Verde Azul	2007-2017	All counties in the State of São Paulo (including the PCJ watershed)	State Public Power	Share the environment policy with the municipalities and prepare the municipalities to carry out environmental licensing and fiscalization.	Environmental legislation; Solid wastes; Bio-diversity; Urban planting; Environmental education; Sustainable city; Water management; Air quality.

UNESCO GLOBAL GEOPARKS AND ENVIRONMENTAL EDUCATION: A DIALETICAL (DE)CONSTRUCTION

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Abstract— It can be inferred that the concept of Geopark enables a systematization and compilation of segments whose activities tend to exist, function and develop in an autonomous and parallel form. Created by European Geoparks Network in 2000, assumed the auspices of UNESCO in 2004, and in 2015, with the official designation of UNESCO Global Geoparks, integrated in the International Geosciences and Geoparks Program and became official in UNESCO. For such purpose, it aims to formalize and seal the concession of the title of Geoparks through guidelines whose outcomes pass through several areas of knowledge, such as geology, biology, tourism, economy and history. That is where it is necessary to build an Environmental Education that allows the installation and creation of a geographical space, whose potential is to capture materialities and subjectivities by which individuals and local communities recognize themselves as the backbone and the center of projects or programs that encourage an Ecological Awareness, allowing an Environmental Awareness.

Keywords— Geographical spaces; ecological awareness; environmental praxis; environmental awareness.

Thematic line— Education, Teaching of Geosciences and Teacher Training.

1 Introduction

1.1 Initial motivation

The purpose of this paper is foreseeing questions rather than predicting answers. Because of the current theme, UNESCO Global Geoparks and the environmental issue coverage, it is required reflecting essentially on correlations between territories and Environmental Education (EE). Also, it is intended to show alternatives to traditional and standard model of EE, according to which the participation is still conceived in a passive way, that is, with no effective decision power.

Therefore, it should be analyzed: it is proposed a new EE which pursues to value as a whole the complexities and potentially transformational contradictions of human reality, or that one focused on fragmented and limited ideological projects? An EE based on cultural foundations which rescue the local communities stories, or that one 'tailored' to local communities? An EE built with and to people and communities, or that one granted for extrinsic factors? An EE which limits it and limits itself to Ecological Awareness of that one which aims to become Environmental Sensitization?

Scrutinizing and depurate its repercussions implies basically in conjecturing which and how are the mechanisms that allow transfiguring portions of land or delimited areas in built and institutionalized environments by human action.

1.2 Brief history

Emerging in Europe, at the end of the XX Century, Geoparks appears as a potential connector and coordinator of geological, archaeological, biological and cultural heritage, which aims the improvement of life quality of the population, which lives inside these territories. Regarding the UNESCO Global Geoparks setting, UNESCO (2017) pursues circumscribing it by a set of guidelines. The first one refers to the preservation of geological heritage; the second one aims to guarantee sustainable development by touristic activities, and the third one, in turn, is defined as the process of educating and teaching environmental issues, acting as a fundamental base to the other guidelines.

In general, a UNESCO Global Geopark (UGGp) is conceived from the notion of territory. Conforming to Brilha (2009):

> "A Geopark is a territory, geographically well-delimited, with sustainable development strategies […]".

In compliance with Oliveira et al. (2014):

> "Geoparks correspond to a territorial development strategy which presents itself as a revolution in the way of broadcasting Geosciences".

As alleged by Bacci (2009):

> "a Geopark, which comes from a previously delimited area, must have sustainable development programs and educational projects".

Araripe UNESCO Global Geopark – unique in Brazil, even being the country endowed with excellent natural and cultural wealth – underwent subsequent assessments, which showed failures in the participation of the local community. Established in 2006 in the State of

Ceará and certified by UNESCO to integrate the Global Geoparks Network, its implantation and functioning demonstrated that there are several problems to be solved, for example the maintenance of the UGGp and a greater participation of the community.

Based on the exposed issues, it is justifiable to manifest some reflections regarding possible structures which underlie the project of a UGGp, whose building, inserted initially in the territories, aims institutionalizing itself in the dialectical construction of spaces.

1.3 Theoretical basis

According to the dictionary Houaiss (2017), “Concept is the abstract notion contained in the words of a language do designate, in a general and in somehow, stable, the properties and characteristics of a being class, objects and abstract entities”. Consequently, it appears that a concept out of its context or category may create room for multiple and diffuse interpretations, which are often divergent and contradictory between each other. Hence, the importance of locating, disposing and adapting terms, as far as possible, inside their related epistemological classes.

1.4 Space, Materiality, Totality

From Antiquity to Contemporaneity, the notion of space has occupied the minds of researchers. The object of study in several areas, such as mathematics, physics, geology, sociology, philosophy and architecture, it is not an easy task. In most dictionaries its more common meaning is the one which interprets it by physical measures, like distance, area or volume. Similarly, the synonymy of place carries the Cartesian ideas of point, station or position. Other senses, however, pursue more abstract meanings for such words, allowing them to assume several contours.

Geography evolves historically by multiple currents, each establishing their paradigm by the appropriation of certain concepts. According to Queiroz (2014),

> The current of traditional geography […] owns the territory, the landscape and region as main concepts. The current of humanistic geography, based on existentialism, focus on the concept of place, understood as lived space. The currents which dispose space as key-word are quantitative geography […] and critical geography, consolidated on historical materialism. In the first current, space is optimally comprehended, while, in the second, with objectivity and subjectivity.

It is a fact that the passage of quantitative to critical current succeeds in untying the notion of space from the measurable field or numerical accuracy. However, it is essential in highlighting the appearance of humanistic geography as an important counterbalance to the renovation currents driven by the theoretical geography itself as by critical geography. According to Queiroz (2014a),

> The humanistic geography […] reclaims some elements from traditional geography and criticizes the lack of subjectivity in quantitative and critical currents. This current owns as main philosophical basis the existentialism, as method, the phenomenology. The space, in the humanistic current, is not a key-concept, where the concept of place is privileged. […]. Returning to the current of critical geography, there are at least three varieties of this (Soja 1993). The first […] had as purpose adding, to geography, the concepts and analysis categories created by Karl Marx and by Marxism, the concepts and categories of geography in a flexible form, with influences from philosophical currents of structuralism […] and existentialism.

It is observed that the overcoming of the geographic determinism paradigm creates a new conflict, now represented by the dichotomy between space and place. Such confrontation presents itself peculiarly, in turn, considering that both strands are based on existentialism; variations of the critical current, on the other hand, they pursue to broaden the horizons of geographical thought by approximating themselves to other philosophical matrices, while preserving, nevertheless, materialism and dialectical method.

It can be explained the existence of this contradiction by the careful reading of the word flexible. In fact, it enables two interpretations: the first reveals the latent difficulty found by geographers to conceive the notion of space. Corrêa upholds apud Queiroz (2015), that

> “there is not a consent about the concept of space due to the different philosophical matrices and to the different approach methods from each current”.

That is, the second, consequence of the first, denotes the necessity to establish a dialogical relationship between the concepts in contest, abandoning radical thoughts which tend to totalizing binary and fixed ideas. Concordant with Abbagnano (1987),

> “However, it should not be considered that Marx wished to become an advocate of an economical fatalism, according to which the economic conditions would necessarily lead man to certain forms of social life. The historical M. caused a stir to an interpretative canon, to which is many times essential to turn, in order to explain historical-social events. In fact, to it they turn in all fields of human activity, since sometimes the way open by this kind of historical explanation is the only one possible. Yet it is not always the only one possible. Nowadays the tendency is to interpret the historical M. as an explanatory possibility, to which they appeal in appropriate circumstances, not as a dogmatic principle […]. In other words, stating that events or historical-social situations always must be explained by the determinism of economic factors is thesis as dogmatic as any other which intended to exclude absolutely and in all cases the determinism from such factors.

In this sense, the Brazilian geography influenced by Milton Santos confirms this tendency, according to Queiroz (2014 a),

> As observed, the author did not limit himself to the historical m., suffering influences from existentialism, focusing on Lefebvre, Althusser and Sartre dialogue. Likewise, he was able to establish a dialogue between the works of Marx, Weber and Durkheim, which is considered almost impossible by social sciences. Such achievement shows that in his thought there was no concern about following a philosophical current. Beyond this, Milton Santos pursued creating, producing and developing a geographical analysis method based on dialectic.

In this perspective, the thought of the geographer meets Marxist theory in Marx (1845),

> “The philosophers only interpreted the world in different ways; what it is about is transforming it”.

No wonder, a third variety of the critical current requires from geography a new hermeneutic, according to which materialism not only explains reality, but also can – and primarily – transform it in the light of socio-spatial totality. Queiroz (2014 b) reports:

> The geographical space (Santos, 1996) is different from social space (Lefebvre, 1974), however this is inserted in that. The geographical s. is concrete; it is the junction of material space and physical space. The material space is the physical space, that is, it encompasses the natural space and the space produced from human work. The social s. is the immaterial space, although it depends on materiality to exist (Souza, 2013). The social s. is the space of networks and spatial interactions, of territories and territoriality, of places and social representations. The geographical s. is defined by Milton Santos as a fact and a social factor. That is, the geographical s. would not only be a reflex, a means to the action of society. […] The geographical s. is a cultural instance like others – economics, politics and culture or ideology (Althusser, 1974) - being at the same time a subordinated and subordinating instance (Santos, 1978). In light of this context, the nature of geographical s. is the dialectic between inertia and dynamic, between the inert and practical, between the form and content, between the material space and the social space.

In short, such reflections start to comprehend and to define the geographical space not in a fragmented form, but in its totality. That is, the awareness, before a product of purely economic social relationships, is now explained not only by objective abstraction of reality but also by realities, endowed with subjective practical and quotidian dimensions.

1.5 Awareness versus Sensitization

Environmental Awareness (EA) and Environmental Sensitization (ES) are terms related to EE, and their meanings are, many times, mistaken for each other. Marques (2004)

> "in spite of the issue "environment" being a fad in our daily lives, this idea is not incorporated yet in the consciousness of people and communities […]. To perform a proper EE, it takes having some measures which are able to sensitize the population" (our emphasis).

According to Costa Filho (2014); Amaral & Abreu (2014), the practical activities are a way to the process of Sensitization and Environmental Awareness (Brasil *apud* Lopes 1997):

> "by the educational process it is possible to promote Sensitization and Awareness in order to preserve ecosystems" […]

Souza (2014) the punctual practices which do not present effective continuities of formal Environmental Education, even considering their importance, do not interfere in the process of Sensitization. According Butzke (2011), Sensitization and Awareness are the Environmental Education performance indicators and conceptualize, generically, as commitment action and motivation of people. Similarly, *Política Nacional de Educação Ambiental (PNEA)* – Law 9795/1999, states in its article 13 that non-formal Environmental Education should be comprehended as educational practices aiming the sensitization of community about environmental issues in BRASIL (1999).

Finally, emphasizes Marin et al (2003) that the process of EE, initially connected to EA, is based on the transmission of information, where it differs from ES, whose purpose is transposing these conceptual barriers and to propose behavioral changes. In addition,

The sensitization brings, therefore, the purpose of transposing rational focus on educative practices and the pursuit of reaching an emotive dimension, a spiritual perspective in their interaction with nature. By making an analysis of developed practices in several contexts where environmental education is required, it is observed that a minority of actions, those which are able to reach that complexity and awakening contemplation, the nostalgic interactivity, the reflection and the emotion, are represented in Marin et al (2003).

With the aim of clarifying the points of connection between EA and ES, it is stressed – for example – the improper disposal of waste: an aware individual understands the harm, which does not prevent them from performing irregular waste disposal. It means that, besides being aware, it makes them sensitive to the environmental cause resulting also in practical behavioral changes. Galvão (2017):

> "Being aware is the beginning, but it is not the end […]. Sensitization for sustainability, is making people value properly environmental responsibility so that they start to act spontaneously and regularly to reverse the situation in which we are".

Therefore, on the basis of the above, it can be inferred that EE should be understood in its complexity, and approximating it from the foreseen guidelines in PNEA means to highlight the process of ES as a result of a successful EE, thereby overcoming the simple idea of awareness.

1.6 Education and Praxis

An education which is possible is a product of a possible reality. According to Boff (1997), "Every point of view is the view from a point. To understand how one reads, it takes knowing what they see and what their world perspective is."

In this sense, it is highlighted:

> "It is not conscientiousness that determines life, but life which determines conscientiousness. The first way to consider things, is to comprehend conscientiousness as a living individual; the second, which corresponds to real life, is to comprehend the actual living individuals themselves, and it is considered conscientiousness only as its conscientiousness" (Marx 1845).

A viable EE that conquers permanent and constant advances, is not just able to receive the nuances and features of historical social subjects, but to also to make them able to see themselves and see it reflected in the space. Marx et al (1845):

> "We only know one science, the science of history. The history can be seen by two sides: it can be divided into natural history and man's history. Both sides, however, should not be seen as independent entities. Since man exists, nature and man influence each other mutually".

Likewise, Batista (2007) corroborates and supports,

> "The praxis, to whose meaning Marx attaches transformative revolutionary action, transcends the condition of simple action. Nevertheless, it does not express any transformative action, since it is rooted in a dialectical conception of history and society, it connects conscious thought and real action, aiming at the radical transforming of society. This is because praxis enables the transformation of theory into practice, essentially, a revolutionary and transformative practice".

Notwithstanding, underrating the human condition as intrinsic and inseparable from its historical identarian construction makes this EE dependent exclusively on external factors. Weil apud Bosi (2012) highlights,

> "We have to think […] about a project – what kind of knowledge we are pursuing and building. Because the reconstructed past is not a refuge, but a source, a wealth of reasons

to fight. Hence, memory here no longer has a restorative character of the past and goes on to be the memory that generates the future: social memory, collective and historical memory. […] the bond with the past, which is vital, because from it is extracted the sap for the formation of identity. In this sense, there is also the notion of right to set roots, by Simone Weil, to whom this is a human right similar to other rights connected to the survival of man."

Consequently, alienated severely from the behavioral changes increased by stories and local cultures, such education establishes itself by purely mechanicist bonds, which prevents it from conceiving Environmental Sensitization as a process, by which EA engenders dialectically the Participation.

2 Methodology

The dialectic between several theoretical-environmental currents interspersed by philosophical concepts are the methodological bases for the proposition of this work. In order to do so, a research is made in the geographical theories that can establish links between such seemingly disconnected fields of knowledge. Based on elements of textual analysis, a new reorganization and juxtaposition of these areas is sought, whose purpose is to create instruments that enable existing EE to reveal and remedy its contradictions, thus enabling another EE model.

The rupture with the traditional, however maintaining its essential aspects, is inherent to the dialectic of ES. Imagined before the need for perennial transformation of singular and collective behaviors, it is its initial challenge providing EA with the means to recognize itself as a power, from where thoughts and action are the substrates of ethical actions. According to Chaui (2017),

> "In short, an action is only ethical if it performs in the free, responsible and rational nature of the agent and if the agent respects the freedom, responsibility and rationality of other agents, so that the ethical subjectivity is an inter-subjectivity. Ethical subjectivity and inter-subjectivity are actions and ethics only exists by and in the action of social and singular subjects, defined by bonds and forms of sociability, also constructed by human action in certain historical conditions."

Thus, an EE endowed with criticality, because of its complex and wide approach in several areas of knowledge, must embody the current challenges for the purpose of mobilizing for ruptures in traditional forms of thinking and acting. Heidegger apud Giacoia Jr. (2013),

> "According to Heidegger, thinking does not disconnect originally from acting – it acts while it portrays itself as thinking. In this sense, thought does not transmute into action because of the effect which can result from its application. Thinking is acting on a higher level of meaning, not being separate from action by any abyss to be recovered or transposed by diverse forms of application or usage."

In this perspective, it is encouraged to enclose methodological alternatives before an ES process which allows deconstructing – not destructing – the hegemonic EE models. According to Barcelos (2008),

> "The theoretical production and initiatives in the pursuit of understanding the possible origins of ecological questions, as well as different invoked methodological alternatives, have challenged us to promote some ruptures and changes in direction. Our philosophical tradition of copying, instead of creating, is not able to handle the current challenges anymore."

Therefore, starting out from the basic definition of territory stamped by UNESCO, it is necessary to locate the analyses of this project across the spectrum of geographic sciences, a field of study which gives a new constructive meaning while classifying it as an element inside the category of geographic space.

3 Conclusion

Besides constructing UGGp, it is necessary to architect them before. This implies saying that social relationships flow not only by space materiality, but also by the perennial flow of time, since human constructions neither are linear, nor occur by magical thoughts. Therefore, further development on the issue is supposed to be expanded upon in a future paper, as well as the posing of other relevant questions, among which elaborate a collegiate management before any possible intercity connections regarding the Geopark territory.

This paper sought to propose the construction and establishment of UGGp from an interpretation of the established guidelines by UNESCO, which, in turn, should consider characteristics and specificities from each area, not guiding themselves only by criteria and "universal recipes", but by apprehension and comprehension of natural and human singularities as a whole.

Furthermore, it aimed not only at rationalizing how a UGGp institutes itself, but mainly what it is in its ontological essence. In this context, it proposed to define geographical space's own nature as the canon of human relationships, whose ramifications enable a simple physical territory or geographically delimited area to become, by socio-spatial-pedagogical praxis, institutions endowed with human dimensions.

A plausible model of the implantation of a UGGp should come from a reflection about how social existence overderminates consciousness, and how this one, being a necessary condition for Participation, foments Sensitization. It proposed, therefore, to comprehend it and to visualize it as a process, by which reality explains Environmental Awareness, propelling it towards the stage of Environmental Sensitization, the supreme level of an Environmental Culture which seeks to perpetuate itself by an Environmental Education.

Finally, while urging a rupture of "the regular and standard" by integrated actions constructed with and by spaces, this article requires that the institutionalization of Geoparks, if institutionalized with and for local community and in socio-environmental dynamics, contributes to the process of ES. In other words, it is the dialectic existence itself among spaces, EE and ecological interaction, that is responsible for the development, maintenance and survivorship of UGGp.

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GEOSCIENTIFIC KNOWLEDGE IN THE CONTEXT OF ECOSYSTEM AND ENVIRONMENT SERVICES

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Abstract— Payment for Environmental Services is a policy implemented from the revision of the Forest Code of 2012, which has been applied to rural producers, whose main objective is to encourage the maintenance of vegetation and / or recovery of permanent protection zones in rural areas. The "Produtor de Água" and "Projeto Nascentes" Programs are examples of projects aligned with this policy, and their objective is the water protection in the country. The programs adopt initiatives to reduce erosion and sedimentation of water sources in rural areas together with producers and owners of these areas, who voluntarily join the programs and are committed to adopting sustainable practices and management in their lands for the conservation of soil and water. These programs are designed in a partnership format between different actors of society: federal, state and municipal public management; nongovernmental entities; rural producers (owners of the areas to be reclaimed); and private initiative. It is understood that, for these programs to be successfully developed and their continuity guaranteed, payment for environmental services must occur in parallel with a continuous process of Education for the Earth System, which establishes the acknowledgment of the natural processes that surround it as a premise for the involvement of the rural producers in the recovery and / or conservation of springs areas. Based on this scenario, this article aims to present a methodological proposal to define a set of social and environmental indicators that must be monitored throughout the implementation and establishment of such programs, to ensure an effective and sustainable management, given the complexity of the scenario in which they are created and implemented, involving several social actors. The methodology involves qualitative research, based on semi-structured interviews with local political agents and rural producers. The communities of the municipalities of Salesópolis and Jundiaí, in the state of São Paulo, will be focused on. The municipalities in question present distinct situations both in relation to the programs' progress and the political and social scenarios. Besides the interviews, two parameters that involve the management of water resources in Brazil – quantity and quality – will be discussed in workshops with the local actors. The construction of indicators that can demonstrate socio-environmental improvements with the involvement of the various actors participating in these programs is considered the key factor for this research. Coupled with these objectives, the involvement and application in two realities will bring a rich discussion and learning to create these indicators and their analysis in future projects and other experiences.

Keywords— Environmental services; payment for environmental services; water resources.

Thematic line— Geosciences and Science, Technology, Society and Environment.

1 Introduction

The land misuse caused by unsustainable agricultural practices, including deforestation and burning, together with the impact of infrastructure works and non-compliance with agricultural zoning criteria, have been identified as the main causes of land degradation in Brazil. According to Shiki (2008), the main consequences of this scenario are the drop in food production, the drop in soil productivity and in the production of water in the large drainage basins for lack of conservation of riparian forests, and soil erosion. As a result, there is a marked reduction of ecosystem or environmental services, with great damage to landowners and society.

Upon addressing sustainable development proposals, ecosystem services are incorporated into the concept of sustainable economy, so as to provide not only human well-being but at the same time to protect the environment in an economically balanced way. According to Gjourp et al (2016), these services are integrators, enabling interdisciplinary researches, gathering environmental and socioeconomic concepts.

Ecosystem services are those provided by natural ecosystems and the species that make them up, sustaining and fulfilling the conditions for the permanence of human life on Earth (Daily, 1997). There are a number of definitions for ecosystem services, and, invariably, all deliver the benefits that ecosystems bring to society and that guarantee human life on the planet.

In Brazil, laws and public policies aimed at protection, conservation and environmental repair have economic incentive instruments. Among these instruments, Payment for Environmental Services (PES) is an innovative policy whose main objective is to transfer resources, monetary or otherwise, to those that help conserve ecosystems, thus benefiting the community.

According to Favretto (2012), the first experience of PES arose in Costa Rica, due to the fact that this country has faced the highest rates of deforestation in the world. In Brazil, the legal forecast is set out in the revision of the Forest Code of 2012 and many experiences and projects are under development, most of them aimed at improving the quality and quantity of water resources in municipalities of great importance for the supply of large populations.

At the federal level, the "Produtor de Água" Program is also an example of a project aligned with this policy. Based on an initiative of the Brazilian National Water Agency (ANA), the objective is to protect water in Brazil through initiatives to reduce erosion and sedimentation of water sources in rural areas.

The projects, which are voluntary, are aimed at rural producers who intend to adopt conservation practices and management in their lands in order to conserve soil and water The Program stimulates PES and provides subsidies to users that generate positive externalities in the country's watersheds. (ANA, 2017). This program also articulates political actors such as the federal government and the municipalities, as well as Non-Governmental Organizations (NGOs).

In the State of São Paulo, the State Policy of Climate Changes establishes the Forest Remnants Program, whose objective is to promote the delimitation, demarcation and recovery of riparian forests and other types of forest fragments. The program provides for payment for environmental services to beneficiaries as well as economic incentives to voluntary policies aimed at environmental protection and reduction of deforestation to encourage the preservation and recovery of native forests.

The “Projeto Nascentes” Program, created by the state government of São Paulo, provides for the restoration of forests and soils in areas of springs, support for public policies for forest recovery and the commitment of the rural producer to the preservation of water sources. The program involves, besides the state government, private companies and city halls of the municipalities selected for the plantations, as well as the involvement of non-governmental organizations. This articulation aims to adopt measures that seek the protection of springs in the Piracicaba, Capivari and Jundiaí river basin (PCJ), which supply essential dams for the population of the countryside and the metropolitan region of São Paulo.

The common and key point among these projects is what can be called a coalition between the different actors: government in the three spheres (federal, state and municipal); non-governmental organizations; companies and the rural producers. The importance of this coalition is to successfully incorporate the preservation of rivers and springs as an essential tool for sustainable water management.

The articulation between the various actors and a broad approach to the issue in the environmental, social and economic spheres is fundamental. For the most part, the programs associated with payment for environmental services have an environmental and economic focus, often leaving aside social factors and the development of educational actions with those involved, which would allow the sustainability of the programs.

The involvement of the producers is a way of: stimulating the perception of these communities with their environment; understanding the relationship between land use and occupation and the ecosystem services; discussing elements that involve the dynamics of the Earth System; understanding fluvial and pluvial erosion processes; recognizing the environment from a geosystemic view; and promoting the debate in and with the community, to subsidize public policies and the effective engagement of all the actors involved in the different spheres.

The purpose of this article is to present a methodological proposal for the definition of socio-environmental indicators that must be monitored throughout the implementation and establishment of these programs, so that the public management is effective and the projects present continuity and sustainability, regardless of the alternation of managing groups.

In addition to the management issues, it is intended to identify with rural producers how geoscientific knowledge is applied in their land use practices, and, regarding the management of natural resources, to identify in the social and political spheres elements that involve ethics in the use of natural resources, as a principle of geoethics.

Within this scope, two distinct dialogues will be established, through proposals for public management actions at the federal, state and municipal levels, involving the municipalities of Jundiaí and Salesópolis, located in the basins of PCJ and Alto Tietê (AT), respectively, in a scenario of very similar socio-environmental complexities.

2 Methodological Approach and Study Areas

This work has as main methodological reference the qualitative research. In view of the proposed objectives, it is understood that this type of methodological approach becomes interesting, since one of its great objectives is the understanding of the participation of different social groups involved in PES programs.

According to Gerhardt et al (2009), the qualitative research is focused on aspects that cannot be quantified, focusing on the understanding and explanation of the dynamics of social relations. For Stake (2011), the qualitative researcher has strategic options, with the purpose of generating knowledge or assisting in the development of practice and politics. Observation, interviewing, and analysis of materials (including documents) are the most common qualitative research methods.

The qualitative research of this work involves semi-structured interviews with local political managers (responsible for technical areas of the town hall, mayors, environment directors), and rural producers, through visits to rural properties. The communities of Salesópolis and Jundiaí will be focused on. In addition to semi-structured interviews focused on environmental perception for sustainable societies, two parameters that involve the management of water resources in Brazil will be discussed: quantity and quality. Concerning the quantities, the practices of land use, maintenance of vegetation and silting of watercourses will be discussed. In terms of quality, monitoring the quality of physical and chemical parameters as indicators of environmental improvement was proposed. The proposal aims to involve rural producers and, therefore, after the end of the PES, environmental procedures and behaviors will be maintained and valued by the community.

Thus, the option of focusing on qualitative research, as a methodological option, aims to generate knowledge and / or help in the development of local practice and policies; represent common cases or maximize understanding of single cases; and highlight the most logical view or show multiple realities, from generalization or with particularization.

In this project, the option for the case study, based on the observation of the two municipalities (Salesópolis and Jundiaí), can be understood as a way of defining cases, but not as a way of analyzing cases or a way of modeling causal relations, since it will allow "an intensive study of a single unit, with the aim of generalizing to a larger group of units" (Steiner 2011).

This project aims to study two municipalities that are distinct in environmental and social terms, and that are at different moments of implementation of PES projects.

Salesópolis is a municipality of the metropolitan region of São Paulo located 96 kilometers to the east of the Capital. It has an area of 427 km², with 98% of its territory protected by the Water Protection Law, and the other 2% are part of the Permanent Protection Zone (PPZ), part of Parque Estadual da Serra do Mar. Known as "Cradle of Tietê", it presents an economy based on agricultural production and ecotourism, in the face of diverse restrictions of use and occupation of the territory.

Figure 1. Location of Salesópolis in the State of São Paulo

The municipality composes the Alto Tietê Water Producing System. This System is formed by the river springs of the Tietê River, regularized by Ponte Nova Water Supply Reservoir (Tietê and Claro rivers), Paraitinga Water Supply Reservoir (Paraitinga River), Biritiba Water Supply Reservoir (Biritiba River), Jundiaí Water Supply Reservoir (Jundiaí, Grande and Doce rivers) and Taiaçupeba Water Supply Reservoir (Taiaçupeba Mirim, Balainho and Taiaçupeba-Açu rivers), and it produces about 15 m³/s of water to supply the Metropolitan Region of São Paulo (RMSP).

Figure 2. Schematic Drawing of Alto Tietê Water Producing System

Through the Municipal Law 1704 of 2014, the Salesópolis Water Producer Program was created. The project intends to plant trees in an area of 320 thousand square meters, among which there are about 32 species of native trees of the Atlantic Forest, whose main objective involves the recovery of the sources of the Tietê River. The plantation was started in some rural properties registered in the municipality, with priority for PPA areas according to the Forest Code: surroundings of springs, banks of streams, rivers, lakes (riparian forest).

Jundiaí is a municipality in the state of São Paulo located 57 kilometers from the capital. The urban agglomeration of Jundiaí also includes the municipalities of Várzea Paulista, Campo Limpo Paulista, Louveira, Itupeva and Cabreúva, and presents continuous urbanization and conurbation process between urban areas.

It is supplied by the fountains belonging to the Piracicaba, Capivari and Jundiaí rivers basin (PCJ). The municipality is located in the basin of the Jundiaí River, which starts in the city of Mairiporã and goes eastwards, crossing the municipalities of Campo Limpo Paulista, Várzea Paulista, Itupeva and Indaiatuba, arriving in the city of Salto, where it flows into the Tietê River. Among the several sub-basins present, the Jundiaí-Mirim River, that starts in the municipality of Jarinu, is considered the main source of water for public supply. There are also the micro basins of the Ribeirão Caxambu, Moisés and Ribeirão Caguaçu streams. Also present in the municipality of Jundiaí is the spring of Capivari River, belonging to the Piracicaba River Basin.

Figure 3. Location of Jundiaí in the State of São Paulo

In Jundiaí the "Nascentes" program involves a process of valuation of the rural area. The first phase of implementation occurred in one of the micro-basins within the Jundiaí-Mirim river basin, and the interest in a second phase from other owners of the remaining micro-basins was observed. The municipality of Jundiaí has obtained a group of partners, and has been discussing the possibility of implementing the Payment for Environmental Services mechanism to owners who join the program, in accordance with Municipal Law 8,607 of 2016, resulting from the Participatory Master Plan.

The connection between both hydrographic regions, the SPAT and the PCJ, occurs through the Cantareira System, formed by a series of six reservoirs: Jaguari, Jacareí, Cachoeira, Atibainha, Paiva Castro and Águas Claras, the first four being tributaries of Piracicaba River. The Cantareira System transports water to the Alto Tietê basin, from where, in the Paiva Castro reservoir, the waters are pumped to the Águas Claras reservoir, with the purpose of supplying part of the Metropolitan Region of São Paulo.

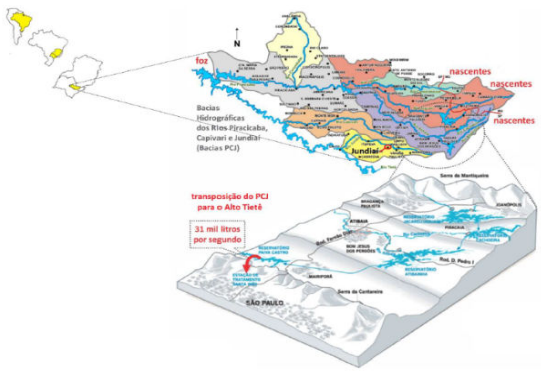

Figure 4. Transposition between the Alto Tietê and PCJ basins in the Cantareira System

Thus, the definition of the two municipalities for the present research project intends to study a scenario in which we have the SPAT and Cantareira System, because together these reservoirs are responsible for supplying approximately 50% of the population of the RMSP.

In each municipality PES programs are taking place in distinct deployment phases, such as the involvement of different actors and different situations, at different political moments, and an analysis of this scenario should also be performed in order to understand to what extent these issues interfere in the success of the program and how the socio-environmental issue is dealt with or needs to be dealt with so that the indicators to be created can contribute to similar projects and other initiatives.

The key issue involved in this context, which justifies the present study, is that current PES programs lack socio-environmental indicators that actually indicate possible improvements not only from the environmental point of view, but also with regard to the quality of life of those involved and their effective participation and perception within the concept of Earth Sciences. It is necessary to create and monitor these indicators so that the advantages of the involvement of these actors also appear as good results.

3 Conclusion

The development of a socio-environmental culture with the creation of indicators that can demonstrate improvements through the involvement of rural producers and other actors participating in PES programs are key factors for the success of these programs.

Allied in this regard, the comparison of two experiences, each in its moment of implementation and its moment of involvement of the different actors (public power, producers, NGOs, university), brings a rich discussion and learning so that environmental indicators are created and in the future demonstrate through data how the social question and the knowledge of Earth Sciences are favorable for projects to continue and to be replicated in other experiences.

Establishing a methodological tool to create environmental indicators so as to obtain and, later, monitor the involvement of these actors becomes necessary for the survival of these programs, aiming at improving environmental services, especially in areas with very complex realities, and great importance from an environmental point of view.

It is a big challenge. However, the results that will be achieved will greatly contribute to broadening the scope and importance of the topic, with a high potential to benefit Brazilian society at its different levels.

In order for a project like this to be successful, it must be taken into account that it occurs in a process of continuous education, which, in addition to Sustainability Education, should address issues focused on Earth System Sciences, so that actors in the complex scenario in which these Programs occur have the perception of also integrating this system.

Thus, Education for the Earth System, incorporated into the practices in Education for Sustainability, presents itself as a tool for the construction of knowledge and values in these rural communities, contributing to the transformation of practices currently impacting the environment, since these producers become agents responsible for the recovery and maintenance of environmental systems, and for the valorization of the environmental services provided.

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KNOWING THE SOIL: A PROJECT OF ENVIRONMENTAL AND CITIZEN EDUCATION IN THE PAULO MARANHÃO SCHOOL, BELÉM-PA

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Abstract — Soil is an essential component of the environment, whose importance is usually disregarded and little appreciated by society. This work is based on the need to value soil studies in basic education in the perspective of Environmental Education. This proposal is in line with the theoretical assumptions of Soil Education, whose main objective is to bring the meaning of the importance of soil to people's lives and, therefore, the need for its sustainable use. The contribution of Geology to soil education is outlined from its object of study, the origin, the structure, the composition and the transformations of the Earth. Thus, the present study is the result of a university extension project developed by students and professors of the undergraduate course in Geology of the Federal University of Pará, aiming mainly at the construction of a "pedological awareness" in students and teachers of basic education within environmental education, using as a laboratory the Escola Estadual de Ensino Fundamental Paulo Maranhão (State School of Primary Education Paulo Maranhão), located in a peripheral zone of the municipality of Belém, Pará.

Keywords — Soil education, Environmental education, Basic education, Sustainable use.

Thematic Line — Environmental Education, Education for Sustainability and Geoethics.

1 Introduction

Even today, the human being does not realize that the environment is the result of the connected functioning of its multiple elements and, consequently, the interference on any one of them will be affecting the whole. One of these elements is the soil, an essential component of the environment, whose importance is usually discounted and undervalued (Bridges & Van Baren 1997, Muggler et al. 2006). For the majority of the population, soil is not understood within the framework of ecological interactions with the necessary acuity (Bridges & Catizzone 1996), and still less as a dynamic product of the interactions between large terrestrial systems (Pipkin et al. Trent 1997), thus reflecting the changes affecting the natural balance of the planet. Thus, soil is not recognized by the function it performs in human life and the environment as a whole.

According to Muggler et al. (2006) people have an attitude of low awareness and sensitivity towards the soil, which contributes to its degradation, either by its misuse or by its disordered occupation. The problem around soil conservation has been, in most cases, neglected by people. The consequence of this negligence is the continuous increase of environmental problems related to soil degradation, such as: erosion, pollution, landslides, flooding of watercourses, etc.

In addition, according to Favaretto & Diecknow (2007), soil has traditionally been considered a renewable natural resource, but because of the intense degradation promoted in recent centuries, soil availability is being seriously compromised. For this reason, in actual and practical terms, soil must be considered a natural, non-renewable resource. Still according to these authors, the amount of soil that is lost each year by degradation caused by men, can greatly exceed the amount of soil that is formed each year by nature. This creates an imbalance, which leads the soil to its exhaustion and, consequently, future generations will not have the opportunity to enjoy this valuable resource.

Another relevant aspect is that the soil and other natural elements of the planet must be seen as collective patrimony and, therefore, conserved by all. However, preserving the environment as an act of citizenship still does not have its full recognition in society. The lack of knowledge in this aspect requires the development of ecological awareness (Frasson & Werlang 2010).

In view of these issues, it is therefore necessary to develop and promote the awareness of people, individually and collectively, regarding the soil, within a conception that considers the principle of sustainability. This awareness can be born of an educational process that privileges the notion of sustainability in the relation between man and nature. Education can contribute effectively to this process, since it offers objective instruments to elaborate and re-elaborate values, behaviors and attitudes (Muggler et al. 2006). In this sense, the education sector, recognized as Environmental Education, is particularly noteworthy, as it is procedurally assumed as the set of experiences and observations that contribute to everyone's understanding of their relationship with the environment and their responsibility to it (Sato 2003).

Becker (2005) reports that the study of soil is occurring widely by many scientists and researchers who seek knowledge about its formation, use, occupation by man and so on. However, with regard to the approach of the soil in schools within the scope of Environmental Education, the space dedicated to the study of this important component of the natural system as a didactic activity, in most cases is nonexistent or superficially approached. Likewise, Lima et al. (2007) also came to the conclusion that, despite its importance, the space dedicated to soil in elementary and secondary education is often null or relegated to a lesser plane, both in urban and rural areas. According to these authors, content in didactic materials is often in disagreement with National Curricular Parameters and is often outdated, incorrect or out of the reality of Brazilian soils. In addition, this content is often given unsatisfactorily, without being related to the practical or daily use of this information, causing disinterest to both the student and the teacher. Such reasons contribute to the fact that the population does not know the importance and characteristics of the soil, which amplifies its process of alteration and degradation.

In contrast to the scenario previously discussed, it is possible to highlight several other initiatives in Brazil corcerning proper soil education, such as the Soil in School Project, developed at the University of Paraná, with primary and secondary schools, whose objective is to support the development of the theme through the elaboration of didactic materials, the creation of mechanisms that allow the visitation of schools to the University and the training of teachers (Lima 2002). Another initiative is the Soil and Environmental Education Program, which is being developed by the Department of Soils, at the University of Viçosa, Minas Gerais, with an interdisciplinary character, which articulates students, teachers and technicians from different areas of knowledge of the University, having as a common objective to work on soil and environmental issues in the context of formal and informal education, in the practice identified as Soil Education (Muggler et al. 2002, 2005).

Thus, inspired by these initiatives, this work presents the results of a university extended learning project, carried out by students and professors of the undergraduate course in Geology of the Federal University of Pará (UFPA), in the context of a teaching, research and extension program of the Faculty of Geology, denominated "Nova Escola", with the main proposal being the development of an experience between the university and the public school, aiming to stimulate students and professors to develop a pedological and citizen conscience through Environmental Education, using soil as an object of work in an urban periphery environment with few social facilities, such as the Guamá neighborhood in Belém-PA, where this study was developed.

2 Methodology

The study was developed in a peripheral zone of Belém-PA that integrates the Guamá neighborhood, where is located the "Prof. José da Silveira Netto University City", in which the Federal University of Para (UFPA) is situated. Initially, visits were made to several public schools in the region, where the project's objective and systematics were exposed in an attempt to form partnerships for the implementation of the activities. In this sense, the school that showed higher interest in the proposed objective, the “Escola Estadual de Ensino Fundamental Paulo Maranhão” (State School of Primary Education Paulo Maranhão), was selected. Then, we decided to carry out the planned activities with the participation of students from the 9th grade of elementary school, whose main characteristics can be summarized as follows: higher maturity due to their age, compared to other primary school students; and higher educational level due to the accumulation of knowledge and experience since the beginning of elementary school. In this way, the work was developed simultaneously with three 9th grade classes of the school, with the involvement of about 80 students.

For the development of the project activities within the school, some questionnaires with objective and subjective questions were first prepared to evaluate the students' previous knowledge about important subjects in the area of Environmental Education in soils, as well as their experiences and involvements with the theme. The first questionnaire was composed of five questions, as listed below:

- Q1: Have you studied about the soil? In what subject?
- Q2: What is soil according to your knowledge?
- Q3: Do you consider the soil an important element in life? Why?
- Q4: Among the environmental impacts to follow, which are related to the soil?
  ( ) silting of the riverbeds
  ( ) landslides and mudslides
  ( ) contamination of the water table
  ( ) reduction of agricultural areas
  ( ) reduction of fauna and flora
  ( ) flooding in urban areas
  ( ) pollution of rivers, lakes and oceans
  ( ) none of the above
  ( ) I do not know
- Q5: Do you know of any activity that contributes to soil conservation?

Subsequently, based on the general result of the questionnaires, a series of lectures and workshops were elaborated aiming at discussing the problems observed when analyzing the forms. The methodology for preparing these activities was based on the work of Muggler et al. (2006) which deals with the principles, theories and methods on soil education. The lectures and workshops were conducted by students of the undergraduate course in Geology of UFPA in weekly consecutive meetings, during the months of September and October 2017, at the Paulo Maranhão school.

Following a pre-determined schedule, after these activities, the students and some school teachers involved in the project visited the UFPA facilities. The places visited were the edge of the university on the banks of the Guamá river, the Museum of Geosciences and a small auditorium in the Faculty of Geology, in which a series of practical expositions were held, addressing the subjects previously treated in the school.

At the end of the activities, different questionnaires were applied to the students, with a view to evaluating their progress before and after the project activities. The results of the initial and final questionnaires were accounted for in percentages and presented as charts.

3 Results and Discussion

After the establishment of the partnership and the schedule of the activities with the school board, the first contact with the students occured with a general presentation of the project and the application of the initial questionnaire for prior evaluation of their knowledge about the subjects that would be approached (Fig. 1).

Figure 1. Presentation of the project and application of a questionnaire in one of the classes of the Paulo Maranhão school

From the results of the questionnaires, it was possible to obtain a perspective of the students' knowledge about the main subjects related to the soil and its importance in the ambit of Environmental Education. Considering the results of question Q1 (Fig. 2), it can be seen that 85% of the students stated that they had already studied about the soil, mainly in the Sciences and Geography subjects, while 15% reported never having studied this theme.

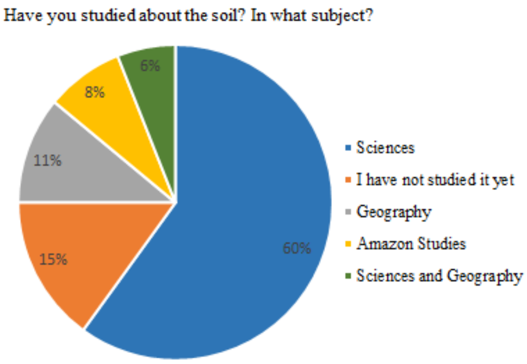

Figure 2. Results of question Q1 obtained from the initial questionnaire.

Analyzing the results of question Q2 (Fig. 3), we observed that more than half of the students interviewed responded that they didn't know what the soil was or didn't answer, whereas only 3% responded more closely to the scientific concept dealing with the soil as a product formed by rocks. The other students treated the soil more abstractly associating it only to what they understood as "ground"; or relating it to a "product of nature" that has a connection with "sand", "stones" or "ground". Similar results were also found in Oliveira's study (2014).

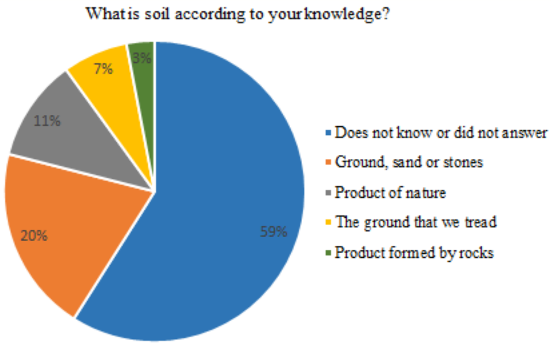

Figure 3. Results of question Q2 obtained from the initial questionnaire

By associating the results obtained in Q1 with the information given in Q2, the table presented in the papers by Becker (2005), Lima et al. (2007) and Oliveira (2014) becomes apparent, noting that despite its importance, the space dedicated to soil in elementary education is often null or relegated to a lesser plane. Moreover, it confirms that the content presented in the didactic materials is often in disagreement with the National Curricular Parameters and is often found to be outdated or incorrect.

Regarding the results of the question Q3 (Fig. 4), although more than half of the students answered positively with good arguments, the percentage that could not answer about the importance of soil for life was significant. In this sense, these data corroborate the analysis made by Lima et al. (2007), reporting that the content related to soil in elementary education is often given unsatisfactorily, without linking the theory to the practical or daily use of the information, causing desinterest to both the student and the teacher, and contributing to the population not knowing the importance and the fundamental characteristics of the soil, which extends its process of alteration and degradation.

In the multiple-choice question Q4 (Fig. 5), it was verified the students' knowledge about the main environmental impacts that may be related to the soil. Based on the results obtained, it was noticed that the majority of the students related the soil mainly with problems of landslides (81%) and the reduction of agricultural areas (62%). However, when it comes to other serious and common environmental problems that may also be related to the misuse of soil (directly or indirectly), such as silting of riverbeds, flooding in the urban environment, contamination of water resources and reduction of fauna and flora, it was noticed that less than half of the students chose to relate the soil to these environmental impacts, and 6% of the public interviewed stated that they did not know about the subject and thus could not respond to this question. These data are in agreement with the results of the study by Bridges & Catizzone (1996), in which they emphasized that for the majority of the population the soil is not understood with the desired precision, within the scope of the ecological interactions, and even less as a dynamic product of interactions between large terrestrial systems (Pipkin & Trent 1997), thus reflecting the changes that affect the natural balance of the planet.

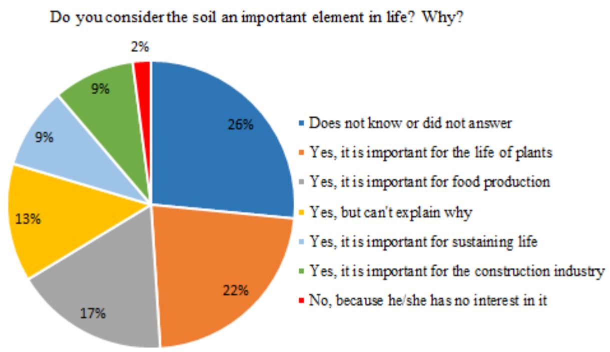

Figure 4. Results of question Q3 obtained from the initial questionnaire

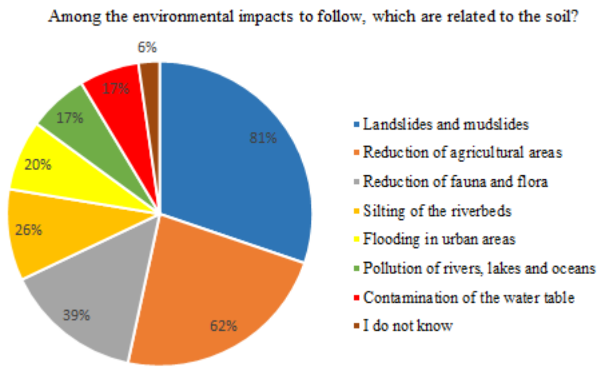

Figure 5. Results of question Q4 obtained from the initial questionnaire

When analyzing the question Q5 (Fig. 6), we can see that the great majority of the students (77%) don't know any soil conservation practices or have responded with activities that often collaborate with the process of soil degradation. Only a small percentage responded with practices that actually assist in conserving the soil, such as vegetation cover, waste recycling and avoiding pollution. These results corroborate with the study of Muggler et al. (2006) showing that people have an attitude of low awareness and sensitivity towards the soil, which contributes to its degradation, either by its misuse or by its disordered occupation. The implication of this negligence is the continuous increase of environmental problems associated with soil degradation.

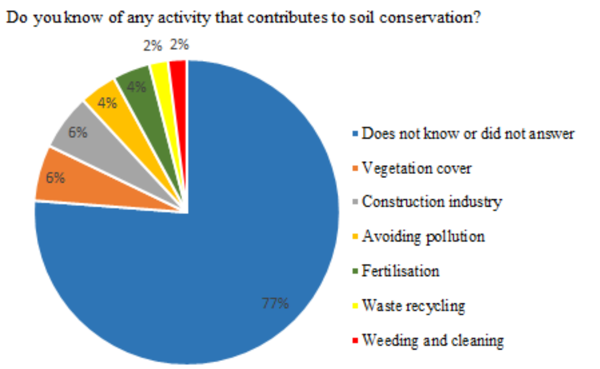

Figure 6. Results of question Q5 obtained from the initial questionnaire

Based on the results of the initial questionnaire, it was revealed the low perception of the students concerning the Environmental Education fundamentals, with regard to the question about the importance of the soils. This was the starting point to motivate the preparation of didactic and pedagogical materials to be used in the following stage of the project. In the second meeting, a series of lectures and workshops on the origin, composition and types of soil were conducted by the Geology students for the students and teachers at the Paulo Maranhão School (Fig. 7). For this activity, a number of materials were made, with particular emphasis on: soil profile in PET plastic bottles; kit containing the main types of rocks (igneous, sedimentary and metamorphic) and samples of different types of soils. The whole activity aimed to reaffirm in practice the information presented in each lecture given.

Figure 7. Lecture and workshop on the origin, composition and types of soils given by undergraduate students in Geology for students and teachers of the Paulo Maranhão school

In the third meeting with the students, more lectures and workshops were held on the importance, degradation and conservation of the soil (Fig. 8). In this activity we presented the main functions of the soil as an essential component of the environment and its importance for society. It was also shown several daily situations, observed in Belém, of actions that lead to soil degradation. This set of activities ended with the presentation of several examples that lead to the practice of soil conservation followed by the experimental demonstration on the importance of maintaining the vegetation cover or, in a particular way, showing how the spread of soil litter can be used as a protection vector against erosion (Fig. 8). At the end of each meeting, the didactic materials produced were donated to the school to compose their science laboratory.

Figure 8. Lecture and workshop on the importance, degradation and conservation of the soil given by the undergraduate students in Geology to the students and teachers of the Paulo Maranhão school

To crown this cycle of lectures and workshops, the students and teachers of the Paulo Maranhão School were taken to a visit to UFPA, aiming to reinforce the contents and practices that had been discussed previously in the school. The first activity of this visit was developed on the edge of the university on the banks of the

Guamá River (Fig. 9). This scenario was used to show pedological examples about the origin, structure and composition of the soil, as well as its importance, mainly in what concerns the respect that people must have to avoid its degradation. The effects of erosion - which also occurs due to human actions - occurring along the water-front of the river, as well as the works that are being implemented with a view to its containment were also discussed.

Figure 9. Students and teachers of the Paulo Maranhão school visiting the edge of the University for a practical presentation of the topics covered in the classroom

The second activity in the university consisted of a visitation to the Museum of Geosciences (Fig. 10), which counted with the collaboration of the technical team of the museum and the support of the PET-Geology group. Visitors were able to see the enormous variety of rocks and minerals, which are the main raw material for the formation of our soils. At the end of the visitation, the students were taken to the Faculty of Geology to watch a documentary about the subjects in question and then responded to the final questionnaire of the project.

Figure 10. Visit with the students and teachers of the Paulo Maranhão school in the Museum of Geosciences of UFPA

From the analysis of the responses to these questionnaires and the comparison with the answers obtained when the first questionnaire was applied, a significant improvement in the perception of the importance of respecting the environment was observed, based on a better knowledge about the soil element.

By analyzing the question Q2 in the final questionnaire (Fig. 11) applied, it was observed that all the students were able to respond coherently to what is the soil and what it represents, from a more scientific approach. When applying the initial questionnaire 59% of the same public interviewed had no clear idea of what the soil was.

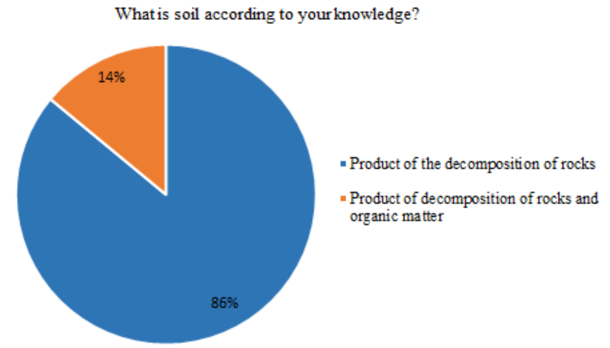

Figure 11. Results of question Q2 obtained from the final questionnaire

Through the evaluation of the results of question Q3 in the final questionnaire, after the project activities (Fig. 12), it was observed that all students responded positively with coherent arguments on their opinion about the soil being an important element for life. Differently from the results of this same question in the initial questionnaire, there were no percentages of negative responses, nor any responses stating lack of knowledge or familiarity with the subject or blank responses.

From the analysis of the responses obtained for question Q4 in the final questionnaire (Fig. 13), it is observed that a considerable proportion of students came to understand that the various environmental impacts listed in the question (among others) could be related to the misuse of the soil. In addition, there were no blank responses, nor any stating lack of knowledge about the subject.

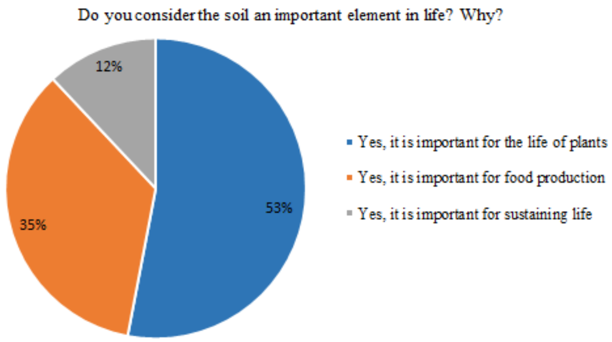

Figure 12. Results of question Q3 obtained from the final questionnaire

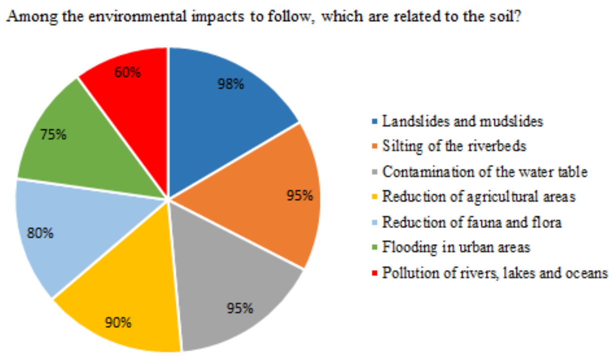

Figure 13. Results of question Q4 obtained from the final questionnaire

Finally, in question Q5 of the final questionnaire (Fig. 14), all students answered positively with some correct example of a soil conservation practice, unlike the results of the same question in the initial questionnaire, in which 77% of the same public interviewed stated that they didn't know of any soil conservation practice or mentioned some non-coherent practice.

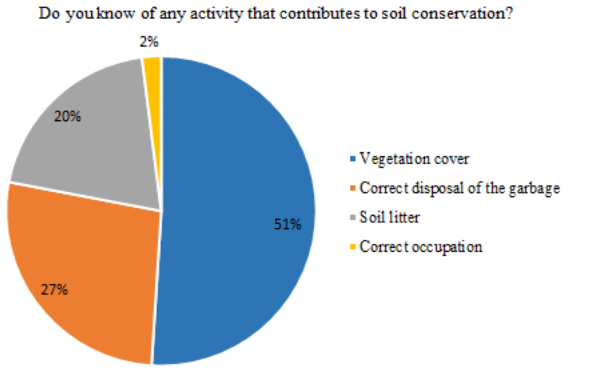

Figure 14. Results of question Q5 obtained from the final questionnaire

4 Conclusion

Considering the results obtained after all these activities carried out with students and teachers of the Paulo Maranhão school, it was observed that the students of the 9th grade of elementary school, even having had contact with a subject related to the soil in the classroom, have a perception quite limited in its nature, main properties and environmental and economic importance.

The development of teaching and extended learning experiences such as this shows that students and teachers of basic education can be encouraged to take a new posture regarding environmental issues, using elements included in the curricular guidelines of their educational level, in this particular case the formation of the soil and its responsible use.

This type of practice also serves to help in the foundations of a participatory and citizen education, which in the medium-long term implies changes in the context of Brazilian society.

Thus, the final evaluation of this experience was that the students, in general, had a good understanding of the content addressed, indicating that the discussion of the themes and concepts proposed during the lectures and workshops was positive. In addition, the development of this project, which is part of the "Nova Escola" program, developed in the Faculty of Geology of the Federal University of Para, has achieved the objective of providing geology students with an extension of their vocational training process, in the perspective that this training should not be only technical, but above all one that provides a citizen conscience.

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MINGLING CHEMISTRY, PHYSICS, AND GEOSCIENCES THROUGH THE TEACHING OF VISCOSITY

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Abstract— The comprehension of basic processes of crust formation has one of its pillars on the study of magmas and igneous rocks. Viscosity is a key feature of magmas, related to silica content and presence of complex mineral structures. In this paper, we point the teaching of viscosity as a way to stablish interdisciplinary relations among Earth sciences, Physics, and Chemistry. The basic concept of viscosity is presented initially, related to capacity that a fluid has to flow. Magma, here defined as molten rock, holds the features of its main minerals, as explained using the Bowen's series. As long the crystallization of a given magma proceeds, simple silicate tetrahedrons (nesosilicates) give place to progressively more complex mineral structures. The well-known relation which high-silica magmas have to viscous lavas is explained by higher grades of complex silicate minerals, as phyllosilicates (micas) and tectosilicates (quartz and feldspars), more abundant in acid rocks. So, basic and ultrabasic magmas are less viscous because of their less expressive amounts of silica-rich minerals. Since viscosity is related to friction, the presence of larger basic mineral lattice is accountable for higher viscosity in acid magmas. Building up models of rock-forming silicate minerals can be a useful tool to illustrate the known variety of mineral structures. Volcanic eruptions can be displayed on online videos, intending to link with natural models. The relations of magmas microscopic features and viscosity are based on basic Chemistry and Physics concepts, such as Newtonian forces and interatomic bonding, so is possible to explore them in multiple contexts.

Keywords— Viscosity, magmas, igneous rocks, modelling, interdisciplinarity.

Thematic line— Geosciences and Science, Technology, Society and the Environment.

1 Introduction

To comprehend natural phenomena under a single science perspective, physico-chemical properties of natural materials are often neglected. Because of their matter of study, Chemistry and Physics tend to get deep into experimental data, seeking for a better fit for mathematical calculations, while Geosciences points to a more descriptive approach. Although lots of concepts bring together multiple science definitions, the effective uses of interdisciplinary relations are still a growing field among STSE (Science, Technology, Society and the Environment) publications. STSE teaching has been debated since 1970 decade, when a growing concerning about environmental impacts in societies caused by science and technology emerged simultaneously in different western countries.

Models and comparative examples play a major role on science teaching, in general, and represent an important start point for multiple science relations, when supported by case studies took from nature. A model in science is used to understand a phenomenon through a simpler representation and can be based on concrete entities, abstractions, or even an idea (Gilbert et al. 2000). From verbal discourse, printed material, objects, and digital sources, models usually require a mixed mode of symbolization to explain both structure and dynamic processes (Boulter & Buckley 2000).

Viscosity refers to the capacity that a fluid has to flow in a given amount of time, and it has a primary emphasis on Physics, through the understanding of fluids features and behavior. A similar taken is brought on Chemistry courses, even though is taught in a shorter period. Reference materials for these sciences usually are supported by lab inferences and experiments carried out on artificial materials (mainly oils and lubricants). For Earth scientists, mainly geologists, viscosity figures out as an important factor to understanding and predict magma behavior. While its dependence upon silica content is often related to this physical property, the concept of viscosity is poorly explored as it comes as one between lots of features (temperature, whole composition, mineralogy, etc.). This lack of basic understanding about factors that rule magmas flow through fractures in Earth's interior and on its surface is usually a major hurdle in the comprehension of different magmatic chambers and igneous rocks structures, in general.

In this paper, we bring fundamental ideas to build up discussions about viscosity based on the study of distinct magmas. Our main goal is to open a channel for interdisciplinary relations in Geosciences, Chemistry, and Physics courses focused on features observed in nature. Additionally, we aim to present and discuss factors that alter the viscosity of liquid bodies, such as temperature, particle size and concentration

2 Viscosity: from lab to nature

2.1 Fundamental concepts

Viscosity is defined as "a measure of the resistance of a fluid which is being deformed by either shear stress or tensile stress", by Mott (2014). The author compares to everyday terms as "thickness" and "internal friction", also brings the notion that water is "thinner" than the honey, that has a higher viscosity ("thick"). "Rheology" is the study of flow and deformation of matter, ranging from liquids to solids, deformed under plastic conditions.

Viscosity, as a measure of the fluids internal resistance to flow, is related to the velocity of fluids movement, and is the antonym of fluidity. More viscous fluids (as honey) tend to flow in a slower rate than less viscous (as water). Just ideal (or Newtonian) fluids have constant viscosity, at some scale, as water and most gases. Other materials, known as non-Newtonian fluids, vary their velocity gradient while submitted to different rates of shear stress. The dynamic (or absolute) viscosity is defined by the unit pascal-second (Pa.s, equivalent to $N.s/m^2$), while kinematic viscosity dynamic divided by the density and is expressed in m^2/s, according to SI (Symon 1971). An increase of temperature tends to increase the viscosity of most gases, and decrease in liquids, while pressure do not play an important role, excepting for some liquids when submitted to high pressures.

Magma is a liquid material, mainly composed by molten silicate rock, with some semi-molten material and volatiles which have been originated by endogenous processes and forms igneous rocks when cools completely. Lava is magma when it flows through the surface. The main features of distinct magmas can be pointed out as depending on their silica content, that is related to the temperature. The higher the silica content, the lower the magma temperature and the melting degree required for its formation. Four major groups of magmas can be distinguished, based on silica content: (i) ultramafic or ultrabasic (less than 45% SiO_2), (ii) mafic or basic (from 45 to 52% SiO_2), (iii) intermediate (from 52 to 66% SiO_2), and (iv) felsic or acid (66% SiO_2 or higher; Winter 2001). The ultramafic magmas (formed from 1200 to 1600°C) are composed of olivine and pyroxenites, iron- and magnesium-rich silicates. Mafic rocks, as basalts and gabbros (from 1150 to 1400°C) have also plagioclase, amphiboles, and mica that results in a calcium, sodium, and potassium enrichment. Intermediate rocks (from 800 to 1150°C) Fe-Mg minerals are less expressive, although they have more mica, K-feldspar, and quartz than basic lavas. The felsic rocks, as granites and rhyolites (1000 to 750°C), follow this trend, they hardly have any Fe-Mg mineral and are notably rich in K, Na and Si and have less expressive values of Fe and Mg.

N. L. Bowen [1887-1956], in his most praised work (1922), summarized the crystallization sequence of a fractionating sub-alkaline basaltic magma. The discontinuous series, olivines-pyroxenes-amphiboles-biotites, is accountable for major structural changes in mineral lattice (Fig. 1). The silica tetrahedron is the basic unit of all the silicates, it can be disposed in different ways to create a myriad of silicate mineral structures (Press et al. 2003). In this work, we present just general representative formula of mineral groups, since some of them (as pyroxenes and amphiboles) have more than a dozen solid solution end-members solid solutions. Olivine ($(Mg, Fe)_2SiO_4$), the first mineral of discontinuous series, has a single tetrahedron in his lattice, a feature common to all the nesosilicates. Pyroxenes have more Si, less Mg and Fe when in comparison to olivines. In addition, clinopyroxenes can host elements as Ca, Na, Al, and Ti, as exemplified by augite's formula: $(Ca,Na)(Mg,Fe,Al,Ti)(Si,Al)_2O_6$. Besides the chemical contrasts, a much more intricate structure is described for pyroxenes, classified as single chain inosilicates. Double chain inosilicates that crystallize after, the amphiboles are enriched in silica, also they admit water and a wide range of cations in their structure. It can be represented by the general of formula of the hornblende series: $(Ca,Na)_{2-3}(Mg,Fe,Al)_5(Al,Si)_8O_{22}(OH,F)_2$. After sole tetrahedrons (olivine), single and double chains of tetrahedrons (pyroxenes and amphiboles), sheets of silica tetrahedrons take place, represented by biotite ($K(Mg,Fe)_3(AlSi_3O_{10})(F,OH)_2$), and micas in general. They belong to the group of phyllosilicates, that share the common feature of have water in their structure, also are commonly rich in Al and K. In contrast, no significant change is noticed in the continuous series of the plagioclases ($(Na,Ca)(Si,Al)_4O_8$) that, as tectosilicates, have complex tridimensional structures. They suffer some minor alteration in their lattice due the cation (calcium and sodium) exchange. The convergence of discontinuous and continuous series is represented by the appearing of potassic feldspar ($KAlSi_3O_8$), a tectosilicate, as well. Muscovite is a K-rich mica which represents another phyllosilicate, crystallizes after. Quartz (SiO_2) is last mineral of Bowen's series, has a tridimensional structure, so it is classified as a tectosilicate. In summary, as a magma fractionates its Mg, Fe, and Ca contents decrease, while Si, K, Na, and H_2O grades increase (Winter 2001). These chemical changes result from the appearing of different minerals, as described above. Structurally, is evident that mineral lattice tends to be more complex as the solidification process. In general, simple sole silica tetrahedrons (nesosilicates) give place to single and double chains (inosilicates), that are followed by sheet-structure minerals (phyllosilicates) and, finally, to complex tridimensional unitary cells (tectosilicates).

Three purposes for science education have been identified by Hodson (1993): (i) to "learn science", the understand of achievements, the concepts, the models, and the theories of science, (ii) to "learn about science", related to the understanding of the nature and methods of science, (iii) to "learn to do science", thus becoming able to participate in the practice of scientific investigation. Rutherford & Ahgren (1990, p. 3), through their document "Science for All Americans", argument that "science presumes that the things and events in the universe occur in consistent patterns that are comprehensible through careful, systematic, study". In matter of learning about natural sciences, students do not see through a naïve, neutral, or even illusory view. They are guided to explore, to argument, and to develop their critical view, additionally comprehending that science is a product of human construction and get close to reality. Thus, "modelling is the action of representing an idea, an object, a process, an event or a system" (Oversby 2000, p. 231). Model in science is defined by Gilbert et al. (2000, p. 11) as "a representation of a phenomenon initially produced for a specific purpose". According to Boulter & Buckley (2000), models can be presented in classroom in four main ways: (i) by means of objects, concrete models, (ii) by discourse, as verbal textual models, (iii) print-based, as books, diagrams, and even writing on the board, (iv) screen-based means, related to computational digital models. Information and communication technologies (ICTs) comprise the use of computers, internet, and general digital formats, that aims to develop new educational approach suitable for the technological revolution of the 21st century (Goktas et al. 2009).

2.2 Viscosity of magmas and its dependence upon silica content

Some of the main features of igneous rocks, especially volcanics, are often compared to viscosity of their parental magma. A typical example takes account on the contrast of rhyolitic and basaltic lavas. Silica-rich acid magmas, as rhyolitic, are more viscous, so they solidify before lava can move further, and produce a tall, steep stratovolcano. In contrast, basic silica-poor basaltic lavas can flow through long distances due their lower viscosity, resulting in a wide, shallow-sloped shield volcano. This comparison is used to illustrate the role of silica in magma viscosity, a direct relation that relates more viscous lavas to higher contents of silica. Not as frequent as rhyolitic and basaltic magmas, carbonatites have extremally low contents of silica (from 0 to 30%) and they are just a little more viscous than water. The only known example of a carbonatite volcano is the Ol Doinyo Lengai, in Tanzania. The behavior of carbonatite lavas corroborates the relation between viscosity and silica content in magmas. Carbonatites are considered as a cool lava, because it erupts at approximately 500°C. The addition of a carbonatite magma shows that the grades of silica is more relevant than the temperature, since is the most fluid and cooler magma. Although the relation of silica and magma viscosity is widely discussed among Earth science's teachers and students, these examples are hardly shown in Physics and Chemistry lectures, that focus on artificial produces, as oils and lubricants.

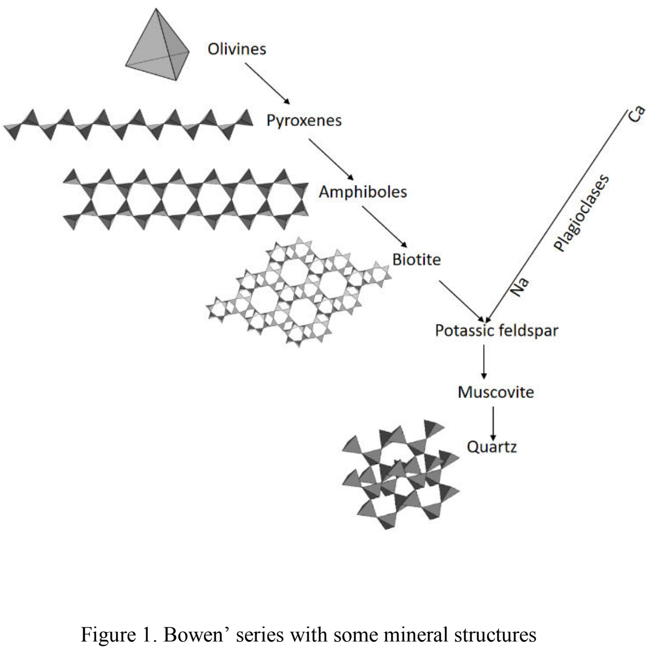

Figure 1. Bowen' series with some mineral structures

2.3 Theoretical approach and microscopic inferences

The main reasons why silica content is responsible for magmas viscosity are not usually explained into the microscopic level. The grade of silica, by itself, is an indirect clue of which features control the capacity of a molten rock to flow. As exposed on section 2.1, rock-forming silicate minerals crystallized at lower temperature have more complex structures, when compared to high temperature minerals. As long crystallization processes, silica tetrahedrons arrange into chains, sheets and finally tridimensional structures. Acid magmas have more feldspars and quartz than mafic and ultramafic, that are rich in olivines and pyroxenes.

As viscosity is the measure of a fluid resistance to flow, larger and more intricate mineral unitary cells will represent more obstacles to a flowing lava. Magma must not be seen as a solution or a "soup of ions", but as molten rock that hosts the basic structures of distinct minerals that will be completely formed at the end of crystallization processes. The use of models that represent silicate minerals structures is a key factor to understand these relations. A sole triangular pyramid, i.e. a tetrahedron, can represent the basic structure of silicates even an olivine lattice. It can be made up from recyclable materials, as paper or plastic. A combination of pyramids in different arrangements will produce a whole variety of structures. This process of creating new structures must be focused on the relations of rock-forming silicate minerals. Lines of pyramids (at least five or six) can represent inosilicates, as pyroxenes or amphiboles, if disposed in a sole or a pair of lines, respectively. Phyllosilicates can be modeled as a group of tetrahedron lines, resulting in a flat, two-dimensional arrangement. The last stage of this teaching procedure will be the composition of an elaborate tridimensional structure, representing tectosilicates, as quartz and feldspars.

The practice of build models from start and then relate then the theoretical background provides a wider view to the student about the differences in mineral lattice complexities. The relation of friction increasing in magmas which host more complex minerals, and consequently in viscosity, can be understood in an easier way. Additionally, fundamental concepts of basic geology must be taught, as well. The use of online videos, as a ICTs practice, is also an efficient way to illustrate magmas viscosity trough volcanic eruptions. For instance, from less to more silica, Ol Doinyo Lengai (Tanzania), Lake of Fire (Iceland), and Mount Etna (Italy) show notable distinct eruptions, well-document on online videos. The use of short videos as a teaching resource tend to increase students interest in scientific explanations.

The above cited teaching practice can be translated to Physics and Chemistry in a STSE context. Since examples from nature are not commonly used in these subjects, volcanism tends to be a matter of doubt and curiosity. Models and ICTs material (as videos) have much more easy language for initial science approach, that will lead to more complicate discussions. In this sense, magma viscosity can be related to its microscopic features, i.e. structures of rock-forming silicate minerals, in a wider sense than other substances.

3 Conclusion

The viscosity of magmas is an interesting subject matter which can be used as a start point to explore contents in distinct science courses. In Earth science's teaching it can bring to the light the processes responsible to produce the different types of magmas. To reach an ideal discussion about viscosity, the student must comprehend distinct mineral structures and what causes that distinction. When presenting the concept of viscosity, a Physics or a Chemistry teacher can prepare lectures based on magmas properties, that will open a way to interdisciplinary discussions. In every case, the construction of models or use of ICTs, as videos, are helpful tools to link microscopic features and magma behavior.

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SHALLOW vs DEEP GEOLOGY

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Abstract— Geoethics is a novel area that is emerging at the intersection of geological sciences, ecological thinking, and ethics. The foundational blocks of geoethical thinking have been put together mostly by scholars in the field of geoscience. As it stands so far, geoethics appears as a fruitful new domain of knowledge, primarily oriented towards a more ethical and aware practice for geologists. Geoethics has been concerned with developing conceptual tools for geoscientists in order to account for the socio-economic, political and ethical dimensions of their activities. In this sense, geoethics seems to be strongly connected to policy because it stresses the consequences that geological knowledge, research, communication and practices have on the public sphere. We think, however, that in this way geoethics remains on shallow levels, and is somehow self-negating the most interesting possibility that environmental thought has been developing over the past three decades: criticize and deconstruct some fundamental assumptions of modernity. Even though we agree that the emergence of geoethics is, by itself, a positive fact, we argue that geoethics has the potential to unveil some of the "problematic" assumptions on which the study of geological sciences have been tacitly carried out. That is, geoethics can show that geological sciences have, so far, mostly operated at the service of specific social forces, such as governments, corporations, etc. within a framework that is characterized by anthropocentric and instrumental views towards nature. In practice, this means that the knowledge produced by geological sciences is basically turned into profits by some humans. In other terms, geoscience has been serving the socio-technical apparatus of the Capitalocene. The striking fact is that this simple fact appears obvious, even though geoscience could study the functioning of the Earth just for the sake of that knowledge, or to ameliorate some conditions. Given this situation, we propose to use the powerful analytical tools of ethics to question some fundamental assumptions that are constantly but invisibly operating within the geological sciences, and consequently have also been influencing the development of geoethics. In this article, we argue that geoethics, like geosciences, has so far been conceived in a rather anthropocentric and instrumental fashion. However, we would like to challenge this state of affairs by suggesting that geoethics should actually challenge the ideas that humans are at the center of nature, and that nature, consequently, is at the disposal of humans. In other terms, we propose an ecocentric geoethics that criticized the historical links of dependence between geoscience on the one hand, and the neoliberal capitalist system on the other hand. An ecocentric re-orientation of geoscience will redefine the human-Earth relationship through the recognition that humans are only a part of nature. We propose to call this novel approach to geoscience "deep geology" mirroring the similar radical step pursued two decades is possible by deep ecology within environmental ethics.

Keywords— Geoethics, ecocentrism, geoscience education, environmental ethics.

Thematic line— Environmental Education, Sustainability Education and Geoethics.

1 Introduction

Since 1992 the International Association for Geoethics (IAGETH) and beginning 2012 the International Association for Promoting Geoethics (IAPG) have been developing the field of geoethics. Geoethics can be broadly described as a novel interdisciplinary branch of applied ethics that sits at the crossroads of geological sciences, ecological thinking, and applied moral philosophy. Geoethics has been defined as the

> "research and reflection on the values which underpin appropriate behaviors and practices, wherever human activities interact with the Earth system. Geoethics deals with the ethical, social and cultural implications of geoscience knowledge, education, research, practice and communication, and with the social role and responsibility of geoscientists in conducting their activities" (Bobrowsky et al. 2017, IAPG 2017, Peppoloni & Di Capua 2012).

Geoethics has indeed the potential to bring moral concern and reasoning into the education of geoscience students while also update the preparation of current geoscience educators and practitioners. Besides IAGETH and IAPG, several educational institutions in the area of geoscience have also started to pay attention to the broader impacts of geoscience' research and activities, and especially to their ethical dimension. This demonstrates that, overall, there is a growing demand for a deeper engagement of geoscience with issues traditionally considered extraneous to the field, which are connected to social, economic and political spheres. These developments seem to parallel similar reflections emerged since at least the 1980s in the field of science & technology studies (STS). STS recognized the fact that, for example, science is not a value-free endeavor (Douglas 2009) and therefore ideas, values and preferences matter and influence the "making of science", especially for "applied" disciplines such as geoscience or ecology.

We recognize that recent scholars of geoscience education have underlined that "geosciences have ethical and social implications". Bobrowsky et al. (2017) affirmed that "in the geosciences, the imperative to act ethically should be emphasized continuously from the first Earth science module in primary school until a person takes off their field hat, lays down his or her maps and compass". Although this is an important first step, we would argue that the claim remains too vague and superficial. In other words, what does it mean to act ethically for a geoscientist? From an ethicist point of view, there are multiple ethical theories that can inform the right action, but scholars such as Bobrowsky seem to assume that there some sort of "imperative" that is supposed to guide the behavior of geoscientists. Ethicists would say that Bobrowsky apparently chooses a deontological ethical theory as the best path to ground a geoethics. However, there are many more options. Indeed, if we maintain that there are several ethical positions that moral subjects (individuals, groups, organizations) can follow, then the study of moral philosophy is capable of enlightening their assumptions in terms of ideas, values, and preferences. Therefore, a serious discussion about the content and role of geoethics should go deeper, and start from the ground-up through an actual interdisciplinary collaboration between geoscientists, geoscience educators and ethicsits. In this paper we propose to do that.

If we turn to the branch of environmental ethics, we can appreciate that since at least the 1970s scholars have been proposing a vast spectrum of ethical approaches extending from strong anthropocentric to non-anthropocentric ecocentrism (e.g. deep ecology). Forms of strong or weak anthropocentrism are typically linked to the idea that the non-human world has only instrumental value, that it exists for humans who can exploit it as they please. Milder or weak anthropocentrists may affirm that conservation is meaningful and long sighted because it maintains resources, but still mainly for the sake of humans. On the other side of the fence, so to speak, there are several theories that are grounded on non-anthropocentric assumptions, namely the idea that nature's existence is independent of humans' and can be valued for its own sake. In this sense, theories of animal ethics, biocentrism and ecocentrism can be described as enlarging circles of moral considerability, moving outward from the recognition of moral concern for animals, to the biosphere, and finally to embrace entire ecosystems. To be fair, some scholars related to geoscience studies have already mentioned the existence of non-anthropocentric approaches to ethics (Nikitina 2016), as well as the crucial idea of limits of sustainability (Bobrowsky et al. 2017). However, none of them have seriously embraced them or suggested that geoscientists should be systematically trained to think and work also in ways that need not be necessarily instrumental. That is, although geoethics allows to see in the education, work and knowledge produced within geosciences something more (or different) from what is immediately useful for humans, governments or corporations, it has failed to seriously propose such alternative paths. For these reasons, we claim that geoethics has remained only on shallow grounds, without offering yet the deeper reflection that is capable of. Therefore, despite these recent enthusiastic optimism among geoscientists, we point out that the current approach of geoethics falls short in many ways, limiting both the enhancement of the professionalization and its impact for present and future generations.

So far, geoethics has not offered a critical conceptual and moral analysis of the actual work of geoscientist. The IAPG has been mainly interested in delineating practical ethical tools such as ethical criteria or protocols for geoscientists, focused on freedom of research, plagiarism or "how can the relationships between geoscientists, media, politicians and citizens be made more profitable". A remarkable example of this concern for an ethical protocol to guide the work of geoscientists is proposed by Nikitina as "the necessity of introducing an oath for those who study and use subsoil" (2016: 204). More generally, geoscience education at large still teaches within a framework that is strongly influenced by mechanistic views in science, neoliberal theories in politics, and capitalistic economic assumptions.

Overall, we object that both geoscience education and geoethics has not yet made a difference in the way the non-human world is conceptualized and evaluated by geoscientists. Without a framework independent from utilitarian and instrumental values, geoethics runs the risk of only serving as a facade, a protocol for geoscientists that is unable, or unwilling, to challenge neither the socio-economic goals nor the broader ecological and political consequences of their activity.

There are fundamentals links between geoethics and environmental ethics (Hourdequin 2015) which indeed seem to deal with very similar inquiries. In this article, we argue that a meaningful geoethics is an eco-centric one, an ethical framework capable of embracing the non-human world with the larger possible scope (eco), and aware of the fact that the human-Earth relationship can be also conceptualized and lived in non-anthropocentric ways. It goes without saying that this understanding of geoethics may appear in opposition to the mainstream worldview on which current geological work is carried out. However, we invite the audience of this conference to remain open to the possibility of thinking in alternative ways about the relationship between humans and the Earth.

2 Methodology

By surveying several relevant sources among major geoscience organizations and journals (both national and international) we analyze the linguistic and conceptual content of their mission statement or otherwise main intellectual goals. From this comparative study, we retrieve evidence to show that geosciences and geoethics, both emerged and are still operating within a rather specific type of "culture" characterized by different types of anthropocentric attitudes tied to views of instrumental value towards the non-human world. From this analysis, we then propose that geoethics should inform the education of the current generation of geoscientists by exploring ways to think and teach also non-anthropocentric, non-instrumental (intrinsic) value. This can be achieved through a dialog with the established fields of environmental ethics and science & technology studies (STS), both of which can provide pivotal insights for geoscience education at large. We suggest that this approach would improve the overall preparation and work of future geoscientists, and potentially have broader impacts beyond the profession.

3 Conclusion

While we partially praise the efforts to develop the novel approach of geoethics, we propose a critique of its current foundations, and suggest ways to expand it towards the creation of a geoethics compatible with a "deep geology" capable of tackling environmental issues in more profound and impactful ways. This is a working paper that will be ready in the fall of 2018 to be then presented at the GeoSciEd conference at Unicamp.

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VALUES AND GEOETHIC CONFLICTS INVOLVING TAILINGS DAM: THE SAMARCO CASE, MARIANA, MG, BRAZIL

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Abstract — The mechanistic view of nature is based on traditional economic development, which is not compatible with sustainable development. We analyzed a groups of students in Brazil. Questions were raised regarding the exploitation of metallic mineral resources and tailings dams, in SAMARCO mine, Mariana, Brazil. From the Textual Discursive Analysis (DTA), the answers were organized in units (unitarization); after were categorized (categorization) for the discussion of the results (communication). For both groups from the point of geoethics view there are values conflicts: an intrinsic value of nature, but also a instrumental value from the needs of mineral resources.

Keywords— Geoethics, textual discursive analysis (DTA), environmental economy.

Thematic line— Environmental Education, Education for Sustainability and Geoethics.

1 Introduction

The epistemological challenges linked to environmental education are confronted by assumptions and utopias about the man-nature relation.

The aforementioned perception about nature, which does not include mankind in nature itself, is addressed by Gonçalves (1998), who comes up with the concept of a "non-natural" man. His proposal, which was solidified by the industrial civilization unveiled by capitalism, lies on the idea of an objective and external nature.

The "social feelings" relations described by Darwin spread through different societies, and members of these forming communities became more resilient; therefore, individuals' feeling of "belonging" to Earth got stronger (Grün 2007). This feeling of belonging points put how individuals "value" nature.

The intrinsic value of nature, which can be understood according to different concepts, is highlighted by the environmental ethics field (Rolston 2012, Naess 1995). However, all these concepts are linked by the criticism to the instrumental value of nature.

In fact, the boom in environmental issues in the 20th century led to a new perception about nature, since they started affecting the quality of life in urban centers. Moreover, at the same time, they made individuals question their consumption patterns, behaviors and values.

The different approaches adopted to plan and implement education reflect the different perspectives about man-nature relations, although they can also be conflicting points (Unesco 2009, Santos & Imbernon 2014). Based on the economic development premises, it is possible saying that the conventional economics science (the dominant Economics) does not understand the environment as a component to be evaluated (Mankiw 2004). Mankind remains far from finding balance between economic development and environmental preservation/conservation, although new terms such as ecodevelopment, green economy, eco-efficiency and sustainable development have been addressed by new models (Martínez-Alier 2010).

According to the economic perspective of ecology, the inclusion of environment as a variable in economic models was possible due to the idea that ecosystems are "warehouses. Environmental economics depends on ecology, since its main motivation lies on internalizing environmental costs in order to set prices that reflect the costs of complete marginal social opportunities (Cavalcanti 2010). According to Morin et al. (2011) and Sachs (2007), the dominant economic model is based on free externalization of socio-environmental costs, although it widens socioeconomic inequalities.

External factors, such as pollution, are adverse effects affecting decision makers. This model ignores these socioeconomic inequalities and, consequently, the willingness to pay the affected parties, which do not participate in the production and consumption of goods resulting from polluting activities.

Unlike the environmental economics, the ecological economics emerges from the growing awareness of the threat faced by ecological systems, which enable life on planet Earth, fact that shows a deeper understanding about the environment-society interactions (Cavalcanti 2010). However, contemporary society still believes in the idea that growth and development are synonymous, since growth is based on assimilation or addition, whereas development is understood as expansion and evolution towards a better stage. However, such concept does not take into consideration the aspects concerning poverty and environmental degradation (Daly 2004).

In fact, according to Daly (2004),

> "market prices are just relevant to local decisions taken under temporal and ecological perspectives, whose main consequences fall entirely on the human good-exchange economy and on the current generation".

Therefore, such perspectives involve ecological and ethical decisions.

Ethical issues involving the exploitation of natural resources have been driving the political and scientific discourses since the late 20th century, when “knowledge” and “values” became inseparable factors.

The relevance of scientists’ ethical awareness of the implication of their work in and for society grows when their actions influence society. Actually, the media turns most of these implications into dissemination and criticism targets.

Scientific fields encompassed by Natural Sciences such as Biosciences and Geosciences coexist with topics related to the use and abuse of natural resources. It happens through the positive connotation associated with technological advances and with the implicit improvement in quality of life, or through nature destruction and the exploitation of some citizens’ lives. Geologists have made a significant contribution to this view because the majority of these professionals work in extractive industries (Almeida & Vasconcelos 2014)

The ethical issues involving the use of natural resources, which are addressed during environmental debates, refer to the real meaning of wrong or immoral, to whether the use of natural resources is legal or not (Light & Rolston III 2003). Thus, individuals living in society often question such aspects; in fact, society’s perception about the ethical relation between the use/exploitation of natural resources, and the “values” associated with the impacts derived from this exploitation, come to the mainstream when major environmental disasters caused by mining take place.

2 Methodological approach and development

2.1 Area setting

The present study involved a case of environmental impact directly associated with metallic mineral exploitation. Tailings from mineral exploitation retained in tailings ponds led to contamination and to matters that have directly and indirectly affected tailings ponds’ neighboring populations, as well as to impacts on physical (soil and water) and biotic environments (flora and fauna).

A survey was applied to 28 Brazilian undergraduate students in Natural Sciences (LCN, *Licenciatura em Ciências da Natureza*) after a 60-minute lecture about Environmental Ethics, Geoethics and Environment Management.

The students were enrolled in the School of Arts, Sciences and Humanities (EACH - Escola de Artes, Ciências e Humanidades) of São Paulo University (USP).

The case lied on the environmental disaster of great proportion that took place in Mariana County, MG (Fig. 1), which had wide national and international repercussions. The catastrophic failure that happened on November 5th 2015 in the tailings dam belonging to the mining company Samarco, located in Mariana County, Minas Gerais, discharged 60 billion liters of iron ore tailings along more than 500 km in Doce River basin, which is the 5th largest river basin in Brazil.

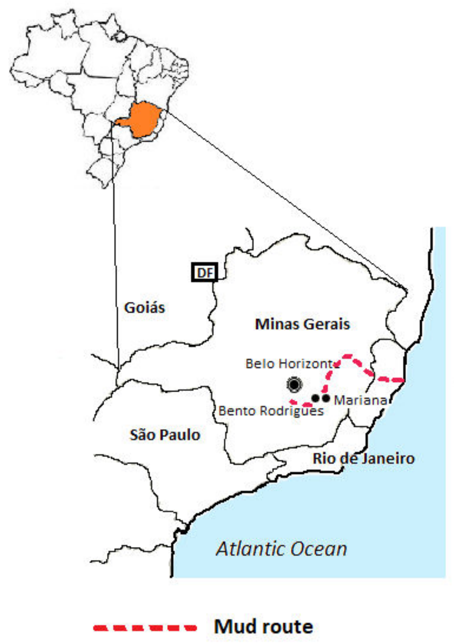

Fig. 1 Location diagram of Mariana, MG, Brazil and mud route

The Doce River Hydrographic Basin has 86,715 km^2 of drainage area, and is 879 km long; its water springs are located in Minas Gerais, more specifically, in Mantiqueira and Espinhaço Sierras, and the basin flows all the way down to its mouth, in Espírito Santo State. The tailing slide generated by the failure caused immeasurable and irreversible environmental damages, which resulted in a devastation scenario that could be seen approximately 2 km away from the area where the failure actually occurred. Human lives and arable lands were lost, the ichthyofauna and tourism were strongly impacted by the accident, and the coastal ecosystems suffered countless direct and indirect impacts; in other words, it was a major environmental disaster. The impact mud had on fresh and seawaters has not yet been measured.

2.2 Development

Students and teacher discussed topics related to Environmental Ethics and Geoethics within the environmental education and management scope by exploring the issue from the geoethical viewpoint, as well as from the perspective of social impacts caused by mining activities in both countries, based on the Environmental and Ecological Economics. Participants were asked to answer two open questions after the open-debates:

- Question 1: What do you think about the environmental impacts generated by mineral resource exploitations by taking into consideration the intrinsic (value of something in itself) and instrumental values (means to fulfil some purpose or objective) of mineral resources?

- Question 2: How can one “value” the environmental impact caused by the failure in Mariana County dam, which released Samarco mining tailings, by taking into account “Biosphere” (in the broad sense), although without forgetting the obligation to not “jeopardize the well-being of objects or natural systems without a good reason to do so”? Remember that the biosphere encompasses inanimate things such as rivers (hydrographic basins), landscapes and ecosystems, as well as living things.

The aim of the first question was to assess “moral considerability” based on the anthropocentric culture perspective, according to which nature is treated, as a good, as a resource and, therefore, it does not have intrinsic value.

Leopold (1933) presented the extensive idea that not only living beings, but also ecosystems and inanimate natural beings hold inherent moral valuation (rights of nature) in his theoretical framework “The Land Ethic”. The author points out that “the right to continued existence” applies to animals, plants and even to the soil.

Although Leopold was criticized for radicalism, some of the aspects pointed out by him, such as “there are obligations to land over and above those dictated by self-interest”, involve elements directly associated with Geoethics. It is so, because such obligations are based on acknowledging humans and Nature components as being ecologically equal (ecological egalitarianism).

Thus, the “value” given to these impacts reflects society’s commitment to a sustainable development when it comes to metallic mineral resource exploitations and to the impacts derived from such processes. It is worth highlighting that these exploitation processes are directly linked to the manufacture of consumer goods that improve the quality of life, as well as are essential to modern society.

The second question addressed the link between previous discussions held in class - when concepts such as environmental ethics, geoethics and environmental management were presented based on an economic bias - by taking into consideration the “value” of a natural good.

Thus, a conflicting situation was presented to the respondents and they had to take a position that would show their commitment to the construction of a sustainable society. Therefore, they reasoned about their own performance as citizens in a context wherein “losses” are immeasurable, regardless of the economic or technological value given to the resource.

The positions taken by the students were assessed through the Discursive Textual Analysis (DTA), which is the qualitative data analysis methodology proposed by Moraes & Garliazzi (2007).

Apart from group studies and open-debates, DTA comprises stages that require dividing the texts produced by the actors involved in the research into units in order to perform a detailed analysis. Next, the relation between each defined unit must be set in order to find the identity of each unit. Subsequently, the same procedure is performed to find the common elements emerging from the text as a whole. Such process leads to a new understanding about the meaning of this “whole”.

The DTA comprises three stages, namely: unitarization, categorization and communication. Unitarization lies on reassembling the texts within units able to show the meaning of these texts to the researcher. The so-called meaning-units derive from text disassembly.

The categorization procedure lies on grouping similar meaning-units into categories that can be constantly regrouped. It is worth highlighting that the texts become less superficial and apparent at this analysis stage, since details in each unit allow advancing to the total of units. Thus, it is possible getting to the categories from the units, and it enables gathering information about them.

The methodological design adopted to analyze the questionnaires is exclusively qualitative; thus, the current study does not intend to present statistically representative results, but to discuss the investigated concepts, as well as to investigate the relevance of scientific literature to the promotion of goals and targets outlined by the United Nations in Agenda 2030.

3 Results and Discussion

The analysis was related to the main textual production ideas, which directly referred to the proposed questions. The herein applied procedure allowed researchers to identify the concepts derived from the lectures, whose topics focused on aspects such as environmental management, environmental ethics and geoethics, as well as on the proposed questions; consequently, the procedure allowed writing more synthetic texts rather than prolix ones. Firstly, the main ideas from each respondent group were separated into units. The analysis applied to question 1 (which involved the respondent’s geoethical perception about the exploitation of mineral resources on the planet and their position on mineral exploitation versus generated environmental impacts) extracted repeated units in students’ textual production, and it involved the unitarization stage (Tab. 1).

Table 1. Unitarization of the most recurrent concepts among respondents, Question 1

Group of respondents	**Unitarization of concepts**
Brazil	Environmental impacts: the value of the impacts cannot be paid; the impacts are not taken into consideration; process valuation, including impacts; the impacts affect the environment, which has intrinsic value; the impacts result from the economic perspective about resources; they result from human needs; mitigation; consumption-associated impacts; impending onus; inspection; laws; public policies; human well-being is a priority; instrumental value of resources and intrinsic value of the environment; anthropocentric nature; Mineral resources: companies only see the instrumental value; the exploitation of re-

	sources is necessary; consumer society's attitude; dominant economic system; the value of nature is instrumental; the exploitation is necessary but lacks environmental ethics; the well-being resulting from the use of resources has intrinsic value; resources have intrinsic value; nature is an externality within the economic context; dependence on nature; society does not perceive the intrinsic value, only the instrumental one; the economic value of resources; extraction of resources for financial gains; society mixes intrinsic value to the instrumental value of these resources.

It was possible to see that student groups presented their concepts in two categories after unitarization: one category was associated with the "environmental impacts" generated by mineral resource exploitations, whereas the other one was linked to the use/need of "mineral resources" by society.

With respect to the categorization stage and according to the dominant economy perspective wherein the environment provides the material and energy necessary to produce consumer goods, the categories identified by the group considered the environmental impacts as the consequence of the instrumental value attributed to the mineral resources. It is worth emphasizing the recurrence of citations pointing out that the exploitation of these mineral resources is necessary to society's well-being.

Question 2 asked respondents to reason about environmental ethics and moral considerability concerning the biotic and physical environments (Tab. 2). The initial approach focused on local issues generated by the exploitation of metallic mineral resources. It involved knowledge about and acknowledgement of existing environmental impacts according to each group, as well as the assessment of these impacts on each location.

Table 2. Unitarization of the most recurrent concepts among respondents for the Question 2

Group of respondents	Unitarization of concepts
Brazil	The environment was valued as instrumental; future precautions; there is no way to value the environmental impact; polluter-pays principle; prevention and precaution principles; there is no way to value the environment; moral and ethical responsibility; difficult valuation; unsustainable; impact is contrary to the sustainability principles; it is not possible setting monetary value; treating it as an environmental crime; there is no way to value the social and cultural impacts; conflict of values (the instrumental value preponderates over the intrinsic one).

The main units identified in the textual productions referred to the generated impacts, to the remediation process, to the cost of technologies involved in this process (in some cases), and to the delay in remediating the impacts.

The group of students kept on mentioning that there is no way to value the loss of fauna and flora or that the loss of fauna and flora has no price, among other citations. Thus, according to them, there is no way to value the environment. It is worth highlighting that this group mentioned the precaution and prevention principles, in the sense of avoiding damages, as well as the polluter-pays principle, as a way to indicate who should pay for the damages. The conflict between the instrumental and intrinsic values, which were mentioned by some respondents, indicates that students perceived that the dominant economy understands the environment according to the instrumental value perspective, only. One respondent who mentioned unsustainability consolidated this perception; he concluded that the environmental disaster took the present environmental quality from future generations.

4 Conclusion

The incorporation of geoethical principles to the conscience and daily life of society worldwide should be the goal not only of natural sciences scientists, ecologists and educators, but also of managers, leaders, politicians and statesmen at all levels. In fact, the ones responsible for the fate of our planet and of all its inhabitants, including future generations, should take into consideration the planet's internal and external dynamics, which are often disregarded in mining activities.

Consequently, it is possible seeing social, cultural, economic and environmental impacts that take us away from the sustainability goals. However, although society repudiates behaviors related to the exploitation of mineral resources and the environmental damages they cause, it acknowledges the need to use these resources and accepts the negative externalities arising from this process.

The acceptance attitude of the students is strongly associated with the need to use mineral resources, including the price to be paid for it, even in situations wherein the impacts are widely spread by the media, such as in Mariana County, Brazil.

The way of thinking about geoethics, when it comes to the "value" given to the environment, should be based on moral and ethical principles often accepted by mankind. Geological factors should be the object of reflections and respected in any environmental sustainability concept, since society shows greater concern about the biotic environment than about the non-biotic environment (river basins, coastal plains, rock formations, etc.).

Overall, society does not realize that many natural phenomena, both in space and time, have periodic and hierarchical nature, as well as that these phenomena could be predicted. However, this knowledge, as the basis for a geoethical behavior in the use of natural resources, goes against the environment valuation by society.

The externalities arising from the use of natural resources are only noticed when the polluting activity affects individuals who do not participate in the production or consumption markets, and it causes conflicts that, overall, are overcome by the instrumental value of the natural resource.

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Thematic Line

Geosciences and Science, Technology, Society and Environment

BRINGING GEOSCIENCE TO A BROADER AUDIENCE VIA A LARGE-SCALE, ROLE-PLAYING SIMULATION CONCERNING ACID MINE DRAINAGE ACROSS SOUTH AFRICA

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Abstract – Geoscience literacy is imperative for all. Yet many students are never exposed to formal geoscience education. A large-scale, role-playing simulation involving acid mine drainage (AMD) in the Republic of South Africa is described. The simulation has been used successfully for six years in an elite French business school graduate-level course that has involved over 600 students from 30+ countries in 12 cohorts. The evolution and design of the course, its use of a large amount of geoscience information related to AMD, and the geoscience learnings of students are described. Its modification and potential use in introductory geoscience courses as well as in schools of business, public policy, public health, engineering, and other disciplines are recommended.

Keywords – AMD, business school, Geoscience, STS, simulation.

Thematic line – Geosciences and Science, Technology, Society and the Environment.

1 Introduction

At a time when Earth science issues such as climate change and dwindling access to clean water figure prominently in the news, Earth science literacy is crucial (The Earth Science Literacy Initiative 2010). Matters related to the geosciences underlay many significant societal issues in the past, present, and the future. The challenge is that students, at least in the USA, receive minimal amounts of instruction in the geosciences, either in compulsory or tertiary education. In the absence of systematic, sustained geoscience instruction, it is unlikely that students will develop even a basic understanding of the interconnected nature of Earth's systems. Further, students who do take geoscience courses often do not retain the information from their courses.

This is in part due to instruction that emphasizes inert information students do not find sufficiently engaging or useful. Efforts to improve Earth science literacy sit within the broader framework of initiatives designed to improve general scientific literacy (National Academies of Sciences, Engineering and Medicine 2017a, 2017b). Recent research on undergraduate learning in STEM fields has emphasized the need to address these deficiencies (Kober 2015, Best 2018) by more use of active learning, authentic experiences, problem-based learning, peer-to-peer learning, modularized tutorials on demand, emphasizing science and engineering practices, social media supports, simulations, case studies, etc.

Simulations immerse learners in a teacher-created "world" in which they must navigate the realities of a situation with its associated ambiguities. The outcome of the simulation depends in large part on learners' creativity in decision-making. Simulations can be thought of as a type of active learning and as problem-based learning. In a science-themed simulation, students must find and synthesize the relevant science concepts necessary to perform their role in the simulation and work with classmates to develop a viable solution to the problem. In this paper, we describe the use of an Earth science simulation focused on an important issue where the geosciences intersect with wider societal dilemmas and environmental problems – the arena of acid mine drainage or AMD. AMD is frequently mentioned as the third most important environmental issue in our modern world in terms of its impacts and import – yet few policy makers and citizens are aware of it. So, we pose the question: What happens when you design a university course with explicit attention to AMD and engage students in a lively, constantly evolving, role-playing simulation about AMD in the Republic of South Africa (RSA)?

The simulation we describe in this paper has been used in two business school courses on business with a social conscience and creativity management. We think it is of interest to geoscience educators for two reasons.

- First, the simulation could be adapted for use in an introductory geoscience course.
- Second, the use of the simulation in a course outside the geosciences raises the possibility of collaboration across the academy to bring geoscience content to a broader audience via the use of timely STS issues incorporated with information and concepts from a wide range of disciplines (Fouché 2017, Khandekar et al. 2017).

The simulation discussed here, for example, could be used not only in business schools but also schools of public health, schools of public policy, and potentially within disciplines such as environmental sciences, engineering, and development studies (cf. Brest 2017).

2 Acid Mine Drainage: A Geoscience STS and Environmental Issue

The Witwatersrand Basin in the Republic of South Africa (RSA) is the largest gold producing region in the world. During the Archean, the area was part of a shallow sea with its associated shoreline. Conglomerates containing gold, along with sandstones and shales were deposited during a period of marine regression. The area is covered by younger sedimentary and volcanic rocks. Since gold was first discovered in the Witwatersrand Basin in 1886 over 40,000 metric tons of gold have been extracted from mines (Pratt 2011). Because the conglomerate lies at depth, mines are as deep as four kilometers below the surface with a vast network of interconnected tunnels. An average gold mine in the country has tunnels that comprise a total of 362 km (225 miles).

The revenue generated from 100+ years of gold mining in RSA has come at an environmental cost. Water in abandoned mines, as well as surface leftovers from the mining process (tailings dumps), is highly acidic due to sulphide mineral oxidation. This acidic water often contains toxic heavy metals. This polluted water poses threats to biota near the mine and downstream. Water in the network of interconnected tunnels carries toxic water far from the site of the mine, while also continually expanding the size of the mine. There are additional concerns regarding soil instability and increasing evidence that the underground movement of the acidic and toxic waters is contributing to seismic activity in the Johannesburg region of the nation.

3 Evolution of the Simulation

3.1 Initial use of the simulation

The genesis for this simulation arose from the article on AMD in RSA in *Earth,* a magazine from the American Geosciences Institute (Pratt 2011). At the time, the first author was teaching at the National University of Singapore in the NUS Business School. The first author's background in biology, STS issues, creativity, innovation, and social entrepreneurship and the second author's background in geoscience education produced several discussions about how to use contemporary geoscience issues to help undergraduate and graduate business students learn about the importance of business with a social conscience. The Pratt article spurred us to think about how we might develop a simulation involving AMD in RSA to achieve that goal. with business school students.

The simulation was first used as one component of a semester long undergraduate BBA course. Students read the Pratt article and a few other print materials posted on the course webpage that explained AMD as part of their preparation. A dyad of students was randomly assigned to jointly pretend to be the CEO of an actual organization in RSA (e.g., government agency, nonprofit, chamber of commerce, mining company executive, trade union of mining executive). They were not permitted to go online and find their actual counterpart in the real world so as not to influence their own thinking about the AMD issues within RSA. All students participated in the simulation as members of a dyad. The culmination of the activity was a live "television" appearance by each organization (dyad), before an international panel of technical AMD experts looking into the situation in RSA (i.e., in front of the entire class). Panelists were a biologist (first author), chemist, and geoscientist (second author). Each dyad could use their joint voices for the simulation, speaking as if they were a single person. Only an initial scripted question was provided to the dyads: "What role and responsibilities do you believe your organization has in reference to the AMD issue?" Beyond their response to that question, they were told the panelists would ask anything they wanted. Students were graded on their responses as well as on a required reflective essay about the relationship between the AMD problem and the theme of the course regarding conducting business with a social conscience.

This experiment in STS participation and its attendant impact on students' learning (Lezaun et al. 2017) prompted the first author to seek an opportunity to develop and implement a more extensive simulation concerning the AMD problem in RSA.

3.2 The simulation as a course anchor

For the past six years, the simulation has been used at IÉSEG School of Management (IÉSEG) in France on a master's level elective course on "Creativity Management." In the 2017-2018 school year, IÉSEG reported a total of 5,150 students (of whom 2,270 were international students)), 281 partner universities in 69 countries, and 2,500+ corporate partners worldwide. The school holds AMBA, AACSB, and EQUIS accreditations placing it among fewer than 1% of business schools globally who hold this triple accreditation. The *Financial Times* ranked its M.Sc. program 31st in the world in 2017.

Courses in the M.Sc. program at IÉSEG are taught in a one-week (16 hours), intensive module. The course has been taught annually at the Paris and Lille campuses of IÉSEG since 2013. The course is an elective within the Innovation and Entrepreneurship track within this elite French business school. It is cross-listed and open to students across IÉSEG including those pursuing a Master's in International Business (MIB) and all foreign exchange graduate and undergraduate students. The course was first offered in the second semester of the 2012-2013 academic year with a total of 116 enrolled students in Paris (57) and Lille (59). Subsequent annual course enrollments resulted in a total of 651 students over the past six years with 344 at the Paris campus and 307 at the Lille campus. There were no significant differences in males versus females. For the most recent cohort (2018) there were 120 total students (62 in Paris and 58 in Lille) comprised of 43 IÉSEG M.Sc. students, 64 M.Sc. exchange students from 28 nations, 11 IÉSEG MIB students, and 2 foreign exchange BBA students.

Rather than develop a series of lectures on creativity techniques as they could be applied to select business cases, a decision was made to develop a four-day intensive role-playing simulation. The idea was to involve students in playing actual roles from the real world who needed to make some major decisions working with other organizations. The need for enhanced creativity to solve the complex problems associated with AMD would motivate students to acquire several new formal creativity techniques and apply them to meet their specific needs. It would also introduce students to the need to manage team as well as their own performance. The complexities within the simulation were kept to a manageable level by compiling three distinct sets of information for students. This step also prevented information asymmetry from arising as all students have access to identical information. First, a folder containing detailed information about 40+ creativity techniques to generate, refine, evaluate, and improve ideas and approaches. Second, detailed information on the various organizational "roles" for the simulation as well as relevant information on the economy, education, employment, and other essentials regarding RSA were assembled. Finally, detailed information on varied geoscience and sociotechnical aspects of the AMD problem in RSA were curated. The guiding principles for the selected materials included:

1) English language only (since the course is in English) and readily accessed electronically;
2) Variable sources ranging from semi-popular to technical;
3) Sufficient but not exhaustive content;
4) Disagreements among the various sources as to certain facts or the importance of various issues;
5) Relevance to AMD issues in RSA with some examples from elsewhere to act as provocations or preliminary prompts for ideas and
6) A sufficient but not exhaustive catalog of some important techniques students could use to stimulate their own creativity.

Materials given to students regarding AMD matters have varied each year as some items are withdrawn and new ones are added. In some cases, these are more recent editions of the same document; sometimes new materials are added to introduce further complexities or withdrawn to limit complexity consistent with the addition or deletion of other relevant materials. The annual package includes the creativity techniques folder as well as several thousand pages of print materials organized into two AMD folders: one labeled "Essential Readings" and the other "Optional Readings." The span of items covers topics such as:

1) Annual reports of select mining companies operating in RSA;
2) Annual RSA national budget summaries (as well as the most recent full budget – a 400+ page document which the National Treasury has to master and other teams just have to know important pertinent aspects related to their specific roles);
3) Position papers issued by various nonprofits;
4) Scholarly papers and international documents related to AMD issues;
5) Geochemical information related to AMD (at both introductory and more advanced forms);
6) Economic and labor information;
7) Overviews of the RSA mining industry;
8) Overviews of relevant RSA laws and regulations;
9) Information concerning corruption in RSA;
10) Large scape maps of the mining areas and
11) Reports on other pressing national issues, e.g., health and safety, fresh water, and droughts (there has been a three-year intense drought in Cape Town in western RSA since 2014).

Students were allowed online access only to the folders and two external websites (both of which dealt solely with creativity techniques). Students were forbidden to access or use any knowledge from the wider Internet, newspapers or other print materials, friends or family, or social media to eliminate information asymmetry, constrain the complexities they already face from information in the three folders, and require them to produce solutions rather than simply locating existing ones and making these their own. They were permitted to use any information they already had inside their heads upon entering the first day of class, e.g., a few students over the past six years have visited the RSA for brief periods or some knew about some recent political developments; occasionally a student had some awareness of mining problems in their home nation. There has yet to be a student entering the course familiar with AMD.

4 Detailed Structure of the Simulation

Students enter an intense 16-hour, role-playing simulation whose content and processes are bounded by the following parameters:

1) symmetry of information across all teams in the simulation,
2) each team playing an assigned role acting as they believe their real-world counterpart would act throughout the simulation,
3) guided by the procedures and directions of a team of students that play the role of an international consulting firm commissioned specifically to facilitate this national gathering called by the President of the RSA for the express purpose of resolving the AMD issue, and
4) the task of collaboratively and mutually deciding on a suitable course of action to address the AMD issue and its derivative issues across RSA. A total of fifteen distinct teams have been developed which correspond to actual RSA organizations; in smaller cohorts the number of teams is reduced with each team always comprising a minimum of 3-4 members.

As is true of any role-playing simulation, the course flow is determined to a large extent by the students and their decision-making processes. Each course begins with a one-hour introductory lecture delivered by the professor. The lecture highlights the nature of the course and the designed experience that students will soon be enmeshed within, performance expectations, demands that the course imposes on individuals, teams, and the entire class, the 360^0 grading process that will be used, and the interrelationship among the simulation, imagination and creativity, and business knowledge are highlighted.

Table 1. Teams within the Simulation

International Consulting Group (class leader)	Federation for a Sustainable Environment (NGO)
Mining Communities Federation (NGO)	Office of the RSA President
Cape Town Chamber of Commerce (Business federation NGO)	National Treasury of RSA
Congress of South African Trade Unions (NGO)	Committee on AMD, RSA Parliament
National Union of Mine Workers (NGO)	RSA Department of Water and Sanitation
Johannesburg Chamber of Commerce (Business federation NGO)	RSA Department of Health
Government of Johannesburg (largest city in RSA)	South African Democratic Alliance (largest opposition party in RSA)
Chamber of Mines (mining industry NGO)	

Students are urged to take risks in this "safe" environment and to step out of their own cultures and usual ways of conducting themselves. The importance of experimentation and the rewards and non-punitive nature of the risk-taking that is required for success are underscored. The need to challenge each other and to draw the very best out of every member of their team and other teams across the class is emphasized. Finally, students are encouraged to "have (serious) fun." Students are given an opportunity to ponder what they've just heard during a class break. During the break, students who wish to volunteer to be considered for the important and challenging role of the international consulting group are interviewed by the professor and the team is constituted. Factors influencing the choice include undergraduate major, country of origin, facility in English, and prior consulting experience. A balance of race, ethnicity, and gender is also maintained among the 4-5 person consulting group. All who volunteer and were not chosen are placed in advance on other respective teams where their background and talents will prove useful for the simulation about to commence.

The remaining students are randomly assigned to a team by the professor – consistent with what happens in a large corporation where you often do not get to pick your teammates. During the assignment process the international consulting group meets outside the class for the first time and decides what to do next as the class will shortly pass over fully into their "hands and minds." After all students are assigned roles the simulation commences under the direction of the international consulting group. The professor now assumes the role within the simulation of an international expert on AMD who has been contracted by the President's office to provide scientific and technical information upon demand of the various teams in the room throughout the four days. In that role, the professor only answers scientific and technical questions; all process and procedural questions are referred to the international consulting group. All teams then meet independently and get to know one another and read the Pratt article. Then the President of the RSA greets the attendees of this important AMD consultation to which they have been summoned to aid their country. The last fifteen minutes of each class session are given over to the professor to provide a high-level view of key insights as to how teams are doing and what can be learned from the experiences of the day.

Teams work outside of class and utilize their own processes and procedures to share information, track their ideas and arguments, compile their evidence and presentations, prepare to defend their positions, etc. Students who are ill and unable to attend class are expected to be in touch with their teams via social media and support their team as fully as if they were physically present. The class is very demanding of students' time but also their attention and the full use of their minds and spirits.

About three-fourths of the way through the simulation the President of the RSA welcomes his personal guest, the Honorable Archbishop Desmond Tutu, Nobel Peace Prize winner - a role played by the professor who dons an African shirt for the occasion. Tutu's visit serves as a stimulant to class deliberations, reminds the class that some South Africans are globally recognized and influential (since RSA needs external help with the AMD issue), and helps reenergize students to solve this complex problem which thus far has proved beyond their capabilities. (This role could also be played by a budding student actor or someone else outside the class, but the physical presence should be maintained as it has a demonstrable effect on the audience.)

Tutu delivers his carefully crafted remarks in a speech pattern resembling the actual archbishop to the entire consultation which is covered "live" by international media in attendance due to his prestige and renown. He reminds them of the importance of their efforts, the need to persevere in their difficult task, insights from the long and difficult anti-apartheid struggle that highlights the importance of ethics, the vital role of the nation's women, the pressing demands of social justice, the potential to lead the world on this important issue of AMD, and his own belief that the world will help RSA in its AMD efforts if it can fully and honestly face itself, resolve to make a difference on this issue, and put in place effective mechanisms that give promise of effectively addressing the many issues raised by AMD. The entire class receives an electronic copy of the speech within minutes of its delivery. Tutu departs, and the class returns to its ongoing debates, problem solving, and coalition building. There is plenty of evidence from students' oral and written responses that this speech spurs students to dig deeper within themselves, renews the resolve of some who were flagging in their frustrations at the many seemingly intractable aspects the AMD problem presents, and alerts everyone to some considerations that had not yet entered their minds. For many teams it releases their anxieties and opens their minds to consider new paths towards resolution.

5 Outcomes

The 12 cohorts across the two campuses over six years have always produced some reasonable "solutions" given the time constraints under which they were functioning. Each cohort derives its own unique set of solutions and even though they sometimes highlight the same issue there are many differences in the details of their respective approaches. The class ends with a summation by the RSA President who thanks the participating organizations for their important efforts this week, a word of thanks from the International Consulting Group who was privileged to serve them throughout the week, insights from the Professor regarding some take-aways from the final day of the simulation, and then a closing karaoke song "I Did It My Way" by Paul Anka that was written specifically for Frank Sinatra. It is to the same tune as an original French song "Comme d'habitude." The class is reminded that when faced with these types of complex issues in the real world you can either just do what you have always done in the way you have always done it, or you can lead and do it your way – finding your way forward to unique solutions drawing upon resources within yourself and the resources of others to make a difference in the world. After an initial solo by the professor (which could be substituted by a YouTube rendition by a suitable artist, including Frank Sinatra), the entire class is invited to stand and sing together. They leave the class elated to have "solved" a very difficult problem about which they knew nothing only four days before and reporting greater self-confidence than before this four-day designed experience.

Seventy percent of students' grades are based on their participation in the simulation. Half of that score is derived from students' assessment of their own individual team members, including themselves and the performance of all teams in the simulation, including their own. The other half of the score for the simulation is based on the professor's evaluation of individuals and teams. Students are reminded to base their assessments on considerations of whether their peers were faithful to their assigned roles throughout the simulation (thus even "obstructionists" to the solutions being proposed can be rewarded equally to those advancing such solutions if these were acting in ways consistent with their counterparts in the real world). Students are also asked to consider the relative difficulty of the various roles in the simulation (with the international consulting group have the toughest role overall), the fact that team members can contribute effectively to their own team's efforts in myriad ways, and that realistic solutions matter and those who were central to their formulation should be recognized appropriately.

Students also complete two out-of-class essays at the end of the course which supply the remaining 30% of their course grade. The first is a reflective essay on what they learned about themselves, their team, and managing creativity during the week. The second essay they select from three set questions:

1) What they think should be done regarding AMD in RSA;
2) If they were to start a business focusing on aspects of the AMD problem what would they launch and how;
3) A critique of two creativity techniques they used during the week (they are not allowed to discuss the widely known "brain storming" or "mind map" approaches).

6 An Invitation to Bring Geoscience Content to Business School Students

The design of this course fits very well with the goals of the new strategic plan that IÉSEG put in place in 2016 (Ammeux & Roussel 2016) and is consistent with its efforts on improving teaching and learning across the school (IÉSEG School of Management 2016). The strategic plan flows from a Vision 2025 effort that drew wide input from faculty, staff and students throughout 2015. It articulated a vision of "Empowering Changemakers for a Better Society" through IÉSEG increasingly becoming a source of:

1) *innovation* – providing inspiration, knowledge and creativity for organizations,
2) *managerial impact* – nurturing, inspiring, expert and ethical pioneers of change, and
3) *social impact* – promoting a greener, fairer and more inclusive society.

Many business schools have similar strategic plans that seek to link business school education more explicitly with creativity, innovation, entrepreneurship, broader issues within society where business has a role, and business leaders as a force for social good in the world. These documents provide touchstones for determining prospective business schools that might be open to a geosciences-rich simulation like the one described here. They are a perfect entrance point for geoscience, STS, and social impact and alert the world's future business leaders and their professors to the importance of geoscience to business, industry, and the global economy (cf. Hommels et al. 2014).

The focus of the course is on creativity management. Given the focus of this conference, we leave aside the many important insights students have shared in their reflective essays regarding their own creativity, the creative potential of others, and the ways in which creativity is much wider and more useful than their preconceptions led them to believe. Instead we focus here on some of the learning that occurs regarding AMD, mining, and geosciences in general. These insights are gleaned from students' written responses to set essays as well as some proposed solutions and argumentation that emerged during the 12 different simulations that have taken place over six years.

The four days of debate, coalition building, intense problem solving, solution evaluation, and solution rejection, refinement, or endorsement, provide abundant evidence of students' grasp of essential aspects of the characterization of the AMD problem, the array of technical solutions that are clearly available, the varying feasibility of those solutions when applied to the large land area over which the abandoned mines are found, and relevant financial, practical, and logistic aspects of the problem. Cohorts by the end of day two have already considered and rejected a wide range of "solutions" that came quickly to mind through reading of the materials and elementary brainstorming exercises. Days three and four are spent applying a much wider array of formal creativity techniques coupled with meta-level conversations across teams organized and facilitated by the international consulting group to determine new possible solutions and work them through to reasonable proposals for action – accompanied by cost estimates, preliminary procedural steps, and distinguishing short-term from long-term approaches. The flow chart shows the general and iterative progression of the course over the four days.

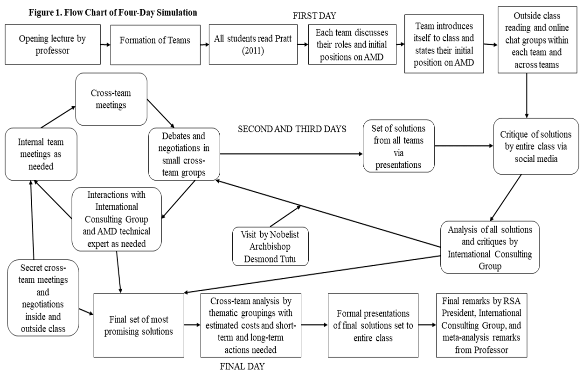

Figure 1. Flow Chart of Simulation

All 12 cohorts have provided good evidence either across the entire cohort or among selected teams of the sample understandings below related to geoscience and the themes of this conference. These understandings are also consistent with Earth Science Literacy Principles - Big Ideas 3, 7, and 9 (The Earth Science Literacy Initiative 2010).

1) Mining companies dissolve, or abandoned mines are sold to offshore holding companies. Governments must assume long-term responsibility for abandoned mines. Some can be repurposed or reopened for select periods. This revolving government portfolio must be managed into the distant future.
2) Existing mining laws and regulations must be effectively enforced, or they breed crises like AMD.
3) Mining revenues and global supply and demand are volatile; long time horizons are needed to recover sunken costs.
4) Mining is fraught with many dangers, both short and long-term, minor and major.
5) Human societies obtain minerals in desired quantity, quality, and costs by exercising tradeoffs. Mining activities provide economic benefits but are also sociopolitical in nature with short term and longer-term consequences that flow from such activities.
6) Past geologic processes create opportunities, impose constraints, and confer benefits on human societies. Humans change environments in their pursuit of such opportunities. Geoscience, mining engineering, and other forms of technical information are useful. Business leaders and leaders from other sectors should become aware of fundamentals regarding mining activities as they impact society.
7) Interactions among the spheres of the Earth system mean that what is below ground does not necessarily stay below ground and things above ground can impact things out of sight (and frequently out of mind).
8) AMD is a global problem experienced by all countries that engage in mining; nations have deployed ameliorative solutions with varying degrees of success.
9) Surface tailings from mining pose threats to health and safety, including respiratory problems, pools of contaminated water, and dangers from children playing in these human-made hills.
10) Multinational companies manage mining assets around the world and shift priorities, production targets, jobs, finances, and personnel as they see fit, answering in most cases to public shareholders.

Final Reflections

Our experience with this ever-evolving simulation that has been used on two continents demonstrates that substantial geoscience content can be successfully introduced into subject areas well outside of geoscience classrooms. Further, it appears that placing such content into a course whose ultimate purpose is not about science *per se*, can create sufficient motivation that students will self-choose to master content and concepts from the geosciences in pursuit of goals that sit outside of the sciences. This leads to a positive interaction with scientifically "dense" materials that develops broad-based geoscience understandings. These future managers and business leaders start to think more reflectively about the Earth they inhabit. Subsequently, they may engage in personal, business, and civic responsibilities with a deeper understanding of the critical role that geoscience and geotechnical knowledge, concepts, and expertise play in the economy and within human societies.

The success of this course underscores the value of collaborative efforts between geoscience faculty and those in other areas of the academy to bridge disciplinary boundaries. This simulation also holds promise for geoscience educators teaching introductory geoscience courses that are often both the first and last geoscience courses a student takes.

A focus on relevant geoscience issues and the use of simulations like the one we've described in this paper can help improve the Earth science literacy of the populace. We are most gratified by the ways in which students have made this course their own. Many students are motivated to learn about problems with AMD in their own countries and other related issues they were introduced to via this simulation experience.

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THE INTERPRETATION OF GEOLOGICAL HERITAGE AS A TOOL FOR THE DEVELOPMENT OF GEOTOURISM: THE CASE OF THE NATIONAL PARK OF CHAPADA DOS VEADEIROS

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Abstract— The interpretation of the Geological Heritage is a subject that has been increasingly discussed inside and outside the academy, mainly because it is a powerful tool for the development of activities such as geotourism. Geology is a science with very specific terms, which often hinders the understanding of who is not from the area. Therefore, in many places of geological interest, there is already the use of tools with geological interpretation. However, it is important that this interpretation is done in the right way and that it reaches all the visitors of the place. There are several tools that use interpretation such as panels and brochures. These tools will be used to disseminate the site with a focus on geological aspects, where time is the main appeal. The present work aims to discuss how these tools work and how they can help in the dissemination of geosciences and the sustainable development of tourism.

Keywords— Geosciences, geotourism, Chapada dos Veadeiros, geological heritage.

Thematic line— Geoconservation, Geotourism and Geopatrimony.

1 Introduction

Many times there are a discussion about the development of tourism and normally the first points to be addressed turn around the tourist infrastructure, such as hotels, restaurants, gift shops and etc (Murta and Albano 2005). However, there are more factors influencing this development than just the infrastructure.

Beni (2004) defines tourism as a social phenomenon that, by originating a series of activities, such as transportation, housing, recreation and others, causes them to generate another series of effects on the environment in which they develop and which may be have an economic, social, cultural and even ecological character.. Considering the different characterizations of tourism, one always observes the common presence of three elements: physical space, time and individual.

The same author points out that for the preservation of tourism assets (natural and cultural), to maximize the economic and social benefits of the State and to enable the exploration of new market segments, it is necessary to think of strategies that appreciate the city and not mischaracterize its origin and nature (Beni 2004).

In this perspective Molina (1997) apud Caetano (2006) affirms that the tourist activity can generate significant benefits for a locality, such as: income generation and foreign exchange from the commercialization of tourist products; job creation; rescue and preservation of socio-cultural values; income distribution; reduction of the rural exodus with the development of tourism in rural areas and contribution to the preservation of fauna and flora in areas of environmental protection. These and other factors make tourism a development opportunity for any potential region.

Murta & Albano (2005) state that:

> "there is always a presupposition that the tourist will discover for himself and marvel automatically with the natural beauties, the buildings and historical monuments" (Murta & Albano 2005, p.9).

However, when it comes to elements of geology and geomorphology the tourist can be enchanted with the landscape purely and simply by the scenic beauties, but the connection with the conservation and preservation of the place will only be created as soon as the tourist understands the importance of such a landscape, how it was formed, and how fragile it can be. The interpretation tools act precisely in this context, to present the tourist with simple scientific data, facilitating the understanding for ordinary tourists who are not specialists in the subject.

2 Landscape and Interpretation

To understand a bit more about the relationship of the tourist with the landscape, it is important to keep in mind the concept of landscape for geography. The term 'landscape' carries an immense range of possibilities of definitions.

Bertrand presents in his 1972 text "The Landscape and Global Physical Geography: Methodological Outline" the following definition for landscape:

> "Landscape is not the simple addition of disparate geographical elements. It is the result of a dynamic and therefore unstable combination of physical, biological, and anthropic ele-

> ments that, by reacting dialectically to one another, make the landscape a unique and inseparable whole, in perpetual evolution. (Bertrand 1972, p. 141)

It is, therefore, not only the natural landscape, but all the elements that are present and form the landscape as a whole. Another definition that brings new characteristics addressed is that of Santos (1991):

> All that we see, what our vision achieves, is the landscape. This can be defined as the domain of the visible, that which the sight reaches. It is not only formed of volumes, but also of colors, movements, actors, sounds, etc. (Santos 1991, p. 61)

It is noted that the last two authors relate more broadly to what is seen with other external factors, such as sounds and movements. Therefore, it can be related to the tourism , since the tourist is experiencing not only by the field of vision, but also through sounds, physical contact, involvement with the local community, among others. All this, causes or does not arouse in the tourist a desire to know better and to protect such a place.

For Murta and Albano (2005), there is a conflict between tourism and preservation that can be overcome through the practice of heritage interpretation. The authors believe that in this way, if we work with the interpretation together with the social development of the place, there is the possibility of convincing people of the value of the heritage and, thus, awakening to the importance of conservation.

Tilden (1977) defines interpretation as:

> "An educational activity which aims to reveal meanings and relationships through the use of original objects, by firsthand experience, and by illustrative media, rather than simply to communicate factual information" (Tilden 1977, p.88).

Therefore, the interpretation aims to create meanings and relationships that go beyond the simple fact of passing information. Applying to the geological heritage, you can create a different experience to the visitor in places already known through the presentation of new tools and information.

In Brazil, Moreira (2008) affirms that environmental education can be used to stimulate interest in Earth's history and to help with conservation strategies of geological heritage, but that to function effectively, it must be part of all levels of formal education.

According to Moreira (2008), the environmental interpretation arose in the United States with the publication of an article that suggested the making of leaflets that would help tourists to understand the environmental aspects of Yellowstone National Park, including a geological phenomenon that have been explained in the wrong way. From then on, the North American National Parks Service created the first program of interpretation of nature.

For Moreira (2005): Environmental interpretation facilitates the knowledge and appreciation of nature, for it is a translation of the language of nature into the common language of people, that is, it translates the technical language into the terms and ideas of the general public, which are not scientific. Thus, in order to entertain, it must stimulate, transmit, reveal, and be coherent. (Moreira 2005, p.250).

It is understood, therefore, that the purpose of the interpretation is to increase the satisfaction of the tourist in order to make it become more attached to the place through the knowledge. One must present the history of the place so that the visitor understands how sensitive and how unique some places can be. In the case of geology, there is a difficulty in the questions of interpretations since there are many specific terms relatively difficult to interpret. However, there are already several projects in Brazil and in the world that work with the interpretation of geology and that reaches the different publics, such as the Geological Pathways Project, carried out by the Geological Service of the State of Rio de Janeiro and the Darwin Paths Project, which is briefly described by Mansur (2010).

3 Geotourism and the Interpretation of Geological Heritage: the case of the Chapada dos Veadeiros

The concept of geological heritage has been discussed by different authors in the world. Ruchkys (2007) discussed the different conceptualizations on the subject, especially of international authors, where the concept has been discussed for a long time. The author presents the following definition of geological heritage:

The geological heritage, represented by geological sites, can be defined as a documentary resource of a scientific nature, important content for the knowledge and study of the evolution of geological processes and that is the record of the total evolution of the Planet. (Ruchkys 2007, p.9)

Nascimento et al. (2008) explain that in Brazil there are rocks, minerals and fossils of various ages and types and different landscapes. There are records of rocks that recede from the earliest days of the Planet's history and run through all geological time to the present. Therefore, it is important that it is possible to understand this type of material to understand the entire geological context of Brazil and the Earth.

Brilha (2015) states that geological heritage can receive other nomenclatures according to the element of geodiversity it considers. Thus, it is common to refer to geomorphological, petrological, mineralological, paleontological, stratigraphic, structural, hydrological or pedological patrimony such as what the author considers subtypes of geological heritage.

The geological heritage is considered as part of geodiversity, since it is composed of geological and geomorphological formations. However, Nascimento et al. (2008) affirm that the concepts should not be considered as synonyms, since the geodiversity comprises the whole abiotic environment of the Earth, since the geological heritage deals with a part of the geodiversity with specific and unique characteristics which must be preserved. Therefore, it is correct to affirm that all geological heritage is geodiversity, but not all geodiversity is a geological patrimony. Brilha (2005) also emphasizes that the idea is not that all outcrops are conserved, only those that have some type of added value.

The practice of tourism activities in areas with marked geological characteristics is common and recurrent worldwide. However, it only received a specific term from the 1990s. The term "geotourism" was defined by Hose in 1995 in a magazine of environmental interest and thereafter became known throughout Europe. The practice of tourism in areas of geological heritage already happened, but was only named after Hose (Nascimento et al. 2008).

According to Hose (1995 apud Ruchkys 2007):

> The provision of interpretive services and facilities to enable tourists to acquire knowledge and understanding of the geology and geomorphology of a site (including its contribution to the development of the Earth sciences), as well as mere aesthetic appreciation. (Hose 1995, apud Ruchkys 2007, p.23).

Frey et al. (2006) state that geotourism is a new occupational and business sector:

> The main tasks of geotourism are the transfer and communication of geoscientific knowledge and ideas to the general public "(Frey et al. 2006, page 98).

It is therefore perceived that one of the objectives of this new category of tourism is the dissemination of geosciences. Moreover, Moreira (2008) points out that the fundamental principles of geotourism are the sustainable protection and preservation of geological heritage.

For Araújo (2005), geotourism can be considered an ecotourism strand because it is also based on sustainable tourism. It can be used as a tool to promote the social value of the place as well as promote the conservation of it. The author states that geotourism and geoconservation have a relation of exchange, since geotourism promotes geoconservation and geoconservation can be used to promote geotourism.

Araujo (2005) considers that geotourism can be used as a tool for the conservation of geological heritage, since in this way it is possible to sensitize the general public and the local community to the importance of its conservation, since one of the objectives of geotourism is the dissemination of geosciences, through tools that enable such a process.

It is not known when exactly the practice of geotourism began. However, it is a fact that many tourist practices are developed in areas with a marked presence of geodiversity.

In Brazil there are several areas that can be practiced in geotourism, including areas where they are already practiced, such as the Iguaçu Falls in Foz do Iguaçu - PR and the Sugar Loaf in Rio de Janeiro - RJ. In the state of Goiás, we can mention some examples of areas of geological interest such as the Pyrenean Mountains and the various waterfalls in Pirenópolis, the Terra Ronca State Park in São Domingos, the thermal waters in Caldas Novas and Rio Quente and the National Park of Chapada dos Veadeiros.

Regarding the determinants of geotourism, Moreira (2008) stated that there are three main ones that can favor or limit their development:

1- The scientific character of the geological community, referring to the limitation and description of the geological heritage;
2- Those of a political nature, such as administration, legislation and promotion of attractions;
3- Those of social and tourist character, which include the tourist trade, where are the private initiative, tourism agencies, operators, hotel sector, transport, marketing, souvenirs, etc. The three groups intervene equally in the development of geotourism and the relationship between the three is not only of proximity but also of dynamic and mutual interaction. (Moreira 2008, p.70).

Considering the implementation of geotourism, Pffor & Megerle (2006) believe that

> "the establishment of communication networks and adequate exchange of this infomation are important to implement geoturism successfully in the region" (Pffor & Mergele 2006, p 123).

Therefore, there should be a participation not only of the bodies responsible for the management of sites with the presence of geodiversity, but of all spheres that are included in the tourist practice.

Bento (2010) states that:

> Geotourism is therefore related to the natural resources often neglected by ecotourism - geological and geomorphological aspects - and can basically have three motivations: recreation, leisure and learning, all contributing to the conservation of attractions such as waterfalls, caves, rocky outcrops, saws, volcanoes, mineral deposits, canyons, among others (Bento 2010, p.23)

The experiences of interpretation of the geological heritage in Brazil has been gaining more ground. Barbosa (2017) presents the experience realized in the National Park of the Chapada dos Veadeiros, with the production of informative panel about two of the attractions open to the public of the park.

The National Park of the Chapada dos Veadeiros (PNCV) is located in the northern mesoregion of the state of Goiás. It covers an area of 65,540 hectares (Brazil 2016.). Its access is given through two highways that border it, the GO-118 and the GO-239. The park's main entrance is located in the São Jorge district, approximately 30 km from Alto Paraíso de Goiás and about 260 km from Brasilia.

The region of the PNCV is known nationally for its scenic beauties and for its attractions such as waterfalls, which are responsible for the tourist activity in the region. This activity moves the economy of municipalities, which invest more and more in infrastructure.

Despite attracting visitors due to their geological and geomorphological formations, the practice of tourism in the region presents few characteristics of geotourism. The Chapada dos Veadeiros National Park currently has 7 attractions open to the public. In relation to geology, all the factors are present in Arraias Formation of the Araí Group, formed basically by quartzites (Dardenne & Campos 2002). However, the visually are large differences (Figs. 2, 3), that is, the geological structures that associate a morphogenetic action sculpted like several geomorphological features (Oliveira 2007). An important feature of geotourism and absent in the PNCV is the presence of tools that allow access to information on local geology as a way of disseminating geosciences.

The experience, in spite of having only one panel, also used the application of questionnaires with visitors, which allowed to have an idea of the vision of the visitors in relation to the production of panels for that place. Issues such as quality of the panel, quality of information, interest in the topic and previous information collection were presented to the interviewees and the result was presented in the graphics format (Barbosa 2017). In addition to these issues, a specific one on the suggestions of the interviewees was presented and attracted the attention of many visitors, who participated with different suggestions, from the quality of the printed images to specific issues such as age of the rocks. This issue served to issue and create a final panel model, presented by Barbosa (2017).

4 Conclusions

Interviews were conducted among 106 visitors from the Chapada dos Veadeiros National Park on the elaboration of interpretive panels and on a prototype presented to them.

Barbosa (2017) shows that 90% of the 106 interviewees stated that they use the panels available in the park, as well as the interpretative panel. Barbosa (2017) also shows that 89% considered the information presented in the panel as good or good. These two information shows that there is interest from visitors, but there is no availability.

It can be concluded that geotourism is linked to ecotourism, but with different specific characteristics, such as the dissemination of Geosciences. Hose et al. (2011) state that for geotourism to work well, it is necessary to have a good knowledge of geology and that this is associated with geoconservation and geointerpretation strategies.

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Thematic Line

Geoconservation, Geotourism and Geopatrimony

BIOLOGICAL EVOLUTION AND ITS RELATION WITH EARTH SCIENCES IN ITALIAN HIGH SCHOOL

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Abstract— Countless studies are developed trying to grasp why students have struggled to understand biological evolution subjects. Beyond religious beliefs, the majority of population does not comprehend many mechanisms inside biological evolution, like natural selection, adaptation and fitness, for different reasons. In this paper, we are trying to go beyond biological concepts and correlating the relationship of biological evolution with Earth Sciences subjects, as deep time and Plate Tectonic theory. Considering that transformations on planet Earth have directly impact on living beings, it is important that students can see this correlation and understand it. Between April and June of 2017, we applied questionnaires in three schools around Italy to students in the first and second year of high school. The objective of this study was evaluate how progress the understanding of students before and after teacher's explanation in biological evolution subjects and its correlation with Earth science, considering that first year students didn't study this subject yet and second year already had instruction in this subject. For this study, 216 students filled out a questionnaire structured in Likert scale with 20 affirmatives about biological evolution and Earth Sciences subjects. Results showed that is a slightly increase of right response from first to second year.

Keywords— biological evolution, education, Earth science.

Thematic line— Geoscience and Natural Science for basic education.

1 Introduction

Students all over the world have some instruction in biological evolution theory subject. It is considered an unifying axis of biology and that is a famous quote reinforce it: nothing in biology makes sense except in the light of Evolution (Dobzhansky, 1973).

Nevertheless, even though Darwin's book completed 158 years old and studies in genetics and fossil have corroborated the validity of this theory, we still found people that does not understand biological evolution mechanisms. More than just not understand, we found researches about people proposing that religious explanation, like intelligent design need to have the same treatment in the curriculum as biological evolution (Matzke 2016). Another important issue is some words used, as 'evolution' that can lead students to believe biological evolution means something better not something more adapted. Moreover, students have some difficulties to grasp biological evolution theory due to some level of lack in geological subjects, as conceptualizing the temporal scale of evolutionary time (Dodick & Orion 2003). Biological evolution does not occur in a close environment, it means that living beings interact with abiotic factors all the time. Thus, the facts and, subsequently, the geological dynamics must be introduced in parallel with the biological evolution (Tidon & Vieira 2009).

In this research, we are investigating Italian students. In Italy, for Natural Sciences (including Earth Sciences, Biology and Chemistry) the recent school reform from 2010 prescribes five years teaching in most lyceum high schools and abolishes the timing boundaries between the different subjects, giving general guidelines for first biennium, second biennium and fifth year (Realdon et al. 2016). Biological evolution subjects are placed in the first biennium, second year of high school. This research took place during a period of interchange, when first author attended University of Camerino.

The research objective was evaluate if students from second year of high school have more knowledge about biological evolution and its relation with Earth Sciences after received instruction in biological evolution theory. In this work, we found students enrolled in Applied Sciences Lyceum and Sciences Lyceum.

2 Material and Methods

2.1 Questionnaires

For this research, we used the same questionnaire developed by the first author, which was already tested in high school Brazilian students and translated to Italian language. Considering that in first year of high school students have not had yet instruction in biological evolution subjects, we applied questionnaires to them to compare to students from second year of high school, whom have already had this subjects in natural science classes.

We perform questionnaires in three schools around Italy, chosen because facility of contact and approach by the supervisor. Questionnaires were applied in first and second year of Scientific Lyceum and Applied Sciences Lyceum, to verify if students whom already received instructions in biological evolution (2nd year) have a better score than those whom didn't study biological evolution yet (1st year). This is a five point Likert scale questionnaire, with twenty affirmatives. In each affirmative, students could choose among totally disagree, disagree, I do not know, agree and totally agree. For first year students, 114 fill out the questionnaire and for the second year, 102 students fill out the questionnaire.

2.2 Data analysis

After fill out data in excel spreadsheet we used *R studio* to run statistics analysis. We used Mann-Whitney U analysis considering the type of data: they come from distinct populations and the samples do not affect each other.

Thinking in a better visualization of results, affirmatives were divided in three categories: Earth Sciences, biological evolution and correlation between Earth science and biological evolution.

3 Results and discussion

Affirmatives from questionnaire is in table 1. We will discuss those results where differences between first and second year were more significant.

In the group of affirmatives about Earth science (affirmatives 01, 12, 19 and 20), we found for affirmative 12, from 1st to 2nd year a decrease in right answers, and also an increase of wrong answers. This happens also with affirmative 20. Considering that 1st biennium (1st and 2nd year of high school) students have instructions in those subjects about Earth formation and movement of Earth's surface, it is not clear why students got confused about those topics. Since teachers of Natural Science in Italy usually are biologists, there is a lack of geological knowledge in their formation as teachers (Realdon et al. 2016).

In the group about biological evolution (affirmatives 03, 04, 05, 06, 07, 11, 17, 18) we found from 1st to 2nd year right answers increases. It is understandable, once that in second year students have instruction in that subject. Only two questions have interesting results: affirmative 07, where 81% of students from 1st year responded that they do not know the answer and less than a half of students in 2nd year agreed with this affirmative. In addition, for affirmative 11, we found that in 1st year, 42% of student do not know the right answer and again, less than a half of students agreed with this affirmative. Those results are similar to results where were found that Italian students have knowledge in this topic (Oliveira et al. 2016). Students can understand common matter, but in this research was not possible go further, due to the type of questionnaire.

Last, but not least, for the group about correlation between biological evolution and Earth Sciences, half of affirmatives had a slightly decrease in right answers. For the affirmative 13, even though occurs a little decrease of right answers from 1st to 2nd year, we found also that students from 2nd year have more doubts, because number of response 'I do not Know' increases. The same occurs for affirmative 09. For affirmative 02 and 16, a slightly decrease in right answers (1%) occurs from 1st to 2nd year. As already mentioned for Earth Sciences subjects, teachers are not well prepared in geological topics, which could lead to this student's unsureness.

4 Conclusion

In general, knowledge about biological evolution theory are adequate. Students understands about some mechanisms and process that leads a population to evolve, like fitness and adaptation, as we found in questions 04 and 05. However, they did not understand very well about ancestry, once that for affirmative 07 many students still had doubts even after instruction in biological evolution theory.

In Earth Sciences affirmatives, students had some difficulties when it comes about Plate Tectonic subjects, as we note for a decrease in right answers in two of four affirmatives, both in this topic. In addition, when we correlated subjects about Earth Sciences and biological evolution, we found that again, students were not very confident in some affirmatives, since for half of them, from 1st to 2nd year right answers decrease.

We need more detailed research to understand why we found those results, using another type of questionnaire that show us with more accuracy where exactly students have difficulties.

01- Formation of Earth was about 4.5 billion years ago
02- Fossils are vestiges of species that lived in the past
03- Current species of animals and plants originate from other species that lived in the past
04- Successful reproductive species have many descendants
05- The advantageous characteristics are transmitted to the new generations, which gradually change
06- Different species can have the same ancestral species
07- Elephants and horses had a common ancestor, millions of years ago
08- The conditions on primitive Earth favored the occurrence of chemical reactions that transformed inorganic compounds into organic compounds that eventually led to life
09- Not all living beings become fossils when they die, since a number of special conditions are necessary for fossilization to take place
10- Fossils provide information on the climatic conditions of the time the organisms lived
11- The first living beings appeared about 3.5 billion years ago
12- Throughout the history of the Earth the continents united and separated several times
13- After the separation of the continents, some living beings were divided and their descendants could be found in more than one continent
14- The emergence of new species can start when a preexisting species is separated into two groups by some kind of geographic barrier that is impossible to cross, such as a mountain, island or desert that did not exist before
15- Throughout the existence of our planet, several geological events have altered the terrestrial environments, influencing the direction of biological evolution
16- History of Earth and the history of life are inseparable, and it was the interaction between them that led to the conditions and forms of life that exist today
17- Dinosaurs and humans did not live in the same geological age, that means there was no interaction between them
18- The enormous variety of living species is the result of processes of genetic changes and natural selection, which constitute the biological evolution
19- Movements of tectonic plates constitute the fundamental cause of numerous phenomena occurring on the earth's surface, mainly the formation of high mountain ranges, volcanic eruptions, earthquakes and tsunamis
20- Earthquakes can be triggered by meeting two or more different tectonic plates, since these plates are in constant movement, being able to form areas of convergence of plates

Table 1. Affirmatives of questionnaire responded by students.

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EDUCATIONAL AND TOURISM USE OF EASY-ACCESS VIEWPOINTS: A STUDY IN THE ITATIAIA NATIONAL PARK, BRAZIL

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Abstract— The inventory of the geological heritage of the Itatiaia National Park, Brazil is being developed based on scientific, educational and tourism criteria. Among the sites of geological interest already selected, the Último Adeus and the Rodovia das Flores viewpoints stand out because of their easy access, viewpoint typology and suitableness for interpretative and educational purposes. This work presents qualitative and quantitative assessments of scientific value, potential educational and tourism uses and degradation risk of these sites. The quantitative assessment was carried out using the GEOSSIT platform, which was developed by the Geological Survey of Brazil (CPRM). According to the numerical evaluation, the Último Adeus viewpoint (classified as geosite) achieved the highest values regarding educational and tourism uses, a result that reinforces its current use for tourism activities. The Rodovia das Flores viewpoint (classified as geodiversity site) obtained the lowest value regarding degradation risk. The data indicate that both sites are quite suitable to be used in educational projects due to high educational and tourism potentials and low degradation risk. Measures to enhance both formal and non-formal education were suggested and involve the development and inclusion of geoscientific information in leaflets, digital media, interpretative panels, interpretative centre, road sign, geotouristic guidebooks and complementary courses on geosciences. Such measures may contribute to the interpretation, promotion, dissemination and conservation of the geodiversity elements in sites of geological interest and in the whole protected area.

Keywords— Accessibility, geoconservation strategies, geodiversity, protected areas, quantitative assessment, viewpoint geosites.

Thematic line— Geoconservation, Geotourism and Geoheritage.

1 Introduction

Geoconservation arose aiming to avoid that the sites with geoscientific importance be destroyed in Sharples (2002), Gray (2004) and Gray (2013). Based on this fact, Brilha (2005, 2016) elaborated a method that consists of a series of steps aimed the conservation of the abiotic elements. This author points out that the sites presenting threats must be submitted to the geoconservation strategies.

The insertion of inventoried geosites into processes of territorial planning, protected areas management, and tourism and educational activities contributes to geoheritage conservation. For Rodrigues (2013) after the conservation of the geosites, interpretation action should be one of the main priorities in locals which aim to work for raising awareness the general public. For this reason, the evaluation of geoheritage is important to recognize, disseminate and define the sites that should be used in the promotion of geodiversity to the general public. These evaluations enable defining their use and management plans regarding the specificity of each site.

According to Henriques et al. (2011) a geosite that illustrates geological aspects for using in the educational system (from elementary school to university), has the good quality of the exposure and easy accessibility, it turns out to be an excellent educational resource.

The sites of geological interest with easy access present advantages regarding the others, because they may be utilized to demonstrate the geoconservation importance, promote and disseminate the geosciences contents for any audience (including children, people with disabilities and elderly people).

According to Amorfini et al. (2015), the first attempt to turn an accessible geosite for tourists in Apuan Alps Geopark was made in 1964 (the Equi Terme Cave). Since then, this Geopark has been investing in tourism facilities, allowing the use of geosites for any public, among these actions, stands out the Serenaia Valley trail, which was specially adapted to people with disabilities.

Other examples of accessible geosites for any public are observed on the inclusive programmes in UNESCO Global Geoparks (UGG): i) interpretative facilities for blind people: interpretative panels in Braille (Molina & Alto Tajo UGG, Spain), tactile models (Cabo de Gata-Níjar UGG, Spain), books for children written in Braille (Naturtejo UGG, Portugal), and outdoor educational activities (Araripe UGG, Brazil); ii) accessible sites to people in wheelchairs or physical disabilities: Molina & Alto Tajo UGG (Spain), Burren & Cliffs of Moher UGG (Ireland), and Cabo de Gata-Níjar UGG (Spain), and iii) programme to test the accessibility of sites in order to allow visits of adults with intellectual disabilities were being developed in Burren & Cliffs of Moher UGG, Ireland in Canesin et al. (2017).

Further to sites of geological interest that presented easy access, the viewpoint geosites also are excellent places to disseminate the geosciences contents. As recently indicated by Migón and Pijet-Migón (2017), viewpoint geosites are locations that allow unobstructed observation of the surrounding landscape and comprehension of Earth history recorded in rocks, structures and landforms visible from this locality. Thereby, viewpoint geosites are particularly suitable places to developing for landscape interpretation due to their panorama view.

According to Fuertes-Gutiérrez and Fernández-Martínez (2010), the geosites may be classified in few typologies, among them, viewpoint stands out for including two different elements: i) a large area of geological interest; ii) an observatory from where this area may be viewed. In relation to natural threats, neither of elements are fragile themselves; the area because of its large dimensions and the observatory due to its site's far external location. In spite of that, the vulnerability (human threats) may be high because the panoramic quality of the view may be injured for any activity that causes a visual impact. Regarding potential use, viewpoint typology presents a peculiar management because they can afford high pressures as the interest of geosites are at a distance; moreover, they are good sites for geoscientific popularization.

Among the proposals for geosciences dissemination to formal and non-formal education, we could quote the actions for geodiversity interpretation and education that have been developing in Brazil: i) interpretative panels developed by the Geological Paths Project of the State of Rio de Janeiro, Geological and Paleontological Sites Project of the State of Paraná, Geological Paths Project of the State of Bahia, Geological Monuments of the State of Rio Grande do Norte, and Geological Monuments of the State of São Paulo in Mansur (2009), as well as geotourism route on the northern coast of the State of São Paulo in Mazoca et al. (2017); ii) Geology education projects formulate by Geological Paths of the State of Rio de Janeiro, Geological and Paleontological Sites of the State de Paraná in Mansur (2009) and for teachers and environmental monitors in Garcia et al. (2016) and Mazzucato, (2017); iii) science dissemination at museums and science centre; iv) road sign installed by Geological Paths and Darwin's Paths, both in State of Rio de Janeiro; and v) leaflets distributed by several institutions.

In fact, geosites that possess easy access and viewpoint typology of which represent the perfect combination for being used in geosciences dissemination proposals in both formal and non-formal education.

Based on these facts, this work aims to discuss the results of qualitative and quantitative assessments of the scientific value, potential educational and tourism uses and degradation risk of two viewpoint sites that possess the easiest access of the Itatiaia National Park. From the results were made proposals for the valorization and interpretation of sites of geological interest aiming to increase the geoscientific concepts dissemination to formal and non-formal education purposes.

2 Characterization of the study area

The Itatiaia National Park (INP) was the first protected area founded in Brazil in 1937 (Federal Decree nº 1.713), initially with a territorial area of 11.943 hectares. By 1982, the decree number 87.586 extended its surface to approximately 30.000 hectares. It comprehends part of the municipalities of Itatiaia and Resende, in State of Rio de Janeiro, and Itamonte and Bocaina de Minas, in the State of Minas Gerais (Fig. 1).

The INP constitutes an integrally protected area as regulated by the Brazilian National System of Protected Areas (law nº 9.985/2000). Among the various classifications for integral protection, there is the national park, which aims the preservation of natural ecosystems, development of scientific surveys and education and environmental interpretation activities, and ecological tourism according to Brazil (2000).

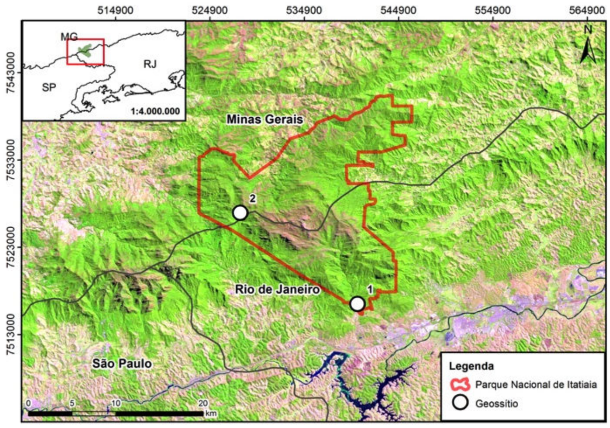

Figure 1. Location map of the Itatiaia National Park with the sites of geological interest studied in this work: 1. Geosite Último Adeus viewpoint and 2. Geodiversity site Rodovia das Flores viewpoint

The study area is drained by Grande and Paraíba do Sul Rivers' basins according to ICMBIO (2013). According to Köppen-Geiger climate classification, this protected area has two climes: i) mesothermic, with mild summer and rainy season in summer; ii) mesothermic, with mild summer without dry seasons in IBDF (1982).

Despite INP is located between the two biggest Brazilian metropolises (São Paulo and Rio de Janeiro), it is integrally inserted in the Mata Atlantic biome. It composes the Mantiqueira Mountain Range protected areas mosaic, which aims to conserve both natural and cultural heritage of the seventeen protected areas of this region.

For administrative reasons, the park area is divided into three areas: i) lower part; ii) upper part; and iii) Visconde de Mauá in Tomzhinski (2012). From of a geology point of view, the main geological frameworks present in the Park belongs to rocks: i) granites and gneisses of Precambrian ages; ii) intrusive alkaline rocks of Meso-Cenozoic ages; and iii) unconsolidated deposits of Cenozoic age. The geomorphological setting of the region is related with the uplift caused for the taphrogenic tectonics, which resulted in the horsts of Serra do Mar and Mantiqueira separated by the graben of Paraíba do Sul according to Neto et al. (2015). In relation to geomorphological aspects, the study area includes the formations of the Mantiqueira Mountain Range and Paraíba do Sul in ICMBIO (2013).

3 Qualitative assessment of the inventory of sites of geological interest

3.1 Method

The inventory of geoheritage of the Itatiaia National Park is being developed based on scientific, educational and tourism criteria.

The selection of potential sites of geological interest was based in the method described by Mucivuna & Garcia (2017), which comprehends the following steps: i) literature review; ii) analysis of the protected area management plan and research bulletins; iii) review of touristic advertisement materials; iv) interviews with researchers who conduct geosciences research in the area; v) analysis of geological and geomorphological maps, topographical charts and satellite images; vi) list of potential sites; vii) analysis of access routes and pathways; viii) field trip for qualitative assessment, description and identification of the new sites; ix) final list of sites with complete characterization.

Based on these steps were selected 72 potential sites of geological interest. Until the moment, 38 were evaluated at field trips, of which 20 were included for the final list. In general, the selected sites have difficult access and they are reached only through long trails with the high-level of difficulty; this fact contributes to limited access to geological knowledge of the region. Despite access hampered mainly for terrain declivity, two sites of geological interest stand out due to easy access (Último Adeus and Rodovia das Flores viewpoints). The access to both sites is not made by trails and they are located on a road with access by cars. In this way, these places may be utilized by anyone because the sites have not obstacles to access. Due to their characteristics, these sites were evaluated in relation to the scientific value, potential of educational and tourism uses and degradation risk to support proposals for use in these sites of geological interest.

3.2 Characterization of the easy access geosites

Último Adeus viewpoint

This site is situated on lower part of the National Park (UTM coordinates 23 K 540414 / 7516328) with 812 meters high. The access is made by BR-485 highway in direction to the head office (Fig. 1).

It corresponds to a viewpoint with a panoramic view of the Mantiqueira and Bocaina Mountain Ranges, and Rio Paraíba do Sul River Valley.

The local allows the observation of distinct reliefs, which present high altitudes related to the morphology of the Itatiaia Alkaline Massif. Its scientific value is connected with the panoramic view of following geomorphological features: i) Campo Belo River Valley and Mantiqueira Mountain Range (Itatiaia Alkaline Massif) (Fig. 2); ii) Dam of Funil hydroelectric power plant, and the Paraíba do Sul River Valley (Fig. 3), both inserted at Continental Rift of Southeastern Brazil; and iii) Bocaina Mountain Range (Fig. 3).

In relation to the possibilities of interpretation, landscape differences may be interpreted based on the distinct lithologies that outcrop in this region.

Rodovia das Flores viewpoint

The site is located on upper part of the INP in UTM coordinates 23 K 528007 / 7526791 with 2173 meters of altitude. The access is performed by BR-485 highway in direction to Rebouças shelter (Fig. 1). The local is a viewpoint with panoramic view of Mantiqueira and Bocaina Mountain Ranges, and Paraíba do Sul River Valley.

Its scientific interest is related to an outlook of mountains relief and Paraiba do Sul River Valley. From the site it is possible to observe: i) Fina Mountain Range, which is a section of the Mantiqueira Mountain Range that present great highlight because it largely coincides with Passa Quatro Alkaline Massif; ii) Paraíba do Sul River Valley, and iii) Bocaina Mountain Range (Fig. 4).

Figure 2. In the foreground, view of the incised valley of Campo Belo River. At the background view of Mantiqueira Mountain Range (Itatiaia Alkaline Massif)

Figure 3. View of the dam of the Funil hydroelectric power plant and the Paraíba do Sul River Valley, in background Bocaina Mountain Range

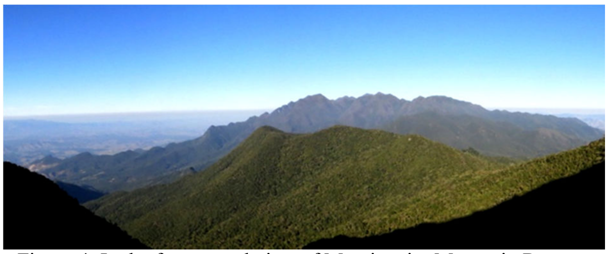

Figure 4. In the foreground view of Mantiqueira Mountain Range (Itatiaia Alkaline Massif), at the background view of Fina Mountain Range (Passa Quatro Alkaline Massif), Paraíba do Sul River Valley and Bocaina Mountain Range

The possibilities of interpretation allow the relationship between both alkaline massifs (Itatiaia and Passa Quatro). Besides that, it is possible to approach the position of the site with the Bocaina Mountain Range and the Continental Rift of Southeastern Brazil.

4 Quantitative assessment of potential use

4.1 Methods

The quantitative assessment consists in assigning values for each criterion (scientific, educational and tourism value, and degradation risk). The quantification of geosites gets important due to the impossibility of applying conservation measures to all the elements of geodiversity in Brilha (2005).

The evaluation of scientific value, potential educational and tourism uses, and the degradation risk was made using the GEOSSIT platform according to Rocha et al (2016), developed by the Geological Survey of Brazil (CPRM). The platform was initially structured on the basis on Brilha (2005) and Garcia-Cortés and Urquí (2009) methods. Recently, it was readjusted and currently adopts the methods and concepts described in Brilha (2016), adapted to the Brazilian reality.

The quantitative assessment of scientific value (SV) is performed with base in these criteria and weights: representativeness (30); key locality (20); scientific knowledge (5); integrity (15); geological diversity (5); rarity (15); and use limitations (10). The result is used for defining if a site of geological interest is classified as geosite, which have geological interest with high scientific value (value ≥ 200) or geodiversity site, which have as main values the educational and/or tourism interests (value < 200).

The evaluation of potential educational use (PEU) utilizes the following criteria and weights: vulnerability (10); accessibility (10); use limitations (5); safety (10); logistics (5); density of population (5); association with other values (5); scenery (5); uniqueness (5); observation conditions (10); didactic potential (20); and geological diversity (10). The assessment of potential tourism use (PTU) applies these criteria and weights: vulnerability (10); accessibility (10); use limitations (5); safety (10); logistics (5); density of population (5); association with other values (5); scenery (15); uniqueness (10); observation conditions (5); interpretative potential (10); economic level (5); and proximity of recreational areas (5).

The quantitative assessment of degradation risk (DR) aims to rank the sites in relation to priority of geoconservation strategies futures. Evaluation of DR takes into accounts the following criteria and weights: deterioration of geological elements (35); proximity to areas/activities with potential to cause degradation (20); legal protection (20); accessibility (15); and density of population (10).

Each criterion may be evaluated with a value among 0 and 4 points. The final value of each geosite is obtained based on the sum of all criteria with their respective weights, which final value ranging from 0 to 400 points. Based on this value, the degradation risk is classified as low (<200), moderate (201-300) or high (301-400).

4.2 Quantitative assessment results

The quantification results of SV, PEU, PTU, and DR of the sites of geological interest Último Adeus and Rodovia das Flores viewpoints are presented in Table 1.

In relation to scientific value, the Último Adeus Viewpoint achieved higher worth, therefore, was classified as geosite; on the other hand, the Rodovia das Flores viewpoint obtained lower value and, consequently, was categorized as geodiversity site. Regarding their potential educational and tourism uses, both have reached at least 250 points, therefore, present national relevance, whereas the values are low for degradation risk.

Table 1. Quantitative evaluation of the scientific value, potential educational and tourism uses, and degradation risk

Site	Scientific Value	Potential Educational Use	Potential Tourism Use	Degradation risk
Último Adeus Viewpoint	275	320	315	155
Rodovia das Flores Viewpoint	165	260	250	135

5 Discussion

Besides SV, the geosite Último Adeus viewpoint achieved the highest PEU and PTU values, which is justified due to its characteristics and surroundings that allows its use by students and tourists. The main criteria that contributed to high score were accessibility, safety, scenery and observation conditions. In relation to these criteria, the geosite is located less than 100 meters from a paved road; presents security infrastructure and rescue services at least 10 km close; is used as a tourism destination in local campaigns; and geological elements are observed in good conditions.

In relation to DR value, the viewpoint Último Adeus is more susceptible than the Rodovia das Flores due to accessibility and density of population. The access to Último Adeus viewpoint is done by asphalted road while the Rodovia das Flores viewpoint through gravel road, moreover, the first site is located on municipality with more inhabitants/km² than the second one. Nevertheless, both presented low degradation risk.

The sites have as main interest the geomorphological features. According to Rodrigues (2013), geomorphological viewpoints are privileged sites for raising public awareness by their aesthetic value, good visibility, magnitude and combination with other heritage sites. For Pereira (2006) the geomorphological heritage consists in the component of geological heritage most noticeable of the population, due to size, configuration and their use potentiality by human activities. Therefore, besides conserving these places, they must be used for dissemination of geoheritage.

The outcomes of the quantification reinforce the approach given by Pereira (2006) and Rodrigues (2013) concerning the importance of viewpoint geosites for raising the dissemination of concepts about geodiversity and geoconservation.

5.1 Possibilities and challenges for educative proposals

The identification and evaluation of these two sites of geological interest in INP confronted the idea that mountain protected areas can only be used for climbers, hiker, and trekking experts. The use of sites with accessibility possesses many advantages, for example, the sites may be used by children in environmental studies; by disabilities people (especially physical limitations) for understanding the evolution Earth; by elderly people and anyone who wants to learn more about the local geodiversity. Worth mentioning that, a lot of these people only can visit places with access by automotive vehicles

Beyond easy access, the sites of geological interest have presented exceptional characteristics that can contribute to educational and tourism use. Nevertheless, both require some security infrastructures to ensure their public adequate use such as fences, handrails, parapet, and parking for more cars.

In relation to current use, the Último Adeus viewpoint is widely utilized for tourism activities, has road sign and security infrastructures, which facilitates its use for any public. However, due to the limited size, large groups should not utilize it. On the other hand, the Rodovia das Flores viewpoint occasionally is used for tourism purposes; it does not possess road sign or any security infrastructures. Due to insecurity, the viewpoint may cause accident owing to their susceptibilities. Although both geosites include high educational potential, currently none they have any educational activity in progress.

According to Brilha (2016), the geosites, with the most relevance and less degradation risk, must be submitted to promotion strategies. Protected areas stand out as places on education and interpretation activities should be developed, either in the formal or non-formal education actions.

In INP both educational actions may be developed. Regarding formal education, this protected area has already been utilizing in the field trip of several Brazilian universities, mainly in the Geology, Geography and Biology courses in ICMBIO (2013). Moreover, it is already used to environmental studies by elementary and secondary schools of the neighbouring municipalities of the area. The use of the sites of geological interest by the students may contribute to increasing their geoscientific knowledge. For this, study materials, games, and the virtual tour be able to be developed to contribute to disseminating of geological aspects this protected area.

In relation to non-formal education, activities developed in protected areas stand out those carried out through interpretive trails, interpretive centre, guided tours, courses, etc. According to Migón and Pijet-Migón (2017), interpretation facilities such as leaflets, geotourist guidebooks and mobile applications are excellent ways to promote geosites regarding educational and tourism uses. However, they often are expensive.

Based on the reality of protected area, with highlight sites studied, the following interpretation facilities be able to be easily implemented:

i. Leaflets are already distributed by Itatiaia National Park therefore, they could be readjusted to include Geoscientific information;
ii. Geosites promotion through digital media such as interpretative points in website www.wikiloc.com, games and virtual tour on the INP website;
iii. Interpretative panels could be installed to increase the dissemination, and interpretation of geodiversity for self-guided visitors or guided visits (Rodrigues, 2013);
iv. Increase the geodiversity interpretation through the additional information about the sites of geological interests in the visitor centre of protected area;
v. Install road sign indicating the location of the main geosites of INP;
vi. Geotourism guidebooks could be sold or made available on the protected area website;
vii. Complementary courses on geodiversity could be applied to environmental monitors in Garcia et al. (2016) for providing a solid knowledge about the abiotic elements for them. From this knowledge, they can add these pieces of information to environmental education activities.

These measures of promotion and interpretation of sites and the protected area as a whole become educational proposals quite suitable, which both in relation to geoscientific knowledge and to awareness-raising about the importance of geoconservation.

6 Final remarks

The sites studied shown that both possess easy access and viewpoint typology. The set these characteristics is essential for being broadly used for any public.

The viewpoint geosites consist in a quite attractive typology to the public. Their panoramic views contribute to awareness raising in relation to the necessity of geoconservation at the same time in which are suitable locals for educational and interpretative actions.

The outcomes showed that one was classified as geosites and other as geodiversity site. Even with different classification, the sites achieved high scores based on potential educational and tourism and both were classified with national importance. Moreover, both sites obtained low value regarding degradation risk, for this reason, they may be established measures aiming their promotion.

It should be noted that the low values of Rodovia das Flores viewpoint in relation to potential educational and tourism are related to the characteristics that can be modified, such as accessibility; use limitations, safety, logistics, scenery and observation conditions, making it possible to increase these values if the necessary measures are taken.

Based on the degradation risk results, the data indicate that both geosites may be promoted regarding educational and tourism uses due to low degradation risk.

The interpretation facilities for formal and non-formal education was proposed and involve the development and insertion of geoscientific information in leaflets, digital media, interpretative panels, visitor centre, road sign, geotourism guidebooks and complementary courses on geodiversity.

Finally, the easy access plays an important role in the use these sites to any public. Therefore, the high scores of potential educative and tourism reinforce the necessity of using these geosites for educational actions. Further, the application the interpretative measures may be contribute to the interpretation, promotion, dissemination and conservation the geodiversity elements in these sites and in the protected area as a whole.

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GEOSCIENCE EDUCATION THROUGH GEOPARKS IN JAPAN

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Abstract— 43 geoparks have been authorized as Japanese geoparks by Japan Geopark Network (JGN). The education has regarded as one of major three factors for its establishment. However, linkage between geoparks and education is ambiguous. In this study, all Japanese geoparks were analyzed in terms of geological interest such as "Active volcano", "Extinct volcano and ancient volcanism" and "Formation of Japanese Islands". As a result, educational and peculiar contents were clarified. This analysis is useful to utilize Geoparks for Geoscience and Disaster Prevention Education.

Keywords—Geopark, Disaster Prevention Education, Geoscience Education, Japan.

Thematic line— Geoconservation, Geotourism and Geoheritage.

1 Introduction

National geoparks are established following the guidelines and criteria (Geoparks Secretariat 2006). 43 geoparks have been authorized as Japanese Geoparks by Japan Geopark Network (JGN) as of November 30, 2017. In a webpage (http://geopark.jp/en/about/) of JGN, the geopark is introduced as follows; A geopark is a journey of bonding and learning about the earth, and a place to enjoy geotourism. It is a place where you can take a close look at mountains and rivers, learn about how they were formed, and think about their links to the ecosystem and human life. Also in the Mt. Tsukuba Area Geopark leaflet, it is mentioned that the goal of geoparks is to contribute to sustainable development of local areas, promoting education and tourism while conserving "geoheritage", landforms and geological features that are scientifically precious or aesthetically appealing. Naturally enough, geoparks may be used as an object of Geoscience Education, and/or Disaster Prevention Education (Heriques et al. 2012).

In Japan, some special issues have been published as results of symposium organized by Earth scientific societies; the *Educational Capabilities of Geoparks: From Education to Learning by Tokyo Geographical Society* in 2015 (Arima 2016), and *Investigation of the Ideal Method of Geoscience Education on Geoparks* by the Association for the Geological Collaboration in Japan in 2013 (Hayashi et al. 2014). In addition, the Japan Society of Earth Science Education had a symposium on "Geoparks and Geoscience Education" on April 2017. As results of this symposium, we realized that each geopark made an separate effort and this is caused by different backgrounds and contents of their establishmental reason and process.

In this study, I analyzed the geological interest and object for all geoparks in Japan, and investigated the relationships between Japanese Geoparks and Geoscience and Disaster Prevention Educations to utilize geoparks in the education.

2 Disaster in Japan

The peculiar location of the Japanese Islands such as a near border between Asian continent and Pacific ocean results in generation of various of natural disasters. The metropolis Tokyo is located near a triple junction of Pacific, Philippine Sea and North American plates. The Japanese Islands, also, are included mainly in the temperate zone and subordinately in subarctic and subtropical zones. More than 10 typhoons attack the Japanese Islands every year.

Cabinet Office, Government of Japan (2015) summarized the Japanese natural disasters as follows; Japan is located in the Circum-Pacific Mobile Belt where seismic and volcanic activities occur constantly. Although the country covers only 0.25% of the land area on the planet, the number of earthquakes and active volcanoes is quite high. Also, because of geographical, topographical and meteorological conditions, the country is subject to frequent natural hazards such as typhoons, torrential rains and heavy snow.

Furthermore, Cabinet Office, Government of Japan (2015) indicated five disasters categories as features of disaster countermeasures; earthquake, volcano, storm and flood, and snow disasters. Accordingly, in the case of relating these disasters to geoparks, earthquake and volcano can be regarded as more important interest to affect geoparks.

3 Analysis of Japanese Geoparks

3.1 Classification of Geoparks in Japan

The geological interests that 43 geoparks (eight Global Geoparks and 35 Japanese Geoparks) involve were classified by the following items; "Active volcano", "Extinct volcano and ancient volcanism" and "Formation of Japanese Islands" (Table1). The last one is subdivided into "Cenozoic", "Mesozoic" and "Paleozoic", and more "Mesozoic" is composed of "rocks" and "fossils". In addition, "key words" was supplementarily set up to represent the geological interest in each geopark. Black and white circles mean major and subordinate significance for each geopark, respectively.

3.2 Use of geoparks as objects for Geoscience and Disaster Education

The ratio for taking subject "Geoscience" in high school was estimated as around 35% (http://www.mext.go.jp/b_menu/shingi/chukyo/chukyo3/060/siryo/__icsFiles/afieldfile/2016/05/12/1370460_8.pdf). If we accept the notion that the gigantic disaster might happen to anytime in the near future, geoscience would be most inevitable subject. Under such circumstances, it will be strongly demanded that geoparks must be wisely utilized together with learning of Geoscience.

In Japan, 100 volcanoes are formally assigned as active ones. As shown in Table 1, 13 active volcanoes constitute geoparks. Active volcano usually provides us beautiful scenery and hot springs, which could be valuable touristic resources. It seems to be proper that active volcanoes become geoparks. It is worth mentioning that almost geoparks on active volcanoes have museums, which are useful to Geoscience and/or Disaster Prevention Educations. On the other hand, as the earthquake is an instant event, the geological object of the geoparks, such as touristic attractiveness, seems difficult to properly appear except for some outcrops of active earthquake faults. However the gigantic landslide (1300 m X 900 m in a plan) triggered by earthquake (June 14, 2008) became major geological interest in Mt. Kurikoma Area Geopark (no.16 in Table 1).

In the case of the above-mentioned Mt. Kurikoma Area Geopark, the gigantic landslide, the public organization such as Kurikoma city Disaster learning center and the school are cooperated each other through the 2008 earthquake. Students can observe the gigantic landslide triggered by 2008 earthquake and then experience the same quake produced with shock device. This learning program will be effective disaster learning.

When the tectonic evolution of Japan is considered, Paleozoic and Mesozoic development of accretionary prisms and Cenozoic formation of Japan Sea are topmost tectonic events in the Japanese Islands. In special, the latter offers numerous touristic and geological interests built by volcanic rocks produced at the times of formation of Japan Sea, 15m.y ago. These rocks are categorized into "Extinct volcano and ancient volcanism". The remaining are regarded as the geological interests which could be evidence for "Formation of Japanese Islands". The geoparks included into this category could be "an outdoor museum". As shown in Fig.1 there are somewhat thick distribution in geoparks. If nearby geoparks (Nos. 21, 22, 23, 24, 25, 26, 27 and 42 in Fig.1) are cooperated each other, this linkage can provide us outdoor geohistorical museums ranging from Paleozoic to Cenozoic.

Table 1. Global and Japanese Geoparks in Japan

					Formation of Japanese Islands				
					Cenozoic	Mesozoic		Paleozoic	
		Japanese Geoparks	Active volcano	Extinct volcano and ancient volcanism		rocks	fossils		Key words
Global Geoparks	1	Mt. Apoi			●				Peridotite
	2	Toya Caldera and Usu Volcano	●						Volcanic front
	3	Itoigawa	○	○	●			○	Fossa Magna
	4	San'in Kaigan		○	●	○			Formation of Japan Sea
	5	Unzen Volcanic Area	●	○					Volcanic front
	6	Muroto			●				Shimanto accretionary prism
	7	Oki Islands			●			○	Formation of Japan Sea
	8	Aso	●						Volcanic front
Japanese Geoparks	9	Shirataki		●		○			Oobsidian
	10	Tokachi Shikaoi		●	○				Volcanic front
	11	Mikasa			○		●		Ammonite
	12	Happo Shirakami		●					Formation of Japan Sea
	13	Oga Peninsula-Ogata	○	○	●	○			Cenozoic beds
	14	Sanriku			○	○		●	Paleozoic beds
	15	Yuzawa		●		○			Formation of Japan Sea
	16	Mt. Kurikoma Area	●						Gigiantic landslides
	17	Mt. Bandai	●						Volcanic front
	18	Sado		●					Formation of Japan Sea
	19	Naeba-Sanroku		●					River terraces
	20	Minami-Alps(MTL AREA)			●	○			Median Tectonic Line
	21	North Ibaraki			○	○		●	Oldest rocks in Japan
	22	Shimonita		○	○	●			Overthrust
	23	Chichibu			○	●			Chichibu accretionary prism
	24	Chosi		○	○	●			Mesozoic beds
	25	Hakone	●						Volcanic front
	26	Izu Oshima	●						Volcanic front
	27	Izu Peninsula	○	●	○				Collision between Honshu and Izu volcanic arcs
	28	Tateyama Kurobe	○		●	○	○		Northern Alps
	29	Hakusan Tedorigawa	●			○	○		Dinosaurs
	30	Dinosaur Valley Fukui Katsuyama				●	○		Dinosaurs
	31	Nanki Kumano			●				Shimanto accretionary prism
	32	Mine-Akiyoshidai Karst Plateau						●	Paleozoic beds
	33	Shikoku Seiyo				○		●	Origin of Japanese Islands
	34	Oita Bungo-Ohno			●				Gigiantic Aso pyroclastic flows
	35	Oita Himeshima		●	○				Oobsidian
	36	Amakusa				●	○		Dinosaurs
	37	Kirishima	●						Volcanic front
	38	Mishima Kikai Caldera	●						Volcanic front
	39	Sakurajima Kinkowan	●						Volcanic front
	40	Shimokita		●	○				Gold deposits
	41	Mt. Chokai Tobishima Island	●	○	○				Volcanic front
	42	Mt. Tsukuba Area			○	●			Plutonic rocks
	43	Asama North	●						Volcanic front

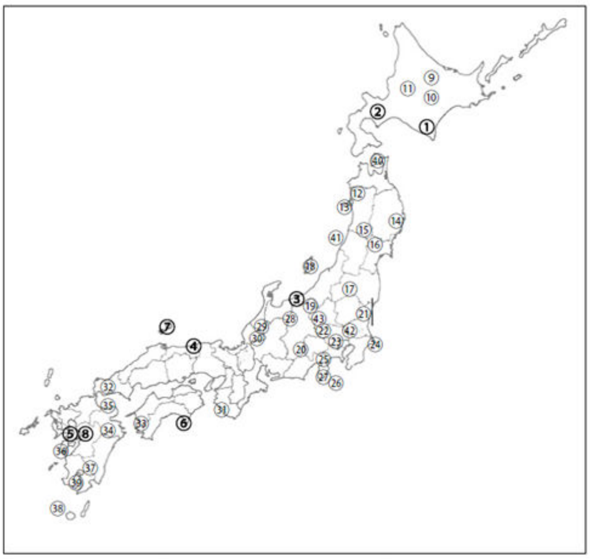

Fig. 1. Distribution of Geoparks in Japan

4 Conclusion

It is common understanding that geoparks consist of Education, Preservation and Tourism. Among them, the real action for Education is relatively ambiguous. The term “Education” has two meanings; one is the process by which your mind develops through learning at school or college and the other is the general area of work or study connected with teaching. In Japanese, Education 教育 is similarly composed of two letters, which represent “Teach 教 and Nurture 育” respectively. However, it has another meaning of “Learning”. Thus, “Teach and Nurture” is more transitive verbwise whereas “Learning” is more intransitive verbwise (Oike 2016). Geoparks has important role of education or alternatively geoparks had better to be a “Learning” place each for Geoscience and Natural disaster through geoturism.

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PLANT FOSSILS AS A "TEACHING TOOL": A BRIEF REVIEW OF SCIENTIFIC PUBLICATIONS FROM THE LAST FIVE YEARS

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Abstract – The geosciences have great potential to promote scientific literacy and understanding of the factors involved in the development of all forms of life, highlighting the paleontology and the paleobotany. Studying the past environments through plant fossils allow the understanding of prevailing events and the prediction of what may happen in the future, making possible the connection between the theoretical and practical concepts in a dynamic way, stimulating the meaningful learning. Although the use of the fossil record provides a very hopeful didactic potential, its use is specific in the classroom, and the publication of the initiatives is incipient and scattered in the literature, hindering its reproduction by other teachers. Thus, the present study seeks, through a bibliographic survey, review the methodologies applied and published from 2012 to 2017 in the journals of national and international academic visibility that used fossils as educational tools, highlighting those that employed the fossil records of primitive plants as instructional instruments of pedagogical value, particularly in basic education. The survey was conducted with the keywords *teaching, learning, education, plants, plant fossil, didactic tool, evolution, plant evolution, angiosperm*, *palaeobotany*, in English and in Portuguese, in national databases and in the scientific journals *Terrae Didatica*, *Ciências & Educação* (Bauru), *Educação Básica Revista*, *Journal of Geosciences Education*, *Science and Children* and *Science Scope*. The articles were selected regarding the following criteria: 1) Use of fossils as a teaching tool for the study of the evolution of life on planet Earth, preferably those that use plant fossils; and 2) application of some assessment method to quantify and qualify the obtained results. From the 47 articles surveyed, only seven met both criteria, indicating poor use of didactic potential of the fossils in the classroom and the lack of publicity of initiatives developed in the classroom by teachers. We present a list of selected articles and a brief summary of each one. It is intended to cooperate with a broader dissemination and understanding of the Paleobotany, as well as encouraging the development of other methodological practices aimed at the popularization of this area of knowledge which sustains concept fragmentation, as all domains of Geosciences addressed in the national curriculum.

Keywords– Bibliographic survey, Paleobotanic, phitofossils, teaching tools.

Thematic line – Education, Teaching of Geosciences, Teacher Training.

1 Introduction

The whole way we can observe and understand today is the result of the work and research of many scientists who in their own way influence the construction of our vision of the world since past times. We can understand the Geosciences as a large area of knowledge that encompasses the Astronomy, Cosmology, Geology, Paleontology, among others. This area of knowledge contributes to build insights and the development of necessary understanding to the intellectual development of each student, in addition to contribute with their responsible citizenship. (Neves et al. 2008 and Fernandes *et al.* 2012).

According to Carneiro et al. (2004), the geosciences help students to form a planetary perspective, since it improves not only their literacy, but their education in social values, the development of critical thinking, the ability of observation / inquiry and reflection on the use of available technologies arising from the advancement of science. But, according to the same author, geosciences are present in the national curriculum in a scattered form and without ordering, not being able to explain the Earth composed of several aspects that are interrelated, giving rise to what we know as Earth System.

Among the areas of geosciences, the paleontology stands out by interdisciplinary potential. The Paleontology is the natural science that studies the life of the past of the Earth and its progress over the geologic time scale (Santos 2014). As emphasized by Moraes et al. (2007), it is an important science from the perspective of education, because it contributes to the comprehension of processes about integration from biological information in the geological record, providing information on the evolution of life on Earth. Among the areas of paleontology, we highlith the Paleobotany because it has been used as a tool in the characterization of Paleoclimates and paleoecology, based on the adaptability of plants to environmental changes, clearly reflected in its morphology and anatomy (Santos et al. 2007).

Although the importance of Paleontology to the broader understanding of geological, biological and environmental issues, there is still little disclosure of its contents to the students of basic education in our country, as stated by Neves (2008). In addition, there is a pre-conceived idea of just dinosaur fossils have didactic potential for teaching the concepts relating to paleontology (Paglarelli Bergqvist & Serodio Prestes 2014). Under the perspective addressed by Mello, Mello & Torello (2005), the deficiency of didactic and paradidactic materials is among the main difficulties for the teaching of this science. And, as well as is observable in Geoscience content that compose the curriculum of basic education in São Paulo, the Paleobotany also suffers with the fragmentation of concepts, which hinders the popularization of sciences (Ernandes & Pinheiro 2016).

The National Curriculum Parameters (Brasil 1998) highlight the importance of the use of fossils, since they may facilitate the understanding of the geological time scale, as well as the understanding of the life evolution process, by means of the comparison between extinct and existing species.

Although still incipient in the literature, there are successful examples from the use of plant fossils as a teaching tool in basic education. However, they are scattered in the literature, hindering its location and reproduction by teachers. Thus, the present article seeks to gather, through a bibliographic survey, the proposals of methodological procedures that make use of fossils of primitive plants as a teaching tool for practical classes with students of basic education. We hope to contribute to teachers and students of basic education to reach a conceptually correct approach, more practical and able to promote the meaningful learning about plant and life evolution.

2 Methods

The survey was performed through bibliographic research using the key words: *teaching, learning, education, plants, plant fossil, didactic tool, evolution, plant evolution, angiosperm, palaeobotany* and their corresponding in Portuguese, especially in the CAPES/MEC (Comissão de Aperfeiçoamento de Pessoal do Nível Superior/ Ministério da Educação) periodicals portal, SBU/ UNICAMP (Sistema de Bibliotecas da Unicamp- Universidade Estadual de Campinas), SIBiUSP (Sistema Integrado de Bibliotecas da Universidade de São Paulo), SciELO (Scientific Eletronic Library Online) and Scholar Google.

From the periodicals used for the preparation of this work, we give emphasis to national scientific journals Terrae Didatica, Ciências & Educação (Bauru) and Educação Básica Revista, and the international Journal of Geosciences Education, Science and Children and Science Scope, since they are renowned magazines in the subject area and emphasis in academic circles besides the quality of its publications.

The survey is delimited to periodic papers only, on theperiod from 2012 until 2017, and so were raised proposals that met the following criteria:

- Emphasize the use of fossils as a teaching tool for the study of Earth's life evolution. We preferably sought for projects which employ plant fossils.
- Usage of some evaluation method to quantify and qualify the obtained results;

Thus obeying the premise that every bibliographic review, according to Cervo et.al (2007), "constitutes the basic procedure for studies, which aims the mastery of the area from the state of the art on a given topic.".

3 Results and Discussions

We surveyed a total of 47 articles, which only seven met the criteria for this research. From selected articles, we highlight those who brought in their content the description of methodologies applied to the most diverse categories of teaching: Elementary (I and II), Middle and High School Graduation in Brazil, Portugal, Italy, Canada and the United States, as well as the published in high-impact journals. The selected articles were grouped in Table 1, organized in chronological order.

Table 1. List of selected articles

No	ARTICLE	Reference
1	Fossil finders: Engaging all of your students using project based learning.	Connor et al. 2013
2	Using Problem-Based Learning to Deliver a More Authentic Experience in Paleontology.	Montgomery &, Donaldson 2014
3	Kit paleontológico: um material didático com abordagem investigativa.	Paglarelli & Prestes 2014
4	“Dig Into Fossils!: A Series of Activities Helps Young Students Learn about Fossils.”	Bogerding 2015
5	Desvendando as Geociências: alfabetização científica em oficinas didáticas para o ensino fundamental em Porto Velho, Rondônia.	Perezi et al. 2015
6	Building an Outdoor Classroom for Field Geology: The Geoscience Garden	Waldron et al. 2016
7	Relato de experiência: o uso da argila para produção de modelos de fitofósseis, usados na formação de conhecimento em paleobotânica	Biagolini & Piacitelli 2017

Below, we give a brief description of each selected paper, seeking to fit out the teacher with suggestions for published and successful approaches.

Paper 01 - Connor et al. 2013

Work done in partnership between the Department of Education from Cornell University and the Institute of Paleontological Research in Ithaca - New York - United States, and that is currently under the scope of the University of Georgia. Based on the strategy of the PBL (Problem Based Learning), the students received real specimens of fossils to examine, and had the opportunity to share their results with real scientists. A successful example of partnership between school and university, enabling the development of student leadership.

Paper 02- Montgomery &, Donaldson 2014

Using fossil replicas and rock fragments collected in Chihuahuan desert in West Texas, the article presents a methodology developed and based on problem-solving with undergraduate students at the University of Texas. The students identified the fossil samples with the support of researchers and sought information about the specimen in the specialized literature. Although the activity has been made from fossils of dinosaurs and not plants, we chose to leave this article in the list as suggested approach using Problem Based Learning, since students were encouraged to investigate aspects of Paleoclimates and paleoecology too. The project can also be reproduced with fossils of plants.

Paper 03 - Paglarelli & Prestes 2014

Describes the experience of the drafting and implementation of a Paleontological Kit. The Kit consists of an array of materials, among them replicas of Brazilian fossils, and a booklet with the information necessary for the development of practical activities. It was applied in FAETEC network classes, situated in the northern area of Rio de Janeiro – Brazil, and brought the analysis about the importance of practical activities as essential tools to assist in the ensurance of theoretical concepts. As well, it as contributed to the demystification of dinosaur fossils as a unique resource for the teaching of paleontology in the classroom, even they used animal fossils only.

Paper 04 - Bogerding 2015

Reports a range of activities proposed and carried out with pre-school students from Ohio - United States. Students could associate and understand background related to paleontology in a practical and didactic way and represent them through drawings and schematic representations. The students analyzed and made inferences from replicas of whole and partial fossils of plants and animals. The activity extrapolated the limits of science classes, allowing the development of skills in subjects such as English, arts and mathematics.

Paper 05 - Perezi et al. 2015

It focus on activities performed with students in Porto Velho, Rondônia – Brazil. Authors carried out a set of nine workshops aimed to elementary school students within the age range of 10-13 years to promote scientific literacy through geoscientific concepts with emphasis in Paleontology using different educational tools such as images, texts and replicas from fossils of beings that lived in the region.

Paper 06 - Waldron et al. 2016

It reports the experience of elaboration and use of a specially designed space called the Garden of Geosciences in the North Campus of the University of Alberta. The Garden led to graduate students a practical activity of immersion in a prepared environment that allowed the improvement of basic skills of field observation, as well as promoting, among others, the recognition of certain fossils and biogenic structures, aligning the concepts addressed in the classroom in situations of field work during their period of study.

Paper 07 - Biagolini & Piacitelli 2017

It reports an experiment carried out in a public school in the periphery of São Paulo with students of the 7th Grade, through the elaboration of models of phitofossils with clay. The students learned about the process of fossilization and paleobotany in a practical and playful manner.

As showed ins Table 1, five (71%) of the seven selected productions were applied to basic levels of elementary education, that correspond to pre-school, Elementary School I (1st to 4th grade) and Elementary School II (5th to 9th grade). It was noted that none of them was directed to the Middle School (1st to 3rd year). The other remaining studies were developed at the undergraduate level.

We observed a trend to describe methodologies which are used for the immersion of the students, whether in relation to field classes or specific practices. They lead students to a process of production and resignification of knowledge in Geosciences through tasks that put them as protagonists in the realization of these activities.

The selected papers are in their majority (4 of 7, or 57%) in the English language, which make them comprehensive and accessible globally, but can become a hindrance to non-native speakers as brazilian teachers

Thus, from the portuguese language productions, we highlight the methodologies that use of low cost materials and develop practices which had the direct participation of students in activities. These activities were workshops, games and production of phitofossils replicas in clay, suitable for poor school units Brasil (1998).

The approach of geoscientific concepts plays a prominent role to the process of scientific literacy in the early years of basic education, because its interdisciplinary character that is not restricted to specific background areas. Also, those concepts contribute to the construction of a broader and extensive understanding of the processes that involve the evolution of life on the planet. Thus, as observed through the study, there is a range of possibilities for the use of the primitive plants fossil records with a capacity of playful, gestural and practical aid in the (re)construction of geoscientific knowledge.

4 Conclusion

Despite its didactic potential, we found few articles published in the specialized periodicals about the use of plant fossils on basic education from 2012 to 2017 that can be replicate by teachers.

The few studies found still brings with it the challenge of language, which can become a handicap, because a good part of the productions analyzed are in english, which further complicates the possibility of adaptation and application of methodologies presented by Brazilian teachers.

The scarcity of published papers about the use of fossils as didactic tool highlights another problem, especially on the national scenario: the little publicizing of the work developed in the classroom. Many of the initiatives and strategies for teaching activities are restricted to the classroom teacher who develops them, hindering the exchange of knowledge among teachers. This study proposes to gather teaching strategies using fossils as a teaching tool, particularly plant fossils, to disseminate successful and already published ideas. The little amount of articles in this issue shows not only the need to increase the use of the didactic potential of fossils, but the need of their publication as well.

In this way, the use of plant fossil replicas in practical classes has, as evidenced by the analyzed papers, a singular capacity to dynamically provide a range of relevant information to the teaching demands and greatly help to the understanding of the evolution of living beings in our planet, as well as the understanding of the Earth as a great and fascinating system.

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RECOGNITION INVENTORY OF THE POÇOS DE CALDAS ALKALINE MASSIF

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Abstract— The recognition inventory of the Alkaline Massif of Poços de Caldas concerns the thematic subject of this paper. The region is located at the South of the State of Minas Gerais in the geographical limit with the State of São Paulo. The Massif of Poços de Caldas has a circular shape, with a diameter of 33 km and an area of 800 km², being known as the largest alkaline complex in Latin America and one of the largest in the world. The survey of the geosites and geodiversity sites was carried out from a systematized inventory methodology of recognition, which consists in identifying features or significant places through bibliographical revisions, specialist consultation and field works, as a fundamental part of the strategies of geoconservation. In the present research the sites were characterized according to the proposal of authors already consecrated in the literature. Each geosite was related to specific categories of geological heritage, and, in the case of the study region, could identify: geological importance, evolutionary history of the massif, ores and thermal waters. 12 selected sites represent scientific interest and others represent geodiversity sites with educational and geoturism interests that make up the map of geological heritage (MAPC). The recognition inventory was the first step in the identification of the geological heritage of Poços de Caldas.

Keywords— Alkaline igneous rocks; Geodiversity; Geological Heritage; Poços de Caldas (MG).

Thematic line— Geoconservation, Geotourism and Geoheritage.

1 Introduction

The Poços de Caldas Alkaline Massif is the second biggest alkaline massif of the world. A reference by Ellert considers the Kola Massif in Russia as the first major intrusion. Poços de Caldas differs from a volcanic feature of the rocks while the Kola massif is plutonic (Ellert 1959).

Different ideas in the literature consider that Poços de Caldas plateau is a volcanic complex (Bonotto 2010).

Proposed development for the caldera of Poços de Caldas by Ellert (1959) are shown below:

1. Uplift of blocks of crystalline basement rocks, after deposition of Botucatu sandstones.
2. Vulcanic activities with development of lava cones and pyroclastics.
3. Subsidence of the central part of the Caldera.
4. Injection of nepheline magmas in circular and radial fractures and the formation of tinguaites and phonolites by differentiation.
5. Formation of Annular dykes.
6. Intrusion of lujaurites, chibinites and foyaites.

Almeida (1977) suggested another geologic model to explain the origin of the massif: deposition of the Botucatu sandstones (Paraná sedimentary basin) over Precambrian gneisses and granites (120 Ma); magmatic activities and formation of mafic volcanic rocks, preceded or not by gentle elevation or uplift of the area; intrusion of the tinguaite annular dyke, collapse and magma injection into fractures (formation of tinguaite and phonolite) and hydrotemal alteration of the previously rocks.

Bushee (1971), Eisenbud et al. (1979), Ulbrich (1984), Fraekel et al. (1985), Motoki (1988), Schorscher & Shea (1992) also present evolutionary models for the region. Bonotto (2010) points out that these different views show the difficulties on proposing an explanation of the Poços de Caldas plateau and such unique prominent highland underlain by alkaline rocks has suffered very complex process since its origin.

Ellert (1959) represents in the geologic map (Figure 1) the basic structure presents the following types of alkaline rocks: effusive and hypabyssal (ankaratrites; tinguaite and phonolite); plutonic rocks (foyaite, lujaurite and chibinite); lava and pyroclastics material (breccias, tuffs and agglomerates).

In field the following types of rocks were identified in-situ in the alkaline massif of Poços de Caldas, expressed by evidence:

a) **Potassium rocks:** extensive areas of the central portion of the plateau are represented by potassium rich rocks (tinguaites and phonolites), concerning to intense hydrothermally alteration and weathering that changed constituent minerals and, consequently, their chemical composition. In this process there is sodium leaching and potassium enrichment. They usually present light color (cream and whitish) or appear infiltrated by iron oxides (Garda 1990).
b) **Lujaurite and Chibinite:** These rocks occur in the north ring of the massif, close to the contact with the crystalline basement rocks. The lujaurite is a "sui generis" rock (Pedra Balão outcrop) presenting gneiss texture and minerals that characterize it as an alkaline rock; probably originated by a phenomenon of metasomatism where "alkaline magma added to silica and high temperature absorbed the minerals of the gneiss, replacing its composition and maintaining the texture of the primitive rock" (Frayha 1972). The chibinites loses the gneisses texture but is rich in eudialite (almost foiayte) (Frayha 1972).

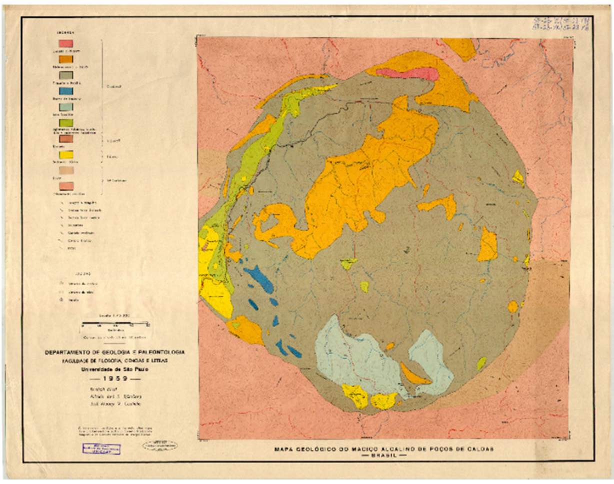

Figure 1. Geologic Map of the Alkaline Massif of Poços de Caldas. Ellert R., Björnberg A.J.C., Coutinho J.M.V. 1:75.000 Dept. Geol. Paleont., F.F.C.L. USP (1959)

c) **Phonolites, tinguaites and foyaites**: rocks with similar mineralogical composition differentiating only by the size of the minerals due to the conditions of magma cooling. The phonolites correspond to the extrusive phase of the magma fast cooling (usually with fluidal texture). Tinguaites correspond to the intermediate phase of crystallization, with the main characteristics fine-grained, compact, gray and greenish color, with fesdspathoids and pyroxene (Bonotto 2010), present in the major part of the complex. Foyaites have a coarse-grained phanerocrystalline texture and are mostly present in the north half portion of the plateau, with other outcrops of nepheline syenites enriched in eudialyte - chibinite and lujaurites (Bonotto 2010). The most abundant igneous rock in Poços de Caldas massif are tinguaites, phonolites an foyaites.

d) **Breccias, tuffs and agglomerates:** The first igneous event on the massif history was the extrusion of ankaratritic lavas and deposition of pyroclastics material (volcanic breccias, tuffs and agglomerates). These rocks are interspersed with metamorphosed sandstone remains in general with fragments (angular and rounded) of sandstone, diabase, tinguaite, quartz and gneiss. The binder cement in the fresh breccia is blue-green color, rich in rolled grain. Both gaps and tufts show great resistance (Frayha 1972).

e) **Ankaratritic lavas**: ankaratrite breccia lavas and overlying ankaratrite volcanic agglomerates are the oldest rocks of the nephelinic magmatism of the Poços de Caldas Alkaline Complex. They are nephelinitic-basanitic, basic to ultrabasic rocks formed from H_2O and CO_2 fluid-rich mantle-derived alkaline ultrabasic magmas. Exsolution of the fluids during decompressive magma ascent and subaerial eruption caused intense vesiculation, autoclastic hydraulic fracturing and autohydrothermal alterations of the ankaratrite flows still during extrusion and finally cimentation of the autoclastic breccias by calcitic carbonate and zeolitic silicate masses (Alves & Schorscher 2003). Occurs in the west ring of the massif. When fresh they are dark gray in color and when altered they have a purplish brown color (Frayha 1972).

f) **Clastic sediments:** Sediments are represented by Botucatu Formation that were transformed by the intrusion of alkaline magma. Occur at the internal board of the massif, which covered the Precambrian rocks during the igneous activity that produced the alkaline massif (Bushèe 1971)

g) **Basement rocks:** the alkaline intrusion (MAPC) is surrounded by rocks of the crystalline basement consisting of gneiss and granite (Precambrian age), affected by *in* situ metasomatism on some parts, originating fenites (Bonotto 2010). In the contact areas they present mixed products as well as the presence of alkali rocks in the contact zone (Frayha 1972)

2 Goals

The main objective of this research was to carry out preliminary investigations for the survey of geosites and geodiversity sites from Alkaline Massif of Poços de Caldas. Such studies will subsidize the Geological Heritage Inventory. Analyze, describe, select and map the geodiversity elements that make up this complex geological system was the challenge of this research. As specific objectives were the elaboration of surveys of the scientific, tourism and educational potential with the possibility of listing the main points with geotourism, scientific and educational value and the elaboration of geoconservation strategies. Secondly, we hope to contribute to a better understanding of the need to develop geoconservation strategies involving local institutions and community for regionalized protection of these sites.

3 Inventory Methodology

Sharples (2002) delimits that a recognition inventory consists of identifying significant features or locations through bibliographic reviews, specialist consultation, and fieldwork. According to Pereira (2010), it is at this stage that the sites in need of such initiative are identified, and based on surveys, evaluations and cataloging, followed by a detailed description of the assets or places of interest of a given location.

In the present research, the sites were characterized according to the proposal of Brilha (2005, 2016). Each geosite was related to specific categories of geological heritage and was possible to identify the following typologies: geological importance, evolutionary history of the massif, ores and thermal waters.

The preliminary inventory of geological heritage in the MAPC consists of a bibliographical review of geology researches in the area. This stage was of fundamental importance for the geological characterization of the area by offering various indications and descriptions of sites with the potential to become geosites. The initial list of potential geosites was later compared to the collection of samples of minerals, rocks and ore from the Resk Fhraya collection of the Historical Museum and Poços de Caldas.

The next step was the fieldwork to identify and characterize selected sites in the list of potential geosites. A total of 456 potential sites were identified, including a list of 115 preselected sites according to criteria of bibliographic recurrence, scientific, educational and tourist representativeness and thematic relevance.

A refined study pointed out to 25 potential geosites and geodiversity sites. From these 12 sites are presented in this paper considering the geologic evolutionary history of the massif. The inventory form template (Brilha 2005), which includes location data, site type (area, complex area, point or section), location IBGE topographic map, justification of scientific potential value potential was used to describe the sites.

3.1. Steps

The bibliography review was the principal step of the research to select and organize it in relation to the main themes of research in study area over time. Graphs were elaborated to show the historiographic retrospective of the scientific productions. The data were organized according to the initial proposal of Ulbrich (1984), which separated the scientific works by themes and authors: [a) geochronology; b) geotectonic interpretation; c) mineralogy and petrography; (d) zircon and caldacite deposits; e) uranium and molybdenum; (f) thorium and iron; g) hydrothermal alteration and "potassium rocks"; h) bauxite and intemperate change. Some adaptations were made and included themes, such as theme; i) hydrogeology; extracted from the survey carried out through CETEC (1987).

The second step was the preliminary selection of geosites using the historiographic retrospective. In this phase 465 geosites formed a general list. Posteriorly 115 potential sites of geological heritage were selected according to criteria of recurrence in the bibliography, thematic relevance and scientific, tourist and educational representativeness. Considering the 134 samples of the collection of rocks, minerals and ore of the Historical and Geographical Museum of Poços de Caldas, the points were refined by methods of combinatorial analysis of criteria, to finally determinate the more representative sites.

The following step was the verification in the field of the sites. At this stage of the research, the physiographic evaluation was performed through visiting the sites and to make a preliminary evaluation in place of the accessibility and condition of the outcrop. This step presents the field annotations and geodiversity elements that make up the 25 points selected for field visit and the samples collected.

Finally, inventory sheets were filled up with condensed data. Within the sites submitted to the field work, the pre-selected sites, we still establish the criterion of tourist points, therefore, we selected 12 geosites or sites of the geological heritage that represented exceptional thematic relevance. This selection was assumed by criteria that geosites should tell the geological history of the region. The selected sites are represented in MAPC's Geological Heritage Map (of this survey). At the end, the following sites were selected.

4 Results – Potential Geosites

The geosites with potential interest in the Massif Alkaline of Poços de Caldas are the following:

1. Águas da Prata: Clastic sediments occur prior to the activities of alkaline magma and are conserved between pyroclastic rocks, lava and tinguaites. The areas with higher outcrops are in Águas da Prata, where they form packages of more than 100 m of thickness. According to Ellert, Björnberg & Coutinho (1958) are composed of shales with intercalation of sandy layers and at the top of sandstone with cross-stratification. These are generally silicified and recrystallized, which is not the case with shales, where no evidence of recrystallization is observed, even when cut by dikes of alkaline rocks. In the sediments there is a diabase intrusion, which appears in dykes and small irregular silts, and surface mainly in the north (N) of Águas de Prata. The texture and mineral composition allows analogy with other basic Mesozoic intrusions (Ellert 1959).

2. Vale do Quartel:it represents the pyroclastic range related to the initial volcanism, according to the model of geological evolution of the resurgent caldera of the Alkaline Massif of Poços de Caldas, proposed by Ulbrich (1984). The textures and structures of the blocks (vesicles, tonsils, presence of phenocrysts) are of centimetric size and the existence of spills (Ellert 1959) show that these initial manifestations are in part the result of sub-air volcanism. In the lower parts of the Vale do Quartel creek there are ankaratritics breccias in tabular bodies.

3. Serra do Mirante – represente crystalline basement consisting of gneiss and granite (Precambrian age). In the northwest (NW) border the gneiss of pink color was transformed into fenite, of grayish green color. From the gneiss to the fenite, along the road to Cascata - São Roque do Fartura, the following sequence can be observed: a) change of pink color of the feldspars in the gneiss to greenish gray color, in irregular zones; b) decreased quartz content of the rock; c) increase in the size of minerals, especially feldspars; d) appearance of sodium amphiboles (Ellert 1959).

4. Morro do Serrote – Cascata (SP): bodies of nepheline syenites with gray and whitish feldspars emerging as the most important facies of the plateaus, which appears laden with enclaves of tinguaite near the contacts. Extends from the Pedreira da Prefeitura to Morro do Serrote, passing by the airport. Occurrence of zirconiferous deposits are associated in this area.

5. Pedreira Bortolan: this site represents the phonolites, tinguaites and nepheline syenites rocks. The nepheline-syenite body of the quarry is extensive, covering an area of about $80km^2$. Also occur pyroclastic rocks. Breccias and tuffs occur in the Vale do Quartel in ooutcrops of elastic rocks, which differ from the sandstone by the conglomerate aspect and marked green color. They are massive and hard rocks, with subordinate quantities of clasts larger millimeter to centimetric, rounded to angular, tabular to equidimensional (Ulbrich 1984).

6. Pedreira da Prefeitura: it is part of the nepheline syenite bodies of the interior of the massif. The occurrences of the nepheline-syenite in the quarry together geologically associated rocks constitutes the most important expression of the plateau. Outcrops account for almost 2/3 of all exhibitions in the district (Ulbrich 1984).

7. Pedra Balão: the Pedra Balão is characterized by being a large suspended block of nepheline syenite, large phanerite (tinguaite) with oriented trachytic structure. The tinguaites are originated by the intrusion of alkaline-sodium magma into radial and concentric fractures that appear after the collapse of the structure of the volcanic caldera, about 80 Ma. The tinguaites appear preferentially in the peripheral part of the massif, forming the annular dikes (Ulbrich 1984). The formation of the nepheline syenites of Pedra Balão should mark the period of transition of the miaskitic to the agpaitic alkaline magmatism (Alves 2003).

8. Morro do Ferro: abundant occurrence of magnetite veins and dykes. It is a unique surface radioactive anomaly almost entirely due the thorium and its daughter products. Associate with rare-earth elements and minor uranium RepresentsTh-REE deposit in the presence of magnetite dykes hosted in clayey layers and within the regional geologic context it belongs to tinguaite mass located at the boarder of an area in which the rock is completely altered by hydrothermalism and weathering, and the product of the alteration is a clayey material formed by kaolinite, illite and gibbsite. The magnetite occurs as a stockwork in the NE direction in the upper portion of the ore body zone (Bonotto 2010).

9 Cascata das Antas e Fonte dos Amores it represents an annular dyke of tinguaite similar to the other occurrences of the massif (Ellert 1959). The tinguaites occupy extensive areas within the massif as subvulcanic invasions. The K/Ar ages for these rocks are 72-76 Ma (Ulbrich 1984).

10. Morro do Taquari: minor body of nepheline syenite, occur as isolated body, which characterize the circular structure of the center-east (Ulbrich 1984). Mineralization of U, Mo and Zr (Castro & Souza 1962 apud Ulbrich 1984). Also occur concentration of small deposits of caldacite and zircon, both uraniferous (Ulbrich 1984). The hydrothermal alteration occurs in the region of the center-east circular structure (mainly the presence of potassic feldspar and illite, with some kaolinite), as a witness of the initial process of alteration.

11. Campo do Agostinho: This site is located at the central part of the alkaline complex of Poços de Caldas, where it was first found, in 1965, uraniferous mineralization. Characterized by mineralization of U, Mo and Zr, represented by phonolites, nepheline syenites, also breccias and pyroclastic rocks that are hydrothermally altered; the color of the soil in this area is quite characteristic, of whitish beige shade. The largest hydrothermal alteration is accompanied by a breccia, local or more extensive, developed in an area of apparently very fractured, accompanied by the more important mineralization, restricted to regions with the presence of breccias and conduit clusters (Garda 1990).

12. Mina Osamu Utsumi - Campo do Cercado, Campo do Agostinho: represent alkaline rocks hydrothermally and U-mineralized potassic rocks. The lithology of the mine is composed mainly of a sequence of subvolcanic phonolites and nepheline syenites intrusions; volcanic breccia pipes characterized by U-Th-Zr-REE mineralization concentrated in the matrix.

The potential geodiversity sites are Cachoeira Véu das Noivas, Cascata das Antas, Monjolinho, Fonte dos Macacos/Balneário Mário Mourão, Fonte Pedro Botelho/ Thermas Antônio Carlos, Igreja de São Benedito, Igreja Santa Rita, Parque Municipal da Serra de São Domingos, Museu Histórico e Geográfico de Poços de Caldas.

Conclusion

The clastic sediments of Águas da Prata corresponds to the sedimentary body associated to a phase before the alkaline intrusion; the pyroclastic band of the Vale do Quartel and Pedreira Bortolan illustrate the geological units corresponding to the development phase of volcanic activity and pyroclasts lavas (agglomerate, ankaratrites, breccias and tuffs). Gneiss of Serra do Mirante (fenite) and quartzite of Véu das Noivas (Clays Sediments) exhibit rock bodies affected by the crystalline basement lifting phase. The nepheline syenite geosite of the Pedreira da Prefeitura can be associated to the formation of the boiler subsidence and rise of the nepheline magma. The geographic gulf of tinguaite of the Cascata das Antas and tinguaite of the annular dike of the Fonte dos Amores exhibit characteristics typical of the annular dam. The intrusion of lujaurite and chibinite is associated to the Pedra Balão. The Morro do Ferro/Campo do Cercado, Campo do Agostinho, Morro do Serrote, Morro do Taquari and the Mina Osamu Utsumi exhibit rocks associated with the hydrothermal alteration phase and Th-Mo-REE mineralization. Thermal Springs as geological upwelling. The studies on the geological heritage of the area lead us to understand the great relevance of this place, already configured in the scientific literature by the innumerable publications, the development of tourism in function of the thermal waters and the local landscape, with possibility of development of trails, hiking and sports. The potential of this area is evidenced by its physical characteristics and by the geological history of a volcanic caldera model with alkaline magmatic intrusions of the Mesozoic (approximately 87 Ma), with a complex relationship between the rock types present and the alkaline rock facies variety.

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RECONCILING GEOCONSERVATION AND URBAN PLANNING IN THE CUESTA RELIEF AND DOMAINS OF THE GUARANI AQUIFER SYSTEM

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Abstract – This paper aims to evaluate the importance of geoconservation in the city of Botucatu and its relations to current territorial planning, land occupation and urban grid expansion practices. The region is an important direct recharge area of the Guarani Aquifer System since most of the city sits on a sandstone ridge that, together with the overlapping volcanic package, determine environmental conditions that restrict the occupation and require some protection measures. Pressed by the voracious pressure of entrepreneurs, government agents often try to approve housing developments which disregard appropriateness and limitations of the occupation and do not follow the principles of geoconservation, which should effectively guide urban growth and city planning. The geological and landscape heritage of the region, and especially the city of Botucatu, far from being a local issue, are actually considered to be connected to the history of the Earth on a global scale, and are therefore part of humanity's memory and interest. This article is a case study: the local public authorities attempted to modify the macro-zoning of the city, by legalizing land development projects in cuesta areas, but organized local civil society carried out an educational campaign focused on information of geological and geomorphological nature, which eventually forestalled the project's approval.

Keywords – Guarani Aquifer System, cuesta, geoconservation, government agents, civil society.

Thematic line – Geoconservation, Geotourism and Geoheritage.

1 Introduction

> ... how a desert is made, how a desert is extinguished. The centuries-old martyrdom of the Earth (Euclides da Cunha, *Os Sertões*).

The municipality of Botucatu is located on an important recharge area of the Guarani Aquifer System (GAS; in Portuguese Sistema Aquífero Guarani, SAG), which houses a large reservoir of fresh, potable water, one of the largest on the planet, capable of supplying hundreds of cities and millions of people with good water. It is indisputable that this strategic water reserve of world relevance should be protected, a fact that, in and of itself, gives each municipal public authority enormous responsibility in decisions related to zoning and urban expansion. Cities should discourage proposals that guide the growth of cities over fragile areas or the adoption of initiatives that impact the environment. Urban expansion and even the creation of industrial districts in the areas of GAS must take place in a harmonious and sustainable way.

Areas in which rocks containing the aquifer outcrop and it is directly recharged are particularly relevant, and in this respect, the state of São Paulo stands out (Theodorovicz 2015). Municipal policies should take into account the environmental fragility, beautiful landscape and recharge areas of the aquifer system, thus avoiding environmental degradation, landscape destruction and groundwater contamination.

The most important and representative planning of the city of Botucatu happened in the year of 2006 with the publication of Law 483/2007, Participative Master Plan. The subsidies offered by the First State Conference on the Guarani Aquifer that took place in 2006, with debates and field visits, involving students, researchers, universities and public agencies (Carneiro 2006, 2007) were valuable. The awareness and knowledge brought by the event certainly contributed to the fact that the protection of the GAS and the cuesta came to be inserted in vital points and devices of the Master Plan.

Dealing with the theme of city growth and expansion is a complex task that should be structured in a multidisciplinary way; it is necessary to guarantee a representation that encompasses the broad needs of the population and the environment, because, after all, a "metamorphosis of the inhabited space" (Santos 2014) comes into play. However, in Brazil, only at the beginning of the 21st century did urban planning decisively enter the national agenda with a positive force, based on Law 10.257/2001, the City Statute (Brazil 2001). The law constitutes a civilizing framework for urban growth and planning, by requiring municipalities with more than 20 thousand inhabitants to establish their Master Plan for periods of 10 years.

The Municipal Law 483/2007, Participative Master Plan of Botucatu (Botucatu 2007), outlined a zone dedicated to the environmental protection of the cuesta relief areas and the Guarani Aquifer System, aiming at its geoconservation and favoring good practices of environmental management, aiming at the preservation of the geological heritage and the cultural landscape. By and large, the most common soils are sandy soils overlying sandstone layers that make up the Botucatu Formation. The relief is generally undulating with open valleys, forming extensive slopes and plateaus. Cuesta is a form of relief supported by layers laying on very mild slopes, with the two sides showing a remarkable asymmetry, since the inclination is very soft on one side and quite steep on the other, which can develop scarps. These unique relief characteristics are present in the region where the municipality of Botucatu is located. The meaning and scope of geoconservation are relatively new; in a way, this concept is the interface between the need for land use and the conservation of geological heritage and natural beauty. This good public environmental policy is a task:

> (...) of interest to humanity, since geosites store important information for the evolution of planet Earth, being illustrative of relevant characteristics, events or processes of the planet's history (Pereira et al. 2008).

The objective of this work is to list various reasons why the geoconservation of the cuesta areas and domains of the Guarani Aquifer System is important, and to try and compare them with the Bills 012/2016, 25/2016 and 26/2016, all of them born out of initiatives from the Botucatu Municipal government, combined with Municipal Law 483/2007, Participative Master Plan. The case study presented here refers to the attempt by the local administration to expand the city to environmental protection areas and to implement housing developments. Organized civil society, in opposition to the changes, promoted debates and public hearings, signaling the negative consequences of such occupation and contributing to the awareness of the population. The members of the administration, convinced by the arguments and/or under pressured by the population, gave up the attempt, withdrawing from the House of Representatives Bills 12 of 2015 and 26 of 2016.

2 Geoconservation

> We forget, however, a remarkable geological agent – man (Euclides da Cunha, *Os Sertões*)

Aquifer is an underground water reservoir, characterized by layers or geological formations sufficiently permeable, capable of storing and transmitting water in quantities that can be used as a source of supply for different uses (Iritani & Ezaki 2012, p.19).

The motivation for the protection of the geological heritage of the Guarani Aquifer System and the domains of cuesta necessarily passes through the understanding of their vulnerability due to human actions. The definition of geoconservation in Sharples (1995, 2002) seems quite accurate, when conceptualizing it as an action that aims to preserve the significant natural diversity (or geodiversity) and to guarantee the course of the natural evolution of geological (substrate), geomorphological (landscape shapes) and soil. Within this concept, the aspects that deserve to be highlighted, regarding the protection of the geological heritage of the Guarani Aquifer System, are the strategic importance of GAS and the vulnerability of recharge areas and soils.

2.1 The importance of the Guarani Aquifer System

The Guarani Aquifer System is considered one of the largest aquifers in the world and an important geological heritage to be preserved. It has approximately 1.2 million km², covering parts of Brazil, Paraguay, Argentina and Uruguay (Borghetti et al. 2004). Brazil is the country with the largest area of the GAS (Fig. 1), corresponding to 70.2% of its total, and the state of São Paulo has a total area of 155,800 km² (FIESP 2005, p.16). Outcrops make up 12.8% of the total area of the System, that is, 153,000 km2, of which 104,000 km2, or 67.8%, are located in the Brazilian territory, according to the Water National Agency data (ANA 2001, apud Borghetti et al. 2004, p.130). They are powerful units; both Brazil, and, within the country, the State of São Paulo, host an important segment of this heritage.

GAS stands out for its extension, quality and quantity of its groundwater, and its hydraulic properties, with special reference to its porosity (number of empty pores), the specific production (amount of water released from the saturated zone) and its permeability (ability of the porous medium to let water circulate) (Barbosa Jr. 2016, p.212).

The Serra Geral Formation is a monumental aquifer, which has served to supply hundreds of cities and millions of people in much of the central-western region, southeastern and southern regions of Brazil.

> It is a sequence of sandy layers deposited in the Paraná sedimentary basin throughout Mesozoic (Triassic, Jurassic and Lower Cretaceous periods) between 200 and 132 million years – consisting of the Pirambóia (Buena Vista in Uruguay) and Botucatu (Misiones in Paraguay, Tacuarembó in Uruguay and Argentina) formations (Rocha 1997).

The architecture of the sedimentary pack that constitutes the Guarani Aquifer is the result of three factors related to Geotectonics: (a) the very thick basaltic lava flows deposited on them; (b) activation of regional failures and arching; (c) uplift of the edges of the Paraná sedimentary basin (Rocha 1997).

2.2 Vulnerability of recharge areas

The recharge areas of the aquifer occur in the outcrops, directly on the Botucatu Sandstone, which, due to its own characteristics, absorbs the waters and processes the slow and complex infiltration. A part of the recharge areas is located in cuesta domains, where small, perennial and temporary streams flow, which flow towards the cliff slopes and domains of Peripheral Depression (Fig. 2). They are drainage systems that contribute to the direct recharge of the GAS. However, if on the one hand geology provides the supply of underground reserves, on the other hand it also facilitates the infiltration of pollutants and contaminants, whether pesticides, domestic sewage, industrial effluents, fluids from fuel stations, cemeteries, swine farming or mining activities, transportation of heavy metals, landfills, dumps, sanitary warehouses, septic tanks and other sources capable of disseminating arsenic compounds or nitrates in the environment (Souza 2009). Recharge areas are the most vulnerable portions of the overall GAS structure. These are fertile soils with high productivity indexes, associated mainly with the weathering of overlapping basaltic rocks of Serra Geral Formation, where most commodity crops are grown. These factors add up to the great development potential of beef cattle. The region concentrates agro-industrial pole and other types of industry (Borghetti et al. 2004). The disputed occupation of the areas promotes and facilitates occupation and increases the possibility of contamination of groundwater. In this multifactorial context preventive public policies are critical for normative protection.

2.3 Soil Environmental Fragility

The soil, composed largely by the outcrop areas of the Botucatu sandstone, is highly collapsible, and much of it is occupied by urban growth. This occupation imposes a severe environmental damage, which is difficult to recover. It is quite clear that this geological situation demands attention and special care, however, in a tragic way, the local reality is not anchored in the scientific understanding of this geological and geomorphological environment. Erosion scars are visible in areas close to the urban area. The Cuesta in Botucatu covers areas of high potential for water erosion, and therefore, there must be constant research and monitoring, as well as care regarding territorial use and urban occupation (Theodorovicz 2016). The occupation of the direct recharge area or outcroppings of the Botucatu Sandstone enclosing the Guarani aquifer is an example of how fragile areas are being carelessly occupied in Brazil. The direct recharge area is

> so called, although there are some points of discharge, because it includes places where rainwater infiltrates, feeding the saturated zone without major obstacles, since there is no rock pack to cross (Gomes 2006).

In view of the fragility scenario that characterizes the Botucatu Sandstone, we are once more faced with the need for responsible and sustainable planning, in order to refrain the pressure and voracity of the entrepreneurs and to counterweight the weakness of the public administration, which often yields to economic pressure or convenience policy authorizing housing developments in areas that jeopardize the environment. This yielding may cause irreversible or costly damages to the municipality and consequently to all residents.

> Thus many cities grow in Brazil: without territorial planning and under tremendous pressure exerted by the voracity of a speculative and environmentally irresponsible real estate market. The rural space ends up being seen only as a stock of space for future urban expansion (Ferrão 2016).

The case study presented in this paper shows an example of Ferrão's (2016) affirmative, as rural areas are marketed as a source of resources for the city, being sold by square meter and not by alqueires or hectares (units of area, normally used for the sale of rural areas – 1 alqueire equals, in the state of São Paulo, ~6 acres, 1 hectare equals ~2,5 acres). This demonstrates that real estate speculation advances over rural areas, expanding the city on the edge of the cuesta, disregarding local fragility and accelerating the erosion rate. If in the past knowledge was not accessible and research was often lacking, today the same mistakes cannot be accepted. The geo-environmental limitations must be respected, and the appropriateness for each type of use must be monitored and supervised.

2.4 Cultural and Landscape Heritage

The concept of cultural heritage is presented in the Federal Constitution of Brazil, of 1988, one of the most perfect and comprehensive in the world (IPHAN 2017), in art. 216, which declares as heritage, among others,

> "urban complexes and sites of historical, scenic, artistic, archaeological, paleontological, ecological and scientific value".

The geomorphological features of the sandstone-basalt cuesta are rugged scarps of rare beauty, which make up the material and immaterial heritage of the citizens, being present even in the city's flag.

Figure 1. Area of occurrence of the Guarani Aquifer. As can be seen in Map 1, the occurrence of groundwater in the GAS occurs under the modes of confinement and outcropping. The confinement areas are those overlain by the basaltic rocks.

The landscape had its first legal recognition with the creation of the Conservation Unit - APA - Corumbataí-Botucatu-Tejupá (São Paulo 1983) which states that the

> "landscaped assemblage formed by them, in addition to their intrinsic environmental values, make up natural amphitheaters of a remarkable scenic beauty" (São Paulo 1983).

The front of the cuesta has qualities that favor geotourism and provide places of contemplation and leisure for the population. Adventure sports and fieldwork are provided for students and researchers. An open-air classroom, enjoyed by all as a basis for culture and knowledge.

3 A case study

The first legal legal reference to the cuesta protection occurred in 1983 in the creation of the Corumbataí-Botucatu-Tejupá Conservation Unit. Only in 2007 would municipal legislation make reference to the patrimony, with the passing of Law 483/2007, *Participative Master Plan of Integrated Development* (Botucatu 2007), which provided for the protection of the cuesta and the areas of dominion of the Guarani Aquifer.

The new Master Plan should be reviewed in 2017 in order to comply with the "decade rule". However, in 2016, the head of the executive branch sent to the City Council the Bill 12/2016, providing for the amendment of Charter I - Macrozoning and Urban Perimeter of article 165, I, of Law 483/2007 - Master Plan, the Bill 25/2016, which proposed a change in the urban perimeter and the Bill 26/2016, which proposed a new definition of the urban perimeter.

Figure 2. An urbanization in Botucatu advances on a top cornice of escarpments, incorporating lands where the drainage system began to flow towards the base of the slope. This factor has accelerated the dynamics of erosive processes

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In Bill 12/2016, the change of the city's macrozoning redefined areas of occupation that had been described as low density (1,000 meters) for priority density (250 meters) creating ZEIS - Zonas de Especial Interesse Social - Zones of Special Social Interest. Bills 25 and 26/2016 altered the urban perimeter and turned some rural areas into urban ones. The new design of the city expanded the urban area to previously protected portions, especially in the southern sector where the cuesta has a steep slope reaching its lower part ("sopé da cuesta") in the Guarani Aquifer recharge area. Environmental backtracking would be tragic. When reviewing the history of irresponsibility with the environment, it is worth remembering that in 2015, therefore prior to the Bills, the local society discussed in several public hearings the revision of the Master Plan, with great and representative participation, proposing that in the areas of southern sector (domain of slopes) the zoning should be preserved and that other areas of the city received protective legislation as well.

For these suggestions of civil society there was no response and the revision of the Plan was shelved.

When the new macrozoning modification was attempted through Bills, civil society organizations, the Aitiara Mineralogy Museum and the Aracatu Valley Association (Fig. 3) asked for a Technical Report on the conditions of the cuesta areas where macrozoning would create the possibility of building popular housing projects with a high population index.

The work was the responsibility of the federal agency CPRM / SGB - Mineral Resource Research Company / Geological Service of Brazil. Geologist and researcher Antonio Theodorovicz, the professional responsible for the study and detailed fieldwork, warned about:

> (...) the erosive power of the floods that arrive at the tip of the cuesta in the urbanized area, producing deep erosion grooves, even on clayey basalt soil, usually not very erodible. It must be considered that, in addition to the negative modification that they cause to the landscape, all eroded soil and trash reach down to water courses that pass through the recharge area of the Guarani Aquifer System and will eventually end up in the Barra Bonita dam reservoir. The erosion of the top of the cliffs is one of the problems that will be greatly worsened, if the water basin of the Rio Verde becomes more waterproofed (Theodorovicz 2016).

Figure 3. Publicity poster of the Public Hearing, with landscape that presents part of the scenic patrimony of the slopes.

Also within the scope of clarification actions, a public hearing was held in the City Hall, in which the Report "Adequacy and Limitations of Geodiversity of the area of influence of the cuesta in the region of Botucatu" was presented, which provided geographic and geological information to the municipal councilors and of the population that filled the galleries of the City Council (Fig. 3). Throughout the day of debates and opposition to the Bills, there was an increasing indignation of the population and demonstration of the sense of appropriation of the geological heritage of a landscape integrated to the daily life of the city. With the mobilization, the defense of the cuesta, which has been "sung in verse and prose in the city", has been further strengthened, besides nurturing the affection of the citizens.

The main consequence of the organized actions of civil society was the relinquishment of the local executive power to keep the proposal of sending the Bills to vote, withdraw them instead, and maintaining the rules approved in Law 483/2007, whose macrozoning is more restrictive.

4 Conclusions

In view of the above written and discussed, the main conclusions obtained are basically the following:

- The Guarani Aquifer System, protected by various legal provisions, is a strategic reserve of finite water resources and an immeasurable geological heritage of interest to humanity. If not monitored properly and protected by society, the areas of direct recharge can receive contaminants that may reach groundwater, which would be catastrophic and an act against humanity.
- The landscapes are cultural heritage of the city, providing recreational and study areas for the population. The areas of the sandstone-basalt cuesta, by their natural characteristic of being friable and erodible, require special conditions of occupation. If landslides, erosions and gullies develop, they can deeply modify the local river basins, perennial rivers and water bodies that have their sources there.
- The urban planning of the city, through the Master Plan, should promote geoconservation of the areas of the Guarani Aquifer and the cuestas, considering geology, geomorphology and the scenic beauty of the area. The voracity of unconscious entrepreneurs should not triumph over protection of the environment and geological heritage.

The participation of organized civil society and the mobilization of the population were crucially important and culminated in positive results, with important outcomes. In this case, this was demonstrated when the social movement managed to win against the intended abusive bills. The actions of civil society, in this case, magnify a paradigm that shows the population as social actors needed to strengthen citizenship and intervene to propose sustainable policies in the management of the geological heritage in Botucatu.

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THE PRESERVATION OF NATURAL LANDSCAPE OF ANALANDIA CITY (SP/BRAZIL) AND ITS REGION AS A LOCAL DEVELOPMENT PROPOSAL THROUGH THE CREATION OF A UNESCO GLOBAL GEOPARK

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Abstract— From the earliest times human beings were related to their environment, building a relationship with the "place", which they transform according to their needs. When a territory goes through a process of occupation, this action dialogues directly with the landscape and with the physical and social processes. The use of the natural landscape as a resource for economic development in the region of the Corumbataí Basin, in the state of São Paulo (Brazil), suggests a careful look at geoconservation actions. The proposal brought by this work is focused on the municipality of Analândia and will use various sources to construct a brief context about how the interaction between this rich natural landscape and tourist interventions took place, giving new directions to the economic development of the municipality, interconnecting these actions with the proposal to create a UNESCO Global Geopark in the Corumbataí River Basin.

Keywords— Landscape, Geoconservation, Geotourism, Geopatrimony, Corumbataí**.**

Thematic Line— Geoconservation, Geotourism and Geopatrimony.

1 Introduction

Over time, the concept of landscape contracted multiple meanings. Initially viewed as a simple analysis of the physical fragments that constitute the presence of humans as participant and transformer of his own reality, is now present in methods and techniques, contributing to numerous fields of science.

In geological aspects, a territory is formed alongmillion years over time shaping its natural landscape. In addition, history is built by the early settlers and is written in architecture, customs and local culture. With the emergence of cities, the relationship between humans and the natural environment, becomes complex, and, at this point, law is interconnected through the environmental and urban areas.

Thus, be the landscape natural or anthropic, it has the power to attract visitors, especially when it comes to singular aspects of beauty. Santos (2004) referred that the landscape portrays a set of forms, which at any moment expresses the inheritances that represent the successive relations between human and nature. And though their forms are conceived in different historical moments, they coexist in the present moment, with a current function, answering to the present needs of society.

> A landscape has always been intimately linked, in human geography, with a culture, with an idea of visible forms on the surface of the Earth and its composition. A landscape, in fact, is a "way of seeing", a way of composing and harmonizing the external world into a "scene," a visual unit (Cosgrove 1998, p.223).

With regard to tourism, this allows the user to distance himself from his usual environment and interact with new places. On the other hand, there are also other characters, those who promote tourism, who in turn, come closer to their environment, conserve their culture and natural resources, and obtain sustenance from this source of income. The phenomenon of tourism is increasingly recurrent in the contemporary world, since leisure through recreation, sport and tourism, is a social right, guaranteed to all Brazilians, according to art. 6 of the Federal Constitution (Brazil 1988), and must also be seen as one of the most important ways to achieve the healthy quality of life, inscribed in art. 225 of this fundamental law.

Thus, the proposal of this work is to take the city of Analândia (São Paulo State) as the area of study and will use several sources to construct a brief context about how was the interaction between the natural landscape and the touristic interventions, which has been giving new directions to the economic development of the city, interconnecting these actions with the proposal to create a future UNESCO Global Geopark in the Corumbataí River Basin, where Analândia is located.

2 The city and the patrimony: law as support for conservation

Analândia is located in an area with great hydro and geological richness and, beside the cities of Piracicaba, Rio Claro, Santa Gertrudes, Charqueada, Corumbataí, Ipeúna and Itirapina, is inside the Corumbataí River Basin, which has a territory of 1,708 km^2. This region is geologically privileged with several geosites cataloged (caves, fossils, waterfalls, hills etc.) and scenic landscapes that portray regional history (Ceapla 2004).

Analândia city has 4,672 inhabitants and an average area of 326,630 km², which results in an average density of 14.3 inhabitants per km², according to IBGE (2010). Located in an Area of Environmental Protection (APA), called “APA of Corumbataí, Botucatu, Tejupá” this city holds most of the springs of Corumbataí River. According to Perinotto (2008), it’s known the existence of a huge local hydric potential. Therefore, there is much to contribute for the tourism development in this city, because:

> It is a remarkable landscape area, with preserved springs and several waterways. It is worth to emphasize that, so far, there are 83 types of water falls in this region cataloged; 90% are located in private units and services, without any signage or ease of visitation, as well as specific relief forms such as testimonial hills, caves, as well as climatic characteristics that provide comfort and well-being to visitors. This set of factors allows the sectors of the critical area to become relics of flora and fauna, con-tuning, as a whole, some specimens in extinction (Perinotto 2008, p.2).

It is important to emphasize that Guarani Aquifer System (SAG) is under this territory:

> [...] notably in Analândia, which has 100% of its territory in the SAG outcrop area. And it is in Analândia that is located the Corumbataí spring, in Serra de Santana, about 800 m of altitude (Ceapla 2004).

Regarding the creation of the APA in Corumbataí, Botucatu, Tejupá, by State Decree No. 20.960 / 1983 (São Paulo 1983), it should be noted that this is a sustainable use conservation unit, which, according to the National System of Conservation Area Units – SNUC (Law 9.985 / 2000), can be generally defined as an extensive area, with human occupation, endowed with abiotic, biotic, aesthetic or cultural attributes that are especially important for quality and well-being of human populations, and its basic objectives are to protect biological diversity, to control the occupation process and to ensure the sustainable use of natural resources, consisting of public or private lands which, with respect to constitutional limits, norms and restrictions, can be established in the Management Plan for the use of private properties located in an APA (Brasil 2000).

Thus, in addition to the legal protection of this territory, the geological heritage protection is based on three axes which, applied together, guarantee the stability of the regions containing such resources: Geodiversity, Geoconservation and Geotourism, tools of interests applied to defend geomorphological heritage.

Looking to geoconservation, it is necessary the joint and coordinated action between several authorities and the local population, aiming the geological heritage conservation, as well as the rational use of the soil. The Law, in this particular, is useful to other sciences, enhancing the Environmental Law and its concern with the cultural and natural value of humanity, as well as Urban Law through the instrument of tipping and the creation of urban policies translated by the Director Plan, aiming at the local urban landscape ordering. The changes undergone by the urban scene over time are incessant and these physical modifications, or the ones caused by using, establish temporal marks in space. Geography as a chain of relation study between human and nature, which is altered in order to guarantee human’s survival, views the landscape, or its changes, as a phenomenon of interaction, whether natural or anthropic.

Considering the understanding of Cosgrove (1998) and Hall (2003) on issues about identity and knowing that this may be a relation of exchange and belonging between the individual and the environment, they point out that identity is sometimes very fluid (individual) and that symbolic landscapes (natural and constructed environments) are not static statements, nor are the cultural values that these landscapes share. Starting from this premise, Brilha (2005) affirms that the individual only protects something that he values, and only values what he knows.

3 Geopark as a promoter of conservation and local development

The creation of a Geopark tends to strengthen Tourism as an active economic process in the generation of income (primary, secondary and tertiary) in the region, especially in Analândia. As well as promoting integration between the local population and the environment, fosters the development of ownership and care by empowering the local people and providing them the sense of belong to their territory.

In the concept of UNESCO (2016), a geopark must guarantee the preservation of the geological heritage, as well as education and environmental education, besides ensuring sustainable development through geotourism, enriching and valuing natural and cultural attributes of some region. Therefore, the proposal of a geopark in this Basin stands out both for conservation and for the way it cares about the development of new types of income generation and the sense of belonging among the residents.

In a tourism context, mainly the ecotourism, the region becomes a target for new phenomena, conceiving new landscapes produced from this new “territorialization” and new economic processes.

It is worth to say that several studies and initiatives wich aimed at the territory protection, looking to the promotion of tourism, have been carried out in the zone. The project "Geological Monuments of Rio Claro’s region", developed between 2007 and 2012, was the protagonist in the presentation of several works, mostly in the region of the Corumbataí Basin, which demonstrated a very diverse natural patrimony. Among the works we could mention here, are those prepared by Zaine & Perinotto (1996), Perinotto (2009), Zaine & Zaine (2009) and Perinotto & Mantesso-Neto (2013), who raised important discussions about the region's tourism potential and several environmental education proposals.

From the interest of Geological Survey of Brazil - CPRM, in 2006, based on premises of which are identification, survey, description, inventory, diagnosis and wide dissemination of potential areas for future geoparks in the national territory, studies about this theme starts in Brazil, since there is only the Araripe UNESCO Global Geopark in the Ceará State, created in 2006, in spite of its significant territorial area (Geopark Araripe 2017).

Therefore, in order to contribute to the implementation of a Geopark in São Paulo State, looking to favor ecotourism and geotourism in Analândia and the whole region, the Aspiring Corumbataí UNESCO Global Geopark is underway with the effective participation of the community and political authorities of the cities inside the Corumbtaí River Basin, headed by the PCJ Consortium and Unicamp (University of Campinas) and UNESP (State Paulista University).

The creation of a geopark brings along a range of development strategies based on the geological heritage conservation (Brilha 2009), in association with other elements of natural and cultural heritage, aiming to improve living conditions of the populations that inhabit it.

4 Conclusion

It is a fact that from the earliest times human has always related to the environment, building a relationship with the "place", which it transforms according to it's needs. The term landscape includes a diversity of interpretations. When a territory goes through a process of occupation, this action dialogues directly with the landscape and with the social processes. The Corumbataí Basin, from the spring to the mouth, has a diversity of landscapes. It is known that the landscape is a picture of space and time fraction, involving all the elements that it contains, as well as its natural and social processes. Therefore, it is possible to emphasize that the Corumbataí River Basin owns a rich natural, social and cultural landscape.

The whole region, especially the city of Analândia, with its unique natural attractions (e.g. Morro do Cuscuzeiro and Morro do Camelo), has huge potential for the development of a touristic offer, focused on into its socioeconomic development and mainly in the preservation of its geological heritage.

The proposal brought by the Apiring UNESCO Global Geopark in the Corumbataí River Basin looks for tourism as a sustainable tool, which works as a link between conservation and income generation for the population there. Besides conceiving a vision that fits to this environment and deals with natural, sociocultural and economic factors as the same. Thus, planning and joint management of interests aim to minimize the negative effects of tourism activities and the quality improvement of local population's life, besides contributing to the return of tourists to the region.

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Thematic Line

Geosciences and Natural Sciences for Basic School

“INTO DARKNESS” ADAPTING A MINERALOGY WORKSHOP FOR LEARNERS WITH VISUAL IMPAIRMENT

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Abstract —The project is an extension to a workshop developed to promote mineralogy/ crystallography in Science Centres in South Africa. The original workshop was developed as an opportunity to promote this often neglected subject, in South African Science Centres and to learners. The aim of the workshop is that learners appreciate that minerals have a three-dimensional crystal structure and that the crystal structure in combination with the chemical composition determines what type of mineral it is. We also want learners to understand the process of how information about crystal structures are obtained. We successfully conducted the original workshop in Science Centres, Science festivals and schools. The workshop consist of three parts: I hear and I forget” which provides a short introduction to minerals, “I see and I remember” which screens some video clips and the “I do and I understand” part in which learners build a crystal structure model. In its cur-rent form the workshop relies heavily on the visual side and is inaccessible for learners with visual disabilities. For the learners with visual impairment we are going to introduce descriptive language and tactile graphics in the first two parts of the workshop. The understanding of the crystal structures of minerals covers the abstract concept of chemistry were learners are requested to understand atomic or molecular structures in three-dimensions. Teachers use physical three-dimensional models of crystal structures as tools to help learners visualize these structures. In the original workshop learn-ers rebuild the crystal structure model of an “unknown” crystal and compare the model to a variety of other structures in order to determine what the unknown crystal is. Ball-and-stick models are routinely used in teaching at high school or university level. As a cheap alternative we used coloured sweets and toothpicks to build the models. To cater for learners with visual disabilities we will provide a more tactile solution in form of either different shapes or different textures.

Keywords— Geoscience education, visual impairment, mineralogy.

Thematic line— Geosciences and Natural Sciences for Basic Education.

1 Introduction

The Science and Technology Education Centre at the University of KwaZulu-Natal (STEC@UKZN) which includes the Geology Education Museum is a place of hands-on informal science learning with the emphasis on Geoscience Education. Numerous geoscience related workshops and educational material have been developed by the Science Centre (STEC@UKZN).

One specific area of concern in regards to hands-on science education is the availability and accessibility for all children, including those with disabilities. Especially learners with visual impairments have considered science a difficult subject, as it is heavily relying on visual instruction techniques (Wild et al. 2013). In South Africa over 700 000 people have severe seeing difficulties (Census 2011) of which about 80 000 are between 5 and 19 years old. We as Science Centre decided that those learners should have the same access as their peers to informal teaching and hands-on science programs. In an all-inclusive education approach we decided to adapt some of our geoscience workshops for learners with seeing difficulties, starting with our already established “Discover the Inside World of Minerals workshop.

2 Discover the Inside World of Minerals” workshop

In 2014 Science Centres were challenged to carry out a crystallography workshop to promote the International Year of Crystallography. STEC@UKZN developed a mineralogy/ crystallography workshop which was made available to other Science Centres in the country. The targeted age group ranges from grade 9-12, but we also presented the workshop to grade 7 learners, at conferences and to special interest groups (Reinhardt 2016).

2.1 Structure of the original workshop

The workshop was developed for sighted learners. The aim is that learners appreciate that minerals consist of atoms that are connected through bonds, that they understand that minerals have a three-dimensional crystal structure and that the crystal structure and the chemical composition determines what type of mineral we get. We also wanted them to be aware that scientists usually determine crystal structures using X-rays. For the visually impaired learners we want to keep the same learning outcomes.

Mineralogy and in this case the understanding of crystal structures of minerals covers abstract concepts of chemistry. Learners are requested to understand atomic or molecular structures in three-dimensions, concepts that even “seeing” University students have difficulties to grasp.

It has long been recognized that physical three-dimensional models are useful tools to help seeing learners “visualize” and understand abstract concepts (Ingham & Gilbert, 1991, Barke 1993). In the original workshop we decided to let the learners rebuild the crystal structure model of an “unknown” crystal and compare the model to a variety of other structures in order to determine what the unknown crystal is. Ball-and-stick models are routinely used to visualise crystal structures in teaching at high school or university level, and ball-and-stick kits are available to build these models in groups. We are using a cheaper version with coloured sweets (Jelly Tots) which represents the atoms and toothpicks which represents bonds to build the models. These easily accessible and cheap materials allow teachers and other Science Centres an easy replication of the workshop.

The workshop consists of an introductory talk and a hands on activity and follows the Confucius quote: "I hear and I forget, I see and I remember, I do and I understand".

"I hear and I forget" - the learners get a brief introduction about what a mineral is, what a crystal structure is, as well as information about crystallography, atoms and bonds and X-ray diffraction. Teachers can decide on how much they want to go into details about the various bond types and the structures of atoms.

"I see and I remember" - the learners will see short video clips about the International Year of Crystallography X-ray diffraction and a about ionic and covalent bonds in the presentation. During the talk we show the learners a single grain of salt and challenge them to estimate how many atoms fit into a salt grain. This provides an opportunity to "show" how small in fact atoms are. We also do a short demonstration on diffraction using a laser pointer with diffraction grating.

"I do and I understand" – the learner do the hands on activity and build a crystal structure (galena or salt) out of sweets and toothpicks. We usually work in groups of 3, so that everybody gets to build a layer (Figure 1). Each group then assembles their three layers and complete the structure (Figure 2). Once the model is finished they compare their model to the crystal structure pictures of sphalerite, diamond, graphite, salt (halite), galena, olivine, fluorite and pyrite and try to identify their structure (Figure 3). To make it more relevant we put samples of the above minerals next to their crystal structures.

2.2 Adapting the workshop for visually impaired learners

According to Dion et.al (2000) to effectively instruct a learner with visually impairment in the classroom, one must be aware of their learning style, which might be different depending on a learner's residual vision. Learners with visually impairment usually have a heightened level of hearing, smell and sense of touch. Therefore, these outlets can be used to connect students to what they are learning. An important rule for making adaptations for a blind or visually impaired student is to keep the changes to the original workshop as minimal as possible. The main reason is that those changes can emphasise the disability of the learner, which creates a gap between the blind or visually impaired learner and their peers if you want to run the workshop with mixed classes. Another reason for minimizing adaptation is because this simplifies the work. We therefore decided to keep the original concept of the workshop the same.

I hear and I forget" - the learners will get the same brief introduction about what a mineral is, what a crystal structure is, as well as information about crystallography, atoms and bonds and X-ray diffraction. More descriptive information are necessary, e.g. explaining different crystal shapes and describing breaking patterns of minerals.

Figure 1: Groups of 3 build the individual layers of the NaCl/Galena structure.

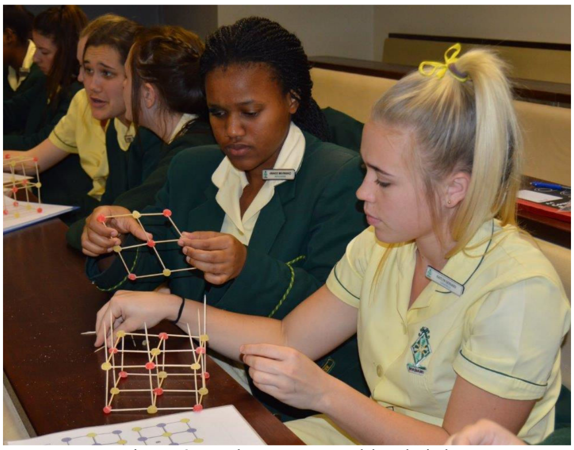

Figure 2: Each group assembles their layers.

Figure 3: Learners compare their 3D structures to the printed 2D crystal structures

In some instances tactile graphics for example the model of an atom can accompany the presentation. Learners with a visual impairment can feel these raised lines and surfaces in order to obtain the same information that people who are sighted get through looking at pictures or other visual images.

"I see and I remember" – this is a part that is better described as "I listen/ feel and I remember". Even though the learners might not be able to "see" the short video clips about the International Year of Crystallography, X-ray diffraction and a about ionic and covalent bonds in the presentation the audio descriptions in these videos provide them with the necessary information.

During the talk we provide the learners with a single grain of salt and challenge them to estimate how many atoms fit into a salt grain. This provides an opportunity to “show” how small in fact atoms are. The demonstration on diffraction using a laser pointer with diffraction grating has to be accompanied by a tactile model.

“I do and I understand” – the learner do the hands on activity and build a crystal structure (galena or salt) out of sweets and toothpicks. In the original workshop we used two dissimilar coloured Jelly Tots to differentiate between the two types of atoms (Lead, Sulphur and Sodium, Chlorine) in the structure. As additional distinction we can introduce different textures (sweets with sugar coating - rough feel and without sugar coating - smooth feel) or different shapes. The instruction sheets have to be adapted with tactile graphics and braille description. As in the original workshop we will work in groups of 3, so that everybody gets to build a layer. Once the model is finished they compare their model to the tactile crystal structure “pictures” of sphalerite, diamond, graphite, salt (halite), galena, olivine, fluorite and pyrite and try to identify their structure. The learners will also have the opportunity to feel the different mineral shapes.

4 Implementation

The implementation of the workshop for the learners with visually impairment will take place over the next few month. A relationship has already been established with the Universities disability unit who will assist us with the tactile graphics and braille instruction sheets.

The workshop will be the first one in our all-inclusive education approach to adapt some of our geoscience workshops for learners with seeing difficulties. Other workshops that we would like to modify is our “Wandering Continents” and “KZN rock-box” workshop.

5 Conclusion

With the original “Inside world of minerals” workshop we were able to design a workshop suitable for South African higher – grade learners and identified areas within the workshop where learners had issues. With the extension we also want make this topic accessible for learners with visual impairments. The costs for the workshop for the sighted learners and learners with visual impairment are minimal and can easily be reproduced by schools, museums or Science Centres. The workshop is also very hands on with the building of the crystal structure and identifying the structure.

The goal of the workshop that the learners appreciate minerals consist of atoms that are connected through bonds is accomplished in the original workshop. Through the building of the model they are also aware that minerals have a three-dimensional crystal structure and that the crystal structure and the chemical composition determines the mineral. They also gain some knowledge about scientific techniques such as the determination of a crystal structures through X-rays. With the adapted workshop we hope to achieve the same goals for the learners with visually impairment.

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AVAILABILITY OF WATER IN RURAL AREAS: EXPERIMENTATION AND TECHNOLOGY APPLIED TO UNDERSTANDING THE ENVIRONMENT IN ELEMENTARY SCHOOL

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Abstract— Water is an essential resource for life and for the various human activities. Its availability is regulated by the hydrological cycle, in which man has progressively interfered. In addition, the amount of water available for use is very low relative to the total water of the planet, since most of it is salty or is stored in glaciers and subsurface. As this scenario points out situations of scarcity, the work about conscious and adequate use has become important since the beginning of school life and citizenship. Therefore, workshops were developed in a municipal school in the municipality of Santa Rita do Sapucaí (Minas Gerais State) in a class of elementary school, aiming to disseminate the learning about the dynamics of the Hydrological Cycle and the distribution of the water using Educational Technologies and Information and Communication Technologies.

Keywords— Water, educational technologies, elementary school, Scratch software, experiments.

Thematic Line— Geosciences and Natural Sciences for Basic Education.

1 Introduction

All life depends on water, a key element for human existence. According to Tundisi & Tundisi (2011) since the beginning of life on the planet and along the history of the human species, Homo Sapiens, water has always been essential. This resource is vital to our existence and has always been present in the formation of civilizations. Bacci and Pataca (2008) emphasize that the presence or absence of water writes history, creates cultures and habits, determines the occupation of territories, wins battles, extinguishes and gives life to species, and determines the future of generations as well. Water is essential to satisfy our daily needs, such as hydration, personal hygiene, hygiene of environments, production of food, production of medicines, among others.

Tundisi & Tundisi (2011) highlight that every form of life depends on water for survival and development. The European Charter for Water, in Silveira (1984), acknowledges the importance of this resource while postulating that there is no life without water. Water is a precious commodity, indispensable to all human activities. It is indispensable to man, as a beverage and as food, for hygiene and as a source of energy, raw material for production, transportation and support of recreational activities.

Regarding availability Soares (2015) describes that 70% of the land surface is covered by water. Of this water, about 97% is salty and 3% is freshwater. However, of this total freshwater only about 1% is accessible to our consumption in rivers and lakes, since the rest is in the basement and in the glaciers.

Therefore, it is evident that the water available for human consumption, in relation to all water exist on the planet, is reduced and, still, a good part is in some way promised.

In this scenario, which involves the need for human use of water in the face of its physical scarcity, it is important to briefly recall the history of this relationship. According to Ferreira & Aoki (2008), when compared to the age of the Earth (4.6 million years) the presence of man on the planet is recent and, in this short time, it has introduced profound changes in the environments.

Water is necessary for food production since ancient times, therefore the resource began to be used for several purposes in Grassi (2001). The first cities, as in ancient Egypt, were constructed on the banks of rivers. With the passing of the years and the great agricultural evolution water stopped being used only for irrigation and began to be used in machines and mills. Up until that time, man posed no threat to the availability of this resource.

Ferreira & Aoki (2008) point out that the great fuse that changed this coexistence was the Industrial Revolution, which occurred in England in the 18th century. Since then production and consumption have increased, cities have become crowded with people and, as a consequence, the imbalance of man's relationship with the use of water has deepened. Another important period was the post-World War II period in which there was a significant increase in urbanization and industrialization processes, which triggered increased pressure and de-grading of this resource.

Tundisi & Tundisi (2011) highlight that while the human societies depend of water surviving and economic development, they pollute and degrade the resource, both surface and underground waters.

Instead of taking into account the physical scarcity, there is a progressive increase of the uses and the pollution and degradation. Braga et al. (2005) describe the current scenario of scarcity, since of the total water, 265.400 trillion tons, only 0.5% is exploitable fresh water, and can be extracted from lakes, rivers and aquifers. If we remove the water that is in places of difficult access and which is already polluted, we have 0.003% of water available for use. In proportion, if all water on the planet were 100 liters, only 0.003 liters would be available.

Another issue worth mentioning is the territorial distribution of water. According to the ministry of the environment Brazil (2005), the country has 13.7% of freshwater in the world, but there is no uniformity in the distribution of this resource, since about 73% of the country's freshwater is found in the Amazon basin where less than 5% of the Brazilian population resides, only about 27% of the water resources are available in other regions of the country where a large part of the population lives, about 95%. In this perspective, it is evident that water scarcity is a very complex phenomenon, involving physical, chemical, biological, historical, social and territorial issues, among others. Further, it is a fundamental question for the existence and quality of life and ecosystems.

Thus, the school cannot forget to work and discuss water issues from various perspectives, at different scales and in different contexts.

From the earliest years of elementary school there is a need to raise awareness of the importance of the conscious use of water resources, since

> "education alone is not enough to change the course of the planet, but it is certainly a necessary condition for that" (Brazil 1997a).

At this stage of schooling, work on water resources should be done beyond the conceptions of Geosciences, also using concepts treated within the scope of Geography. This approach of local and global aspects by an articulated way, according to Callai (2005), allows one to understand the disposition of the natural resources in the landscape, their social importance and the best appropriate way to use them.

According to the Brazilian curricular legislation for Geography in Brazil (1997b), one of the objectives of the discipline is to show the student that citizenship is also the feeling of belonging of the relations between society and nature, forming a whole integrated in constant transformation. It is clear that it is important to educate future citizens so that they can act responsibly and sensitively towards a sustainable environment. So, in Brazil (1997a) points that, for the student to exercise his/her citizenship from an early age the teacher must be able to know the local reality, making him/her to feel part of the environment, and to understand that his/her contribution, even small, is important. Students need to know the environment in which they live, their problems and possible resolutions. In this way, the environmental perspective must offer instruments so that the student can understand problems that affect his life, that of his community, that of his country and that of the planet.

Also detailed in Brazil (1997b), in Elementary School students need to know how geographic space and the functioning of nature are organized in their varied relationships, in order to understand the role of society in its construction and in the production of the territory, the landscape and place. They should also identify and evaluate human actions in society and the consequences in space and time, in order to build references for active participation in local socio-environmental issues.

Faced with these conceptions of complex understanding, it is necessary to reflect on the target audience. It should be emphasized that, in terms of elementary school years, the second cycle grade (children between 8 and 11 years) are more adequate for more comprehensive proposals, because during this period the possibilities for learning are extended, there is autonomy in relation to reading and writing and also a growing dominance of observation, description, explanation and representation procedures. These aspects make the learner more independent in order to carry out research for constructing more complex understandings in Brazil (1997b).

In addition, the method of conducting the work must also be planned and constantly revised. Thus, active learning methodologies through workshops, combined with information and communication technologies can help in the fulfillment of learning objectives. In this context, the role of workshops and technologies in education should be clarified.

> "Workshop is a way of building knowledge, with an emphasis on action, without forgetting, however, the theoretical basis" Paviani & Fontana (2009).

According to Grassi (2013) workshop is a place that develops professional activity. There are several types of workshops: mechanics, cooking, painting, art, music, dance, theater, literature, arts and crafts, among others. All perform a trade and have a purpose.

For this author, the simplest definition of a workshop is that of a place where different types of learning are developed, that is, it is a space in which professional activities are developed, always related to teaching and learning. All the participants, as well as the teachers, are actively and dynamically related around an activity, which results in a production of something concrete and abstract, resulting from an action of expression of feelings and thoughts.

Paviani & Fontana (2009) define that the plans for work under this approach are created with proposals for tasks and problem solving, always focusing on practical activities, with quite different techniques and procedures. The workshop is the chance to experience meaningful and concrete situations that are based on feeling, thinking, acting, for pedagogic purposes. The methodology changes the traditional focus of learning that is the development of cognition and begins to incorporate action and reflection. The theoretical knowledge that occurs in a workshop happens with the appropriation, construction and production of theory and practice in an active and reflexive way.

The purpose of a pedagogical workshop is the articulation of concepts, assumptions and notions with concrete actions, experienced by the participant or learner; and experience and execution of tasks in team, that is, appropriation or collective construction of knowledge according whit Paviani & Fontana (2009).

The same authors report that the workshop should be focused on the learner and on learning, the teacher needs to be the mediator of knowledge in order to achieve the goals set for the workshop. Every action in a workshop requires planning, which needs to be flexible by always adjusting the learners' situations.

As a tool, information and communication technologies, increasingly present in the daily lives of students and teachers, can be incorporated into the workshops, aimed at the implementation and resolution of problems.

Carvalho & Ivanoff (2010) point out that technology can be defined as the set of techniques, processes, methods, means, instruments of one or more domains of human activity. Brito & Purificação (2012) report that technological diversity can be used as an educational tool as long as it is inserted in the school environment and interacting with teaching-learning. The circumstances of information and communication together represent vast new spaces. Teaching and learning with information and communication technologies suggests the adoption of appropriate resources according with Carvalho & Ivanoff (2010).

Several free and free applications have come up to meet the demands of education. Noteworthy is Scratch software, which is a program developed by the Massachusetts Institute of Technology and the KIDS group of the University of California, Los Angeles. The application features programming language that allows the creation of stories, animations, games and other productions. Scratch is designed for children in elementary schools and works in an interdisciplinary approach, that is, with concepts from different school disciplines aimed at setting up specific projects that allow children to learn meaningfully and stimulate creativity.

Therefore, the objective of this proposal was to work on the availability and conscious use of water resources with elementary school students from a rural public school in Santa Rita do Sapucaí (State of Minas Gerais) using active methodologies learning, involving workshops and information and communication technologies. This aim is to contribute to the dissemination of the culture of the conscious use of water resources by learning about the hydrological cycle and its relation with the anthropic uses, determining the amount and quality of water available. In this work it was possible to combine environmental preservation with digital inclusion.

2 Methods

2.1 Population

The research was done in a Municipal School in the rural area of Santa Rita do Sapucaí, Minas Gerais state. The school has 101 students, 8 teachers, 1 trainee, 1 trainer and offers full-time classes.

The selected classes were two that fulfilled full-time schedules, one of the 4th and another of the 5th grade of Elementary School (children between 8 and 11 years). Of these, 10 attended the 4th grade and another 10 the 5th grade, totaling 20 participants.

2.2 Procedures

The research was based on surveys in the field, within the school environment, integrated to the school routine, with data collection on the results done in diary. During the study, some techniques were used to analyze the students' previous knowledge and to develop a new perspective on the topic studied.

After, pedagogical workshops interspersed by experiments (Tab. 1) were developed involved actively the participant children in activities to: 1- understand the scientific presuppositions that determine the movement of water as a closed cycle and the conditions of abundance and scarcity as a resource in the community; 2 - be sensitized to the preservation of water resources; 3 - develop skills related to programming and learning about citizenship, sustainability and environmental preservation through challenges.

Table 1. Brief description of the implemented activities

Activity	**Brief description**
Presentation Dynamics	Initial interaction and presentation of the proposal to students.
Workshop 1	Diagnostic evaluation and first contact with microcomputers.
Experiment 1	Terrarium of the hydrological cycle: comparing the contents of the cup.
Workshop 2	Crossbreed made in tool of virtual tables.
Workshop 3	Programming: creation of the game about the hydrological cycle, abundance and water scarcity and preservation measures by Scratch software.
Experiment 2	Handmade pluviometer monitoring.
Experiment 3	Observation of the influence of land use on the availability and quality of water resources. Importance of the preservation of natural vegetation and the riparian forest.
Workshop 4	Assembling the evaluation panel.

The experiments and the workshops were organized logically forming a didactic sequence, based on the conception that the routing should start from something concrete to the abstract. Thus, all activities that involved formal water content were preceded by experiments, so that students could organize their thinking before implementing it in a virtual environment (Tab. 2).

Table 2. Detailed description of the implemented activities

Presentation Dynamics
With the chairs arranged in a semicircle the children sat at random. On top of each seat was a full bladder in the name of a child. Each participant burst his bladder and read aloud the name noted on the paper. The indicated child answered orally questions related to the different uses of water in daily life and to the importance of water as a resource. After they were asked to draw a picture of the uses of the water.
Workshop 1 - Diagnostic evaluation and first contact with microcomputers.
A quiz was made with questions related to the physical states, availability and water cycle, through a computational slide show tool (Print – OpenOficce®).

Experiment 1 - Terrarium of the hydrological cycle: comparing the contents of the cup.	
The children were taken to the outside area of the school and a terrarium was set up in a glass aquarium. Inside was placed water, grass and an empty glass. The terrarium was sealed with film paper and on the film paper stones were placed just above the glass. Thus, as the water evaporated, it would condense on the film paper and seek the preferential path offered by the protrusions beneath the stones. So over time the glass filled. For comparison, beside the terrarium another cup was placed, but this one was filled with water. Over the days the water in the glass evaporated.	
Workshop 2 - Crossbreed made in tool of tables.	
The results investigated from the terrarium were used and complemented by a brief supporting text to perform a crossbreed in virtual environment (OpenOffice®). In this, it was made the conceptualization of what had been seen during the week in the terrarium on the cross.	
Workshop 3 - Programming: creation of the game about the hydrological cycle, abundance and water scarcity and preservation measures by Scratch software.	
Day 1 - Insertion the programming of games presenting the software from a game previously assembled. Day 2 - The second day was started with the first commands to assemble the game. Day 3- Finishing of the first stage of the game. The game was finalized with the insertion of the answer of the first question related to the hydrological cycle. After the first test was carried out to verify that the programming was correct and a question was asked about water abundance or scarcity.	
Experiment 2 - Handmade pluviometer monitoring.	
In order to contribute to the analysis of the conditions of abundance or water scarcity in the community in which the school is located, a handmade pluviometer was constructed and taken to the students. This equipment was used to measure the amount of rainfall. This experiment was selected since the amount of rainfall is the main factor in the availability of water in the community.	
(Continuation of Workshop 3) Day 4- Continuation of the game's programming with the theme: Abundance or water scarcity Activity 1- Graph and infographic observation on water abundance and scarcity. Activity 2: Insertion of a question and its response by the programming in the game implemented in scratch. When completed, the second test was performed in the game	
Experiment 3 - Observation of the influence of land use on the availability and quality of water resources. Importance of the preservation of natural vegetation and the riparian forest.	
This experiment was carried out to demonstrate the importance of nature forest and riparian forest as well the consequences for the availability and quality of water resources. For that, a comparison was made between three scenarios in three pet bottles, which represented slopes with different uses of the soil: one with grass, representing the preservation; another only with remains of leaves and branches, represented intermediate scenarios; and another with exposed soil, representing unprotected soils. With a watering can, water was added to the three bottles simulating the rains. Thus, it was possible to observe in each simulated slope the amount of water drained and retained, the velocity of the flow and the quality of the water collected after the experiment.	
(Continuation of Workshop 3) After the experiment each pair opened in their notebook the infographic that contained information about riparian forest and the consequences of deforestation. Day 5 - Finalization of the game by the insertion of one more question, this time focused on the preservation of water resources. When it finished the third test was made and it was play the game made by the colleagues.	
Workshop 4 - Assembling the evaluation panel.	
Two panels were used as resources, in which the students fixed notes on the knowledge acquired during the previous stages. The panels stood side by side. One was made similar to the representation of a river, in which they reported the knowledge about the hydrological cycle and the importance of water preservation. The other had the computer-like appearance in which students reported their knowledge of computer science and programming. At the end a brief discussion was held for final conclusion on all that they have learned and the implication of this in the life of each one.	

2.3 Procedures for collecting and analyzing data

The data collection was done from the analysis of the products generated by the students during each activity, the notes in the field diary and the self-assessment.

The evaluation of the results contemplated the three types of evaluation function recommended by Lessan (2011), the diagnostic evaluation made in the first moment, and the formative and summative evaluation in the second moment. Briefly, the diagnostic evaluation served to understand the students' previous knowledge and to apprehend what they brought with them. The formative evaluation was carried out throughout the offices, with activities aimed at overcoming the difficulties of the students. The summative evaluation took place at the end of the process, with the overall evaluation of the results, by the self-evaluation and analysis of the diary records.

3 Results

From the proposed routing it was possible to insert the Information and Communication Technologies in the work on the theme of water, starting from the experimentation and understanding of something from the concrete world to the abstraction of the implementation in virtual environment, with reflections on the conditions that regulate the water availability on a global scale and to the community.

Initially, with the diagnosis of the institution, the material resources and the infrastructure for carrying out the work were verified. Several challenges were posed and were marked, such as the lack of access to the Internet and the impossibility of using the computers of the institution. In order to continue the activities, the support of the Santa Rita do Sapucaí Municipal Department of Education (Secretaria Municipal de Educação), which promptly provided notebook-type computers with adequate programs for offline activities, was fundamental.

At first it was noticed the little or no con tact of the students with personal computers. Thus, the first contact with the equipment was, in itself, a rich learning experience, in fact an experience of digital inclusion. The contact with the tools used attracted the interest of the students for the proposed activities and was fundamental to reach the objectives outlined.

During the workshops the curiosity aroused by the contact with the computers, in some moments, made it difficult to focus on the subject addressed. However, through ludic activities with practices aimed at solving problems in a virtual environment, it was possible to involve the students.

In spite of the peculiarities, all the participants presented an easy learning in the operation and the handling of the machines. However, as expected, some stood out in the handling of computers and others in the understanding of theoretical questions. It is worth emphasizing the active participation of all. Also, the students involved already had some knowledge about the hydrological cycle and, mainly, on the uses of water in daily life and the importance of its preservation (Fig. 1).

In terms of understanding the theoretical questions and formulating explanations about the surrounding environment, it is important to highlight the importance of the experiments, interspersed with the other activities.

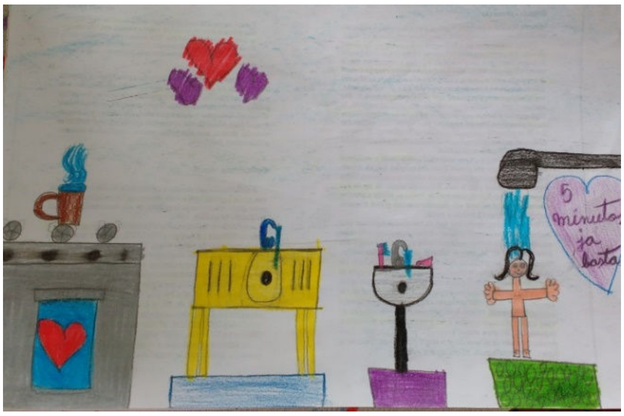

Figure 1. Illustration on "importance of water in daily life" by one of the students during the diagnostic evaluation

In the first experiment, from the terrarium (Fig. 2), during the assembly the curiosity of the students resulted in the first questions: what would happen to the water inside the terrarium? Correctly, the elaboration of logical thinking was identified by the consensual response: “water will circulate inside the terrarium because of the sun's heating”. The second question was about what would happen to the two glasses, a void inside the terrarium and another outside, filled with water. The next hypothesis was elaborated: “the water from the outside glass will dry (sun will pull) and the inside glass would fill up because the water would rise and fall”.

Figure 2. Photograph of the terrarium experiment (14/09/2017)

During the entire process of monitoring the terrarium, the hypotheses raised were realized. At the end of this experiment it was possible to diagnose that the students already understood the hydrological cycle as a closed cycle, but the observation of their general stages (evaporation, condensation and precipitation) was enriching and fundamental to proceed with the activities.

In turn, the second experiment, from the handmade pluviometer (Fig. 3), was constructed to monitor the amount of precipitated water. In this the following questions were asked: how much water would be retained in the pluviometer and how important is the amount of rain to determine the abundance or water scarcity in the community?

Figure 3. Photograph of handmande pluviometer (09/11/2017)

During the monitoring period, many rains occurred which enriched the discussion about how this would interfere with the availability of water to the community. It was concluded that, even with much precipitation in a short period of time, there was no significant increase in the availability of water resources. What happened was the momentary increase in the level of the perennial watercourses (streams and small rivers), but that quickly drained with the decrease of the rains.

The handmade pluviometer then raised questions about the availability of rainfall and the capacity of water retention for the environment. Thus, it was possible to raise a new question: what factors interfere in the capacity of retention of water in the environment?

In the search to help clarify the capacity of retention of water by the environment and the quality of the available water, experiment 3 was carried out, highlighting the importance of the preservation of natural vegetation, mainly the riparian forest. Again, curiosity startled and, by observing the simulated erosive processes on the slopes inside the pet bottles with three different scenarios: with soil covered with grasses, with soil with debris from decaying organic material and with soil completely discovered. So, it was possible to verify how much the way the soil is used impacts on the amount of water and the quality of water available in perennial courses. The conclusion was consensual that deforestation impacts the availability of water and that it is something more dramatic when it occurs in the surroundings of the watercourses, in the riparian vegetation.

All the experiments gave the participants the possibility to verify empirically several concepts already learned during the school life and also the construction of new learning by reading the dynamics of the surrounding environment. In addition, the experiments formed the basis of understandings necessary for the implementation of activities in a virtual environment.

In turn, the virtual environment accessed by technological resources made possible a greater interaction between contents and learning. Through the use of the microcomputers it was possible to provide greater meaning of the acquired knowledge (Fig. 4). Thus, the interaction between experimentation and implementation in a virtual environment was enriching and provided different reflections and conclusions from those usually made by traditional content organization.

Figure 4. Photography illustrating the workshops the Scratch software (09/11/2017)

Throughout the workshops that made use of Scratch, with an interface illustrated in Figure 5, it was necessary to reflect on the contents and the organization according to a programming logic. This logic involved the elaboration of questions and the construction of a logical path for the reading of the answers and the routing according to the correction or incorrectness. In the case of inaccuracy, return paths were created for the issue and in the case of hits, congratulations were given and it was passed on. Thus, students needed, in addition to understanding, to logically implement everything that was worked.

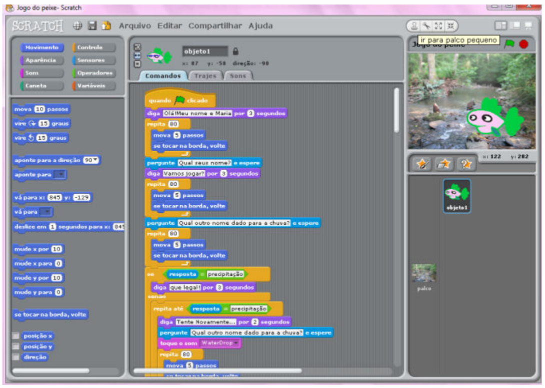

Figure 5. Final game assembled with logical commands by students in Scratch software

It is also worth mentioning that the theme worked during the project provided the students with a better understanding of the place in which the school is inserted, since the school has problems of lack of water supply and during the workshops the participants raised questions such as "if here rain, why does the lack of water occur?". In the course of the processes, these issues were clarified, being proved when we completed the entire cycle of activities.

By the end, it was possible to clarify the scarcity of water on two different scales, on a planetary scale, by the amount of water available for human consumption, and at local scale, by rainfall and man-made land use. Thus, the discourse, to which the students are familiar, of water preservation and its conscious use was justified.

The reports of the students involved in the research were collected in a panel divided into two parts, one about computer learning and another about water use, highlighting the following phrases: "I liked doing my own game"; "I learned that water is sweet and that we cannot waste"; "Do not pollute the water". It was observed that there was difficulty in expression through written language, but verbal language was verified the real contributions that remained as learning. The children spoke about water scarcity in the world and in the community, about how man can interfere with the availability of this resource, about the importance of forest preservation in riverbeds and springs, and on possibilities to contain deforestation.

Regarding the technologies used it was reported that they learned to use the notebooks and their hardware resources and how important it is to learn how to use the computer. On the programming of the game, they reported that this moment of reflection helped in the understanding of contents that still left doubts. Based on these self-report reports and the follow-up done throughout all activities, it was possible to verify how significant it was for students to participate in activities.

4 Concluding Remarks

This proposal was based on the principle that children are disseminating the knowledge they acquire about environmental issues. Therefore, in addition to reflecting on the dynamics of nature interacting with human uses influencing water availability and taking the acquired learning to life, they also help in the dissemination of practices and values related to preservation in the family and community environment.

In relation to the objectives outlined, it was possible to achieve them through the work developed. It was then possible to provide students with educational technologies and experiments a playful and empirical way of thinking about the functioning of the hydrological cycle and the issue of water scarcity at the global and local levels.

Also, this research provided the acquisition of more detailed knowledge about the place of the school and the community, as well as about the functioning of natural systems and the interaction with anthropic uses as conditions for the scarcity of natural resources.

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DIDACTIC EXPERIENCE IN TEACHING OF GEOCIENCES FOR THE PETROLEUM AND GAS ENGINEERING COURSE OF THE FEDERAL UNIVERSITY OF AMAZONAS

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Abstract— The state of Amazonas has been advancing technologically in the recent years, mainly with the advent of the oil and gas industry in the region. Due to the need of expanding new technologies with the advent of the oil industry and the growth of the labor market, the oil and gas engineering has contributed to the demand of a new professional sphere, whose training was once determined by graduate courses in higher education institutions. The major in Petroleum and Gas Engineering at the Federal University of Amazonas (UFAM) prepares professionals to act in the processes of implementation and operationalization of modern technologies in the units of the oil and gas industry. Being the geoscience disciplines the basis for the formation and exploitation of hydrocarbons it is necessary to adopt teaching strategies that instill in the students a greater interest for this area of knowledge. This study aims to apply didactic proposals in the teaching of geosciences specifically for the discipline of geological modeling of reservoirs. The purpose of this study is to improve the teaching-learning process and to stimulate students of the UFAM Petroleum and Gas Engineering major in learning the disciplines of the geosciences area. The proposed methodology involves the didactic application of conceptual maps and project-based learning, in addition to the use of free software seeking to foster the social and scientific integration of the students, thus sustaining a process of continued teaching in the technical-scientific field in the area of petroleum and gas engineering. For the elaboration and development of these didactic proposals, the following steps were followed: (1) Detailed research on the uses of didactic resources in the undergraduate for the teaching of geosciences; (2) Study on teaching-learning techniques and resources as well as possible didactic roles; (3) The basis for the development of the application of the didactic proposals. There was a positive assessment of the application of didactic practices (conceptual maps and project-based learning) by students fomenting correlations with everyday affairs, student engagement in discipline and strengthening of the teacher-student relationship.

Keywords— Teaching, Geosciences, Engineering.

Thematic line— Geosciences in Higher Education.

1 Introduction

The major in Petroleum and Gas Engineering at the Federal University of Amazonas (UFAM) prepares professionals to act in the processes of implementation and operationalization of modern technologies in the units of the oil and gas industry.

For teaching of the disciplines of Geosciences area (Petroleum Geology, Petroleum Geophysics, Geological modeling, rock mechanics and introduction to analysis of basins) the Oil and Gas Engineering major does not have specific teaching laboratories. Therefore, the teaching of these disciplines end up being very theoretical making the learning process slow and tiring.

The elaboration of didactic changes in the application of the contents of the disciplines of the geosciences area for the Petroleum and Gas Engineering major of the Federal University of Amazonas would evidence in a better understanding and learning that it is of paramount importance to the foundation of such course-specific disciplines.

According to Compiani (2006) in the teaching of geosciences, the reign of verbal thought hinders meaningful learning insomuch as the written language does not account for the complexity of the representations of the explanations in geosciences. In general, the courses in Petroleum Engineering have trained professionals to act in the processes of implementation and operation of modern technologies in the units of the oil and gas industry. Hence, for the best performance of the students in the course it is necessary the use of teaching methodologies that enable the use of technological tools. For example, the use of free and/or commercial software, conceptual maps, among others, which would thus provide a more effective involvement in the formation of these students.

According to Biggs (1999), effective teaching requires that we eliminate the aspects of our teaching that encourage the superficial approaches to learning, and that we prepare an appropriate internship so that students can use more readily deep approaches to learn. This involves students agreeing that the appropriate task's involvement is a good and repellent idea (also known as "motivation") and establishes the kind of climate that will optimize the appropriate interactions with these students. An important aspect for effective teaching is reflective practice, using transforming reflection, which allows teachers to create an improved teaching environment, suitable for their own context.

The objective of this study is to apply didactic proposals in the teaching of geosciences specifically for the discipline of Geological Modeling of Reservoirs. The purpose of this study is to improve the teaching-learning process and to stimulate students of the Petroleum and Gas Engineering major at UFAM in learning the disciplines of the geosciences area.

2 Materials and Methods

For the development of this study the following digital features were used: Google classroom and the free Software SGeMS.

UFAM has a registered code with Google Classroom, and this was a facilitator for the opening of the class in this environment. The students and the participating teachers were inserted into the geological modeling class from their e-mails.

SGeMS software is a free interface where you can manipulate wells, reservoirs, and geophysics data for geological modeling purposes. This is an easy-to-use software that offers a wide range of geostatistics tools. The facility to use SGeMS comes mainly from its non-invasive graphical user interface and the ability to directly view data sets and results in a full 3-D interactive environment.

The didactic methods applied were the construction of conceptual maps following the definitions of conceptual maps proposed by Ausubel (1978) and Project-based Learning (PBL), which is a teaching-learning, Collaborative, Constructivist and contextualized methodology where situations-problems are used to initiate, direct and motivate the learning of concepts, theories and the development of skills and attitudes in the context of the classroom (Savin-Baden 2000).

The study was developed at the Federal University of Amazonas, Faculty of Technology, Petroleum and Gas Engineering course. The bibliographic research was a fundamental part of this study, and with this research the shortage of reports of educational research about the teaching of geosciences in the undergraduate degrees was evidenced. Today, the consolidation of geosciences as one of the most important branches of scientific knowledge is undeniable, especially for the understanding of the functioning of the Earth System (Mayer 1991; Frodeman 2000). The development of geoscientific dissemination materials and didactic resources suitable for a specific target audience can collaborate with the insertion of geoscience-related themes in different segments of the teaching and in the individuals' own daily life.

The necessary initial formulation for the elaboration and development of these didactic proposals complied with the following steps:

(1) Detailed research on the uses of didactic resources in the undergraduate for the teaching of geosciences;

(2) Study on teaching-learning techniques and resources and possible didactic roles;

(3) The basis for the development of the application of the didactic proposals.

The methodological procedure initially consisted in the investigation of the difficulties that the students presented in the geological modeling of reservoirs. In this first phase, it was necessary to contact the teacher of the discipline and evaluate the difficulties through questionnaire or interview. After the first stage, the introduction of the didactic proposals for classroom application was initiated, starting with the application of the conceptual maps that are of great importance to the understanding of the concepts used in this discipline.

Following the definitions of conceptual maps proposed by Ausubel (1968), the subsequent steps were prepared for their construction:

1) Take down the main terms or concepts about the topic to be studied in the disciplines of geological modeling.
2) Identify the most general concepts, intermediaries and specifics.
3) Start building the concept map:
   - The concepts are circumvented with a circle (or other shape: oval, rectangular)
   - Find the most general concept at the top
   - Put the intermediate concepts below the general and the specifics below the intermediary.
4) Draw the link lines between the concepts
5) Allocate in the link lines the link words to indicate how the concepts are related – propositions
6) Revise the map.

For each covered topic in the discipline of geological modeling of reservoirs the application of conceptual maps in order to maximize learning by the students was adopted.

Since the concepts were understood by the students, to corroborate even more with their fixation, the use of free software SGeMS started. Its use was for the application of the project-based learning technique.

The application of the PBL divided the class into groups consisting of a maximum of four students.

The proposed project was divided into oriented studies. The topics were:

(a) Presenting and discussing the main geological models to be obtained by using the SGeMS software based on the data provided by the teacher;

(b) Develop a plan for the development of the project;

(c) Discuss the plans developed for the development of the geological model;

(d) Choose the geological model that is suitable for the location of the layers that may contain accumulation of hydrocarbons, defining its porosity and permeability.

On an established date, each group presented a preview of the project, where the whole class evaluates and gives suggestions for the continuation of this. The evaluation was done by the teacher and monitor at the end of each final presentation. Evaluation of the Lickert type was applied in three dimensions: breadth of geosciences knowledge, autonomy/leadership/ competences/ communication, and development/stimulus/work in oriented group. In addition to the didactic proposals presented, the other activities developed were: (i) Resolution of exercises in the classroom with the use of the conceptual maps by students and (ii) evaluation exercises on the understanding of certain topics of Discipline. The final project from the use of the ABP was used as a final note.

With the application of the didactic proposals, contribution to the process of teaching-learning in the course of Petroleum and Gas Engineering of UFAM in the discipline of geological modeling of reservoirs is expected. The results obtained were analyzed according to an evaluation questionnaire for the discipline at the end of the semester. For each question in the questionnaire a simple graphic in Excel was generated, where we will have the percentage performance index for the use of the didactic proposals of this study.

From the development of the application of the proposals, it is intended as a result to have greater integration of the students with the teachers of the disciplines in order to enable a better learning not only in the classroom, thus verifying the applicability in the absorption of acquired knowledge in the discipline of geological modeling of reservoirs. The involvement of teachers of the UFAM Petroleum and Gas Engineering major in the use of didactic proposals facilitates the process of teaching and learning in other disciplines outside the area of geosciences since the Petroleum Engineering Department of UFAM is made up of alumni (engineers and geologists), hence supplying the lack of didactic-pedagogical training.

The strategy of the production and presentation of the didactic proposals made possible the dynamism of the classes that, in general, would present a theoretical body, which was sometimes quite complex. Proposing such a strategy was aimed at reviewing the concepts on the students' part (since they already had such content in previous years).

The conceptual maps built by the students were analyzed quantitatively and, as an additional purpose, we aim to evaluate the students ' opinion about the potential of this instrument to facilitate learning and, in particular, their contribution to the written expression, the difficulties perceived in the construction of its diagrams, the advantages and disadvantages of its use.

3 Conclusion

With the use of the didactic techniques presented in the geological modeling of reservoirs the students agreed that the use of conceptual maps was of utmost importance for the learning of the concepts focused on this discipline.

According to the result of the graphic analysis, the production of the conceptual maps by the students facilitated the understanding of the concepts applied in the discipline of geological modeling of reservoirs.

The use of the project-based Learning technique (PBL) demands higher academic research, favors the student's training for the labor market and the critical analysis of literature in geosciences.

The students agreed that PBL encourages all students to bring ideas, skills and suggestions to the project, and that there has been an improvement in oral expression and concepts worked in group discussions and presentations during the development of this Proposal.

However, the students pointed out that the project undermines the income in the other disciplines of the semester, because the course of Petroleum and Gas Engineering of UFAM comes from the model of course with high hourly load and the mandatory presence in the classroom. It is believed that the PBL can be discussed and implemented in the course as a whole.

Overall there was a positive assessment of the application of didactic practices (conceptual maps and project-based learning) by students fomenting correlations with everyday affairs, student engagement in the discipline and strengthening of Teacher-student relationship. The student felt in the discipline with the role of "builder" of the same having a greater participation in the activities proposed.

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EARTH SYSTEM SCIENCE, AN APPROACH TO UNDERSTANDING THE PLANET: SKILLS AND TOOLS AT SÃO PAULO STATE CURRICULUM

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Abstract— *Geology is considered by several authors to be a historical and interpretative science of nature. Seeking to understand nature's systems and processes, it becomes an interesting starting point for trying to develop some types of integrative reasoning, (including a systemic and complex) when trying to understand the planet as unique system. Following a trend that has occurred in different countries in recent decades, the Brazilian Curriculum has undergone different reforms and currently follows the Law of Education from 1996 (LDB) and the National Orientation Curriculum from 1997 (BNCC). São Paulo State Curriculum (CESP), which is based on skills and abilities (tools), has also been adopted since 2009 in state-run schools. This paper evaluates skills and tools on the geology contents studied in the geography discipline, trying to verify if those are developed during high school when teachers use learning situations contained in the material called "(exercises) student notebook". This educational resource helps to develop a systemic thinking and a global sense of planet. This notion and reasoning are important because they help to create a citizen with planetary consciousness in relation to itself and the planet where we all live.*

Keywords—Teaching of Geosciences, geology, curriculum, basic education, skills, tools.

Thematic line— Geosciences and Natural Sciences for basic education.

1 Introduction

This paper analyses the prescriptive curriculum used at schools in the state of São Paulo. We seek to identify the skills and tools (abilities) that contribute to the cognitive development of a systemic notion of the planet, existent in the geography discipline, particularly in geology (which is not a curricular component).

The state of São Paulo is one of the largest producers of minerals of the Brazil. Mineral exploration is concentrated in sand, stones and water (from groundwater) for the domestic market. Agricultural production is also significant and it is subject, in several regions, to accelerated erosion with economic implications. Urban areas issues related to water management and supply, solid waste management, floods and landslides already suggests that curriculum policy does not help prepare students, citizens and future professionals for the economic and environmental challenges.

From its formation to the present day, the planet in which we live was the stage of successive modifications throughout Earth history. These changes have occurred due to processes involving energy and matter exchanges, internal to the planet, or the relation between the Earth and the rest of the Solar System. During these changes, in addition to the records of these processes present in the rocks, a singular occurrence took place on this planet: the emergence and evolution of life. During life's evolution, many species have developed or disappeared, however, among so many living beings, humankind has built a very peculiar relationship with the use, alteration and understanding of nature and the planet. The interaction between living beings and Earth also changes the configuration (of the atmosphere, hydrosphere and lithosphere) on the planet itself.

According to Morin (2006), the human being is not only biological, but also psychic and social. The societies have improved their perception and understanding of the natural environment and knowledge has been accumulated and transferred between between generations in varied ways. Our society in the XXIth century, has accumulated knowledge in a way that it´s appropriately recognized and called Science. The subjects of different studies were appearing and the research becoming more specific due to the division of knowledge in different areas and the creation of disciplines. The school then appears as place to propagate this scientific knowledge, where as the academic space is more suitable for new perceptions, discoveries and application of the knowledge developed and accumulated by the humankind over the years. We can not forget that both transferred knowledge (at school) and developed knowledge (at universities) are divided and limited by disciplines. "The disciplinary development of the sciences not only has brought the advantages of the division of work, but also the disadvantages of super-specialization, confinement and shattering of knowledge, thus producing knowledge and elucidation as well as ignorance and blindness." (Morin 2017).

In this context, Edgar Morin – French philosopher who writes books about human knowledge – denounces the necessity for a new way of thinking, another kind of interation between sciences and their transference of knowledge to the new generation. This way the citizens (as well as future professionals and scientists) can learn about themselves and nature under a new conception, one of "well done head" (Morin 2017). This term suggests that the knowledge transferred by education "can not transmit a mere knowledge, but a culture to understand the human condition and help us live, at the same time fostering an open and free way of thinking". Thus "education contribute to its own formation and teaches people how to become a citizen" (Morin 2017).

Historical and systemic sciences such as ecology, geology, cosmology and paleontology were strengthened by questions related to the use of natural resources, climate change and environmental problems among other reasons, therefore showing the necessity to integrating the different areas of knowledge so as to obtain the understanding that could solve new challenges presented in today's society.

Some authors acknowledge that the historical sciences can help to develop some less common or obvious types of reasoning in the experimental sciences (physics, chemistry, and others), and as opposed to different historical sciences, geology comes differently to authors, as it is an area that allows development of reasonings that integrate the different parts (spheres, subsystems, disciplines) of the formation of a specific construct due to the relations established between the different parts of a whole

The recognition of the importance to the scientific and academic communities acquired by the geosciences (reason of this Conference and Symposium) of forming an integrator thinking brought a new mindset, one of perceiving and using the nature. This work, based on "first idea key" of Predrinaci et al (2013): "the Earth is a complex system interacting rocks, water, air and life" will be the main reference in the literature so as to emphasize development of a global and integrated vision of the planet. As a complementary reference the texts: "The ten reasons for the inclusion of geology in basic education" (Carneiro 2004) and "Geoscience education: an overview (King 2009)" also suggest the reasons and ways for teaching geological contents.

This paper, based as well on the formation for a "citizen's learning" (Morin 2017), will be bring about the analysis of the skills and tools to be developed when treating geology content in the curriculum of São Paulo's (Brazil) state run high schools. The intention is not only to verify if there are geology contents on the curriculum but also to verify if skills and tools of "Situations Learnig" of "Student Nootbook" help to construct an integrative thinking and provide conditions for the citizens – through the scholar learning process in order to enable the development of a systemic or complex reasoning, necessary for understanding the planet and to build a differentiated relation with nature and occupation of space.

2 The importance of geology for the citizenship

Geology is a field of knowledge present since the works of Georg Agricola (1494-1555), Nicolaus Steno (1638-1686), James Hutton (1726-1797) and Charles Lyell (1797-1875); the term Geology has the following meanings: (from the Greek γη- ge-, "the earth") and λογος (logos, "word", "reason") (Piranha 2006). In our society it is currently considered as a science and it was defined by Potapova (1968) as a "historical science of nature" which tries to develop a better understanding of materials, processes and products of the evolution of planet Earth in its multiple relations.

In addition to the historical reasoning already described by Potapova in his article, Frodeman (1995) demonstrated the hermetic character of geology on account of being also an interpretative science. These reasonings have a high potential of being developed when subjects related to the natural processes existent in the different spheres (and in between) are studied on the planet. Gray (2014) suggests in his paper that geology teaching must be given greater importance, since this science can be an important tool to development of a historical reasoning. According to Gray (2014), geology, compared with experimental sciences, would be one of the most appropriate fields that can be used to develop certain types of reasoning. However, as the development of science itself occurred due to methodologies developed by experimental studies, geology and its teachings were eventually devalued and therefore not incorporated in the most countries' scholar curriculum.

The systemic and global view of the planet together with the historical and hermeutic reasoning leads to geology being as integrated study of the Earth: "the Earth is not the a physical planet, a biosphere or the mankind, the Earth is a complex totality physical-biological-antropolygic, where life is an emergency of Earth's history, and man, an emergency of terrestrial life" (Morin 2017).

After the discovery of the tectonic plates (1960's years) Earth Sciences perceive our planet as a complex system that produces itself and self-organize. The Earth Sciences (with ecology and cosmology) "presents a kind of knowledge that organizes a knowledge previously dispersed by raising on different areas." (Morin 2017).

In some countries geology or geosciences teaching takes part in the national curriculum for K12 like a discipline, but there are articles in the literature reporting that even with the existence of the discipline this knowledge has not been effectively incorporated yet. Pedrinaci et al. (2013) comment in their paper on the lack of a global perspective on terrestrial dynamics when they present "ten key ideas" for the construction of literacy about Earth Sciences.

Compiani (2005) is emphatic in mentioning that:

> "geology is a way of living, of seeing the world, of explaining the world. If we believe that, on democratic society, subjects are more active and transforming according to their baggage in the broadest sense, as depriving these citizens of a fundamental knowledge for the 'literacy of nature'".

Carneiro et al. (2004) think that geology is a

> "science with an integrative perspective of scientific knowledge of nature, which helps to form of citizens as it provides the development of different qualifications and skills (academically). It makes the person feels like an individual integrated, dependent and transforming agent of the environment, identifying its elements and interactions between them".

Geosciences (King 1999) integrates

> "the different spheres of the planet in which matter is organized and all forms of energy generate processes as matter and energy are exchanged." "The concept of the Earth as a system, comprising many subsystems and itself being a subsystem of a larger one … is a concept that can be the theme of science curricula worldwide … It can replace the current disciplinary ap-

> proaches … with a conceptual approach that honours the important conceptual contributions of all sciences." (Mayer & Kumano apud King 1999).

Thus, the Earth Sciences education has stood out as a strong promoter of the integration of knowledge, since it allows to treat planetary matter in its complex organization, constituting resources capable of mobilizing different cognitive components of the learner (Piranha et al. 2009)

Anguita (1996) emphasizes that theses definitions (Geology, Earth Sciences, Geosciences) are not necessarily synonymous due to the epistemological / historical differences in the origins of these sciences / disciplines, although they have coincident fields of study. In this article we have taken an interested in the understanding of natural processes (of matter and energy exchange), in the interrelations between spheres and in the conception of the Planet as a system whole, the terms above will be treated as synonyms.

3 São Paulo State Curriculum: skills and tools

In 2008, the State Department of Education of São Paulo proposed a curriculum for the schools of the state network at the levels of Elementary School (K8) and High School (K12). According to Gimeno Sacristán (2008) this type of material is entitled as "prescribed curriculum".

"The curriculum is a document created to support the teacher's work at states schools and to contribute to the improvement of the quality of student learning ... It presents the guiding principles for a school capable of promoting the skills necessary to face the social, cultural and professional challenges of the contemporâne the world". (São Paulo 2009).

The Curriculum is complemented with some documents made for teachers and students: Teacher's and Student's Notebooks, respectively. This material is organized by discipline, years and bimester. These documents constitute the planned curriculum which can assist the implementation of the "prescribed curriculum" (Gimeno Sacristan 2008). In this material are presented learning situations to guide the work of the teacher in teaching specific disciplinary contents and the students' learning. In the student's notebook are suggested four learning situations which would develop skills and tools during the activities and suggested didact exercises.

According to the own state's curriculum, "personal development is a process of enhancing the capacities to act, think and act on the world. Education must serve this personal development, so that it builds, in a cooperative and supportive way, a synthesis of the knowledge produced by humankind. Such a synthesis is one of the conditions for the individual to access the knowledge necessary for the exercise of citizenship in a global dimension" (São Paulo 2009). A curriculum based on skills is committed to articulating school disciplines and activities with what students are expected to learn from over the years, because the curriculum commits itself to training children and young people to become adults prepared for responsibilities (work, family, autonomy, etc.) and to act on a society that depends on them. (São Paulo, 2009)

In fact, a curriculum referenced on competencies assumes that the challenge of promoting the knowledge in each subject is connected to the student's skills and tools. Because of these, the student will be able to make acritical reading of the world, questioning it in order to better understand it, inferring questions and sharing ideas, without, however, ignoring the complexity of our time (São Paulo 2009). "Skills, in this sense, characterize ways of being, of reasoning and of interacting, that can be deduced from actions and decision-making in contexts of problems, tasks or activities". (São Paulo 2009).

The information described above was taken from the official State Curriculum and resume a general notion about the school's function, curriculum and competencies (skills) in relation to the student. (Gimeno Sacristan 2008). Perrenaud (2015) thinks too the skills refer to the action and they are, in some way, a promisse of performance and their development occurs in a context that can be called learning situations / "problem situations". In a simple way as the skills refer to integrative actions on the resolution of problem situations, certain skills are needed and they are classified as internal and necessary for the individual resources. When we deal with skills and tools, many conceptual confusions occur and were described by Perrenaud (2015). The author also remembers that some of the conceptual problems concerning these terms occur because they are words used informally in people's daily lives, at the workplace and organizations, as well as problems due to the translation of books and papers that deal with business and teaching subjects. Despite this inconvenience, many countries in America and Europe use a curriculum based about skills and tools. Under threat of being considered as late or at the margin of trends, Brazil, as well as the state of São Paulo, adopted a disciplinary curriculum based on the development of skills and tools on the curricular reforms after 1990s enforced in the Laws Basic Guidelines (LBD), the National Curriculum Parameters (NCP) and more recently (2009) in the Curriculum of state of São Paulo (CESP).

4 Data analysis

This paper is the beginning research that seeks to analyse the prescribed and planned curriculum in the state of São Paulo. The reference will be knowledge related to geosciences. In this article we will verify if the planned curriculum, through the so-called "Learning Situations" on the material: "student notebook" used in the schools in the state of São Paulo, creates conditions for the skills and tools, described in the curriculum, to be developed. However, the research is interested in skills and tools related to the development of a systemic (or even complex) notion of the planet. Contents of the geography discipline that are strongly related to the natural processes involving material and energy exchanges have been chosen to be a part of the curriculum. These contents related to the geosciences due to their geological character could help the development of an integrative notion (systemic or even complex) for the students and due to its importance, results in a new way of seeing and relating to the world for a new citizen in formation through the educational process. The content and skills worked at high schools in the state of São Paulo can be found fully on São Paulo 2009.

In Brasil the students attend three years (courses) of high school, each year being four bimesters long. It was verified that contents related to geology / geosciences are presented to the students during three bimesters (there are 12 at total), in the case on 3th and 4th bimester on the first year and 4th bimester and on the second year. There are no contents related to geosciences on the last (third) year of the high school. The (geology) contents selected, year, bimester which are part of the prescribed curriculum is showed in the Table 01

Below are the “Learning Situations” in the student's notebook as well as the skills and abilities to be developed (Table 02, 03, 04).

The student's notebook and the learning situations in it are part of the planned curriculum, where it is sought to create ways to assist in the implementation of the prescribed curriculum. They are provided for four learning situations for each bimester, each learning situation regarding the specific content used to develop the skills and tools. Some skills and tools are very specific in relation to content while others are more general, and some of these skills may occur more than one learning situation, but they are applied to different contents. The set of all skills and tools related to learning situations and their contents can be consulted in São Paulo (2009). These learning situations and their contents, as well as skills ad tools have been selected because they can be related to the development of a systemic notion of planet Earth aiming at the formation of a more critical citizen, as mentioned previously.

Table 1. High school geological contents by year and semester. (modified of São Paulo 2009)

High school geological contents		
1st year 3th bimester	1st year 4th bimester	2nd 4th bimester
Nature and environmental risks Structures and forms of planet Earth. - The earthly relief Internal agents: the movements of the crust. - External agents: weather and weathering. Risks of catastrophes in the unequal world. - Risk prevention	Globalization and emergency enviroment The terrestrial biomes. - Climate and vegetation cover The new scale of environmental impacts International treaties on the environment.	Natural resources and land management South American tectonic plate and the modeling of the Brazilian relief Morphoclimatic domains and river basins. Public management of natural resources.

On the sequence will be presented the “Learning Situations” (LS) and detailing of the studied contents on the first year, 3rd bimester

Learning Situation 1 - Structures and forms of the planet Earth: the movements and the time at the transformations of the structures of the Earth.

Learning Situation 2 - Structures and forms of the planet Earth: the movements of the earth's crust.

Learning Situation 3 - Structures and forms of the planet Earth: the production of the forms of the terrestrial surface.

Learning Situation 4 - Risks on unequal world: natural disasters and prevention - a geographic space construction.

On the table 2 are the skills and tools selected and worked to each Learning Situations (LS)

Table 2. Selected skills and tools and their learning situations

Skills and tools (1st year, 3rd bimester)	LS
To select, to organize, to relate and to interpret information represented in complex tables to apprehend the natural processes that structure the planetary surface	1
To construct and apply skills related to the domain of cartographic language as a means of synthetic visualization of the relation between distinct natural geographic realities.	2,3
To interpret data and information to make decisions and deal with problem situations, such as the prevention of natural risk situations	3,4
Working reflections on the apprehension of nature as a way of building human space	4

On the sequence, Situations of Learning and the detailing of the studied contents on the first year, 4th bimester

Learning Situation 5 - The link between climate and vegetation and environment.

Learning situation 6 - The distribution of plant formations and the issue of biodiversity.

Learning Situation 7 - Variations in the geographic scale of environmental impacts.

Learning Situation 8 - The defense of sensitive points of the environment: the treaties on climate and biodiversity.

On the Table 3 are the skills and tools selected and worked to each Learning Situations (LS).

On the sequence, Situations Learning and the detailing of the studied contents on the second year, 4th bimester

Learning Situation 5 - Plate tectonics and Brazilian relief.

Learning Situation 6 - The forms of Brazilian relief and the functions of classifications.

Learning Situation 7 - Water in Brazil: management and interventions.

Learning Situation 8 - Management of natural resources and the "state of the art" in Brazil.

Table 3. Skills and tools selected and its learning situation (modified of São Paulo 2009)

Skills and tools (1st year, 4th bimester)	LS
Identify and describe phenomena whose dynamics are controlled by factors (simple) or by multiple and related factors (complex)	5
Compare different realities of natural domains in their relationship as the greater or lesser condition to support plant life and biodiversity	5,6
Associate climatic situations of the present and the past to the conditions of the natural domains, as well as of the biosphere, in diverse geographic scales and of the contemporary surroundings of the planet	5,7
Understanding the complex integration of the scales of natural phenomena with humans	8

On the table 4 are the skills and tools selected and worked to each Learning Situations (LS)

Table 4. Skills and tools selected and its learning situation (modified of São Paulo 2009)

Skills and tools (2nd year, 4th bimester)	LS
To group the different processes of dynamic constitution of the natural realities in the terrestrial surface according to its genesis and the theoretical models that try to describe it	5
To construct and apply concepts of physical geography, more specifically associated with geomorphology, as a means of constructing an analytical and dynamic view on the forms of relief on Brazil	6
To relate the new knowledge built on the natural dynamics as the transformations that have been occurring in the relationship of the human being with nature	7,8

5 Findings

The official text in the curriculum of São Paulo State demonstrates that one of the objectives of teaching is the formation of a culture and knowledge that prepares the students for their lives, even after finished basic education. The prescribed curriculum also indicates the concern about managing to articulate students' competences and disciplinary contents in order to be able to train them as citizen.

Morin (2017) agrees that education must form to citizenship (like at the curriculum studied) too and geology is a source that assists in the development of integrative reasoning, which contributes to sytemic and complex thinking. This kinds of reasoning and thinking can be developed when we try to study nature from a geological perspective as reported in the texts of Carneiro (2004), King (2008) and Pedrinaci et al (2013) and others.

In the curriculum used in the state of São Paulo, we find a reasonable amount of geological contents and skills and tools for development this reasoning. This way the precrisbed curriculum would have conditions to provide an integrative rationale, so useful and desired at the citizen formation but this does not happen when the planned curriculum is analyzed thought learning situations and its skills and tools are analyzed, because of these reasons:

There is separation between humanity and nature:

On the learning situations regarding “Nature and environment risks” contents show nature and its processes as obstacles to be overcome.

On the the learning situations regarding “Globalization an emergency environment” the nature appears as victim of capitalist industrial society and the planet and environment must be saved by the mankind.

On the the learning situations regarding “Natural resources and land management” natural processes are not discussed, the focus is extremely classificatory and utilitarian to about relief, hidrography and natural resources existents in Brazil.

These cases they not follow Pedrinaci’s “key idea 1” and consequently not integrate the human beings to nature, also countering Morin's suggestions for a citizen with “a well-made head” and “planetary consciousness”.

There are other skills and tools on the Learning Situations:

The curriculum suggests that all contents, skills and tools must be taught, but it does not always ocurr. Teachers can emphasize more general skills. This way the students will not use the skills and tools selected at this paper and by consequence will not learn how to relate different spheres, systems and natural processes of Earth.

Lack of global notion and time of processes in relation to geological time. The content geological time hardly is revised or usually related to natural processes which hinders an integrative view of any natural process.

The skills and tolls: Understanding the complex integration of the scales of natural phenomena with humans would be ideal to develop integrative thinking. If the teacher works on this skills, it could even try to correct the misconceptions concerning the separation of man and nature from previous learning situations, but there is a great chance that these skills will not be seen by the students. This is because this lesson is the last Learning Situation (number 8), from the 4th bimester of the 1st year. If the teacher has fulfilled the program almost completely, the last weeks of classes are destined for the final tests and extra activities for students with low grades. Thus, complex skills and the those of the last learning situation are normally not explored by the teachers of any discipline in their classes as they approach the end of the school year

The same occurs with the skill “to relate the new knonwledge built on the natural dynamics as the transformations that have been occurring in the relationship of the human being with nature”, planned for the end of the 2nd year.

6 Final considerations

This paper presents a preliminary survey on the content of geology in the curriculum, thus were selected contents, skills and tools that will serve as a starting point for the rest masters' research project.

The analysis shows that despite the existence of contents of geology in the prescribed and planned curriculum, the skills and tools used on the learning situations are insuficient to develop systemic and integrated thinking.

This way, however detailed the information contained on the preecribed and planned curriculum may be, the teachers still need to be careful by applying the suggested exercises so that the objectives of the own curriculum can be achieved.

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GEOLOGY AND MONEY: TEACHING ACTIVITIES IN GEOSCIENCES USING COINS AND PAPER MONEY

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Abstract — This article proposes a reflection on the didactic potential of coins and paper money for Geoscience teaching activities. The practical utility of these materials as didactic resources and scientific diffusion in formal and non-formal environments is discussed. The authors have started with a collection of coins and old banknotes – the personal collection of the first author – and developed a subsequent internet research. The analyzed material allowed to reveal historical-cultural aspects and to identify some money emissions in different countries that have addressed geoscientific themes. The study allows to suggest the use of this material as didactic pedagogical resource as well as a way for sensitizing people about the importance of Geosciences in the social and economic development of a nation. Multidisciplinary and cross-cutting approaches are recommended in terms of the use of money as a starting point for developing scientific concepts.

Keywords— Teaching-learning, money, coins, didactic activities, Geology, Geosciences.

Thematic line— Geosciences and Natural Sciences for Basic Education.

1 Introduction

Geology has fascinated human societies along time either by the curiosity to understand the mechanisms and forces that work in the interior of the planet, and by the discovery and use of terrestrial mineral resources that promote human development and generate social being. Paradoxically, if Geosciences is one of the most applied sciences in people's daily lives, it is also one of the sciences with the lowest scientific understanding in both the formal teaching environment and the general public (Cervato & Frodeman 2012).

Sciences such as Physics, Chemistry and Biology show more consistency, not only on teaching practices and methodology within formal education at any levels of the Brazilian education system (Brasil 2007), but also on research about teaching-learning practices, both in formal and non-formal education.

On the opposite side, there is a large gap on the educational research and practices on Geosciences as a descriptive and historical science (Cervato & Frodeman 2012). Some propositions in formal education take advantage of the "classical" disciplines (Chemistry, Geography) for developing critical, reflexive and experimental understanding of the terrestrial phenomena. Cross-disciplinary approaches between Geosciences-related disciplines such as Chemistry/Mineralogy; Biology/ Paleontology are rare in formal education at all grades. Scarce teaching practices pay attention to Social Sciences such History, as an example. Geoscientists should develop and propose effective methodologies using the geoscientific knowledge, to face the challenge of improving and disseminating Geosciences in formal education.

Cross-cutting approaches may be a good alternative for achieving these results. Both formal and non-formal education environments require innovative teaching-learning practices, adapted to the social-cultural context and with a broad capillarization and self-identification of the elementary essential concepts related to the history and evolution of the planet. Geosciences may be a social property that empowers individuals and communities to develop full citizenship, with socio-environmental dignity and capable of building new social and human values that lead to a perspective of development sustainable integrated development that can help addressing present-day socio-environmental crisis.

Considered those philosophical premises, developing methods and practices that allow effectiveness in teaching-learning strategies are necessary, especially those that are more accessible and applicable.

This article presents a few activities and discusses the didactic potential of stamped images in coins and paper money as a practical tool for teaching- learning and dissemination of Geosciences.

2 Objectives and Methodology

The main objective of this paper is to present and discuss the importance of money in society and the potential of didactic activities using paper money and coins. They are not only a historical source, a characteristic that stimulates didactic work, but they can be valued by three factors: (a) the daily use we make of them, (b) paper money and coins are extremely accessible, (c) they can be easily found in the pocket of us all.

The first author's personal collection was the preliminary material, covering around 100 samples distributed among 50 coins and 50 paper money from 10 countries visited. A complementary search in virtual catalogs on Internet increased the collection, which encompassed 150 samples related to Geosciences themes.

3 Origin of money: a brief historical context

In the remarkable evolution of human societies, an important event, known as the Metal Age, marks the end of the Neolithic Period. When manufacturing of metals became prevalent, the Stone Age ended (Fig. 1). Many metallic items allowed a great advancement of human societies with the construction of working tools and defense weapons, exactly when cities have growed all over the world. The food exchanges have been intensified and the increasing population in the cities demanded larger volume of products, initially by simple exchange or bargain.

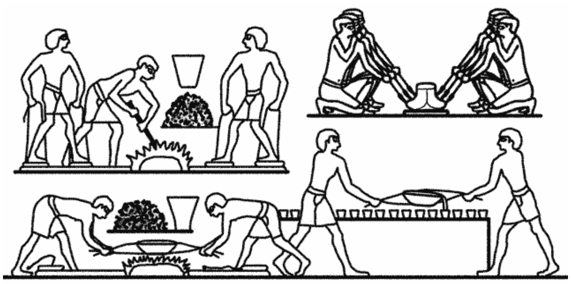

Figure 1. Egyptian mural illustrating stages of copper smelting

Although trading goods were formerly in a natural state, it was difficult not to have a common measure or equivalence between different products, besides the practical difficulties in transportation and storage of materials. Some goods have more acceptance than others, just expanding the search for them. This develops a gain in exchange relations, thus increasing their specific value. As an example, cattle or sea salt (a potent food preservative in ancient times, inaccessible in the interior portion of continents) acquire high commercial value. Over time, the goods become inconvenient to commercial transactions, either by the oscillation of their order, or because there is no way to fraction them and do not allow above all their accumulation and safekeeping.

With the development of metallurgical techniques and the knowledge of the intrinsic value of metals, it was natural to attribute to these materials relative values and mainly to satisfy the needs of production, storage and transport, solving a series of historical inconveniences related to exchange of goods and services.

Reports from the father of history, Herodotus, record that around the 7th century BC, in the region of Lydia (present-day Turkey) the first prototypes of coins have appeared, initially small ingots of a gold and silver alloy called *electro* (Fig. 2).

These pieces were coined using the metallurgical techniques in use and received cold prints with inscriptions that guaranteed a defined weight and value. The coins initially represented symbols and effigies of leaders of the societies from which they emerged in order to guarantee authenticity and reliability.

From this point on, history tells us a rapid expansion of this form of trading with the use of money, and even today money has symbolized the mentality of a people and its age. Simple imprints tell us something about political, economic, technological and cultural aspects. By means of the mere print of coins, History portrays important deeds of a nation, and therefore money carries out greater values than their absolute exchange value, as it was in the beginning.

Figure 2. First coins minted in Greece with representation of pictorial figures of the time

Paper money, by its turn, appears in China by the year 618 d.C (Fig. 3) as a practical solution to traders who could transport considerable amounts for long journeys and at considerable distances. Previous Chinese inventions such as paper itself and ink have contributed greatly to the emergence of paper money in China. This experienced a territorial expansion around the 10th century during the Song Dynasty, when a cut in copper supply caused paper currency to replace the national currencies.

In Western Europe, only in the middle ages did paper money appear in trade relations as the result of paper receipts supplied by the goldsmiths who at the time issued them as a guarantee of gold and silver transactions. Over time these receipts circulated from hand to hand conferring value similar to paper money. Although in the contemporary world the very extinction of physical money (whether currency or paper money) is discussed, throughout the world a commercial relationship has been monetary-based on the last centuries. The History of money is confused with the History of human societies. For these reasons money represents an important iconographic record of the political, economic and cultural evolution of nations trough the time.

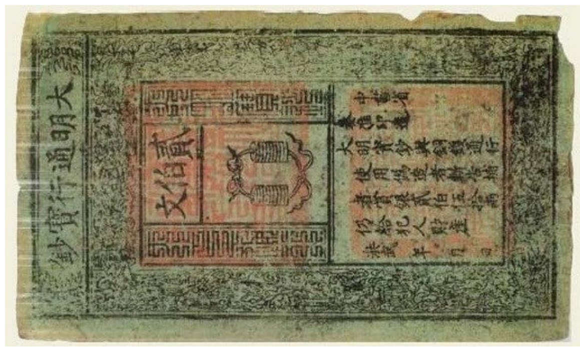

Figure 3. View of first paper money issued in China around 1.4 DC

2.1 Numismatics as a source of research and teaching: potential skills

The practice of collecting is born with the human ability to aggregate objects and to organize them within a logical and systematics. During the scientific revolution of the nineteenth century, commercial and scientific agents of the time witnessed a real fever of collectivism, especially by the expanding bourgeoisie that had access to the most diverse natural and cultural items, creating the most diverse and exotic collections.

In this environment, for example, the first systematic collections emerge and later incorporated into the collections of large museums and institutions that continue to this day. Around the first years of the nineteenth century, large collections began to form the science of numismatics (from the Latin *numisma* = currency), which proposes to collect and study historical, artistic, economic and productive aspects of coins, paper money and medals in general. Like the flag and the anthem, money is a symbol of national identity. It is possible to represent the power and integrity of a nation by pictures, as effigies of leaders, coats and arms of the states. The set of representations of nationality stamped on money is very rich and deserves investigation because they illuminate personalities from the political, economic, social and intellectual life of a country, as: generals, kings, nobles, doctors, scientists, composers, writers, poets, artists and popular people. Using different graphic project and at different historical time, they compose a gallery of characters that come to be identified as a "nation representation". Other elements may be incorporated as nationality marks, as the exuberant and unique as the endemic animals and plants, cultural productions, architectural artworks that "tell" more about the history of a nation.

Although renegated as national themes, there is a large potential for landscapes, geological and archaeological monuments to be represented in paper money and coins, especially in Brazil with its big dimension and astonishing bio-geodiversity. All the iconography represented in money deserves a careful and critical look. This is perhaps the best way to turn the money into a historical document with effective potential for educative purposes and useful by teachers and students.

It is notorious the importance, still today, that this iconographic material has documental historical value and constitutes an important means of communicating the values of a certain society (Castro et al. 2002).

Natural monuments and landscapes create identity and national belonging, promoting mass tourism for example, many times explored by the audiovisual media (movies and television) nowadays. The thematic of paper money and coins has shown great progress in the last decades, especially in the economically advanced countries, where there is a policy of renewal of the money market, using technology for new printing materials, combating counterfeiting and traceability.

Themes of national identity such endemic biodiversity (fauna, plants), archaeological and anthropological themes (popular human types) as well architectural artworks and technological monuments (dams, ports, mining) have been increasingly found replacing the busts of politicians and official effigies used in the nineteenth centuries throughout the world.

Fortunately thematic with busts of great scientists and national intellectuals and general images of his works and inventions has been well used as one can see at: URL: http://www.guerriniisland.com/writings/my-master-thesis-on-banknotes-and-national-identity/#_edn15.

From the historical-sociological point of view, numismatics has a wide field of analysis. The approach may enter the field of symbolic discussion, where geoscientific themes are included, for example in ideological or political discussions. In the field of history, money represents the best tool for analysis of ideological and political discourse about the symbolic representations of a nation.

2.2 Geosciences teaching using money: potential and perspectives

Possible interfaces to be investigated between Geosciences and numismatics are broad both in the historical and thematic fields. From the historical point of view, Geosciences can illuminate issues related to the origin and source of natural resources (mineral and metal deposits), mining and process production of coins, economic role of metals and money on society.

Figure 4. Samples of native metals as gold, copper and silver (images from left to right)

The main geoscientific themes found in paper money and coins of each country are exemplified by the Figures 5, 6 and 7: (a) strategical natural resources (petroleum, electricity); (b) economic and technological resources (dams, ports, waterways) and (c) geodiversity and geopatrimony issues. Also in thematic analyses, basic topics on inorganic chemistry (studied from elementary school level to high school) could be addressed in related didactic practices in Geosciences as melting points of native minerals, where does it occurs (geologic maps), electrochemical process of coin manufacture (chroming, nickeling) in transversal and interpretative focus.

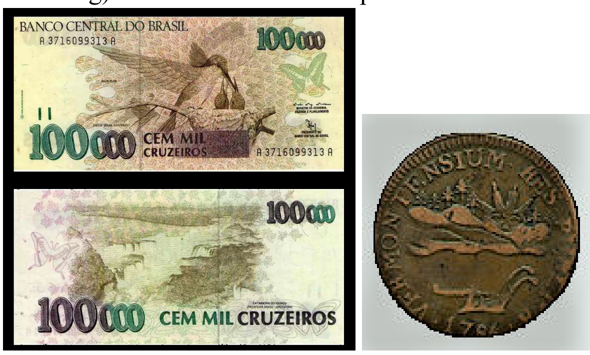

Figure 5. Brazilian paper money illustrating a national geopatrimony, the Iguassu Falls (left). First coin found with lanscapes at 1794 from USA (right)

Figure 6. Examples of coins illustrating themes of Geosciences. Above from left to right: Slovakia, 2014. Dubnik conservation area (opal mines) and gemmological specimens produced; Austria, 2015. Small Quaternary, illustrating scenes of hunting and mammoth fossil; Austria, 2014. Scenes of Prehistoric Life with animals and fossils and represented geological timescale; Spain, 2017. Ibero-American series on Natural Wonders of the country; Canada, 2016. Dinosaur *Tyranossaurus Rex*; Republic of Palau, 2017 illustrating meteorite fall occurred in May 1516.

Paleontology, Astronomy or Meteorology comprise other themes of Geosciences that can be subjected to research and related activities. As long as in the issues natural and scenic monuments predominate (mountains, valleys, lakes and large rivers), they offer good perspectives for using in geography, cartography or tourism classes in terms of didactical purposes.

Because of the rarity of bills and coins when they stop to circulate or to serve as object of trade, the material allows direct analogies to be applied with the geological record itself and the epistemological approaches applicable to the investigative method.

The notes identified with topics of interest were cataloged and tabulated with technical parameters summarized in Figures 8, 9 and 10.

5 Discussion

The review of the Geosciences theme on samples indicates 97 issues related with the theme geosciences distributed in 75 paper money and 22 coins around 22 countries (Table 1). The distribution of countries indicates Canada (9 issue), Spain and Chile (5 issues each) dominates the issues. In terms of thematic issues, scientists honor (25 issues) and Geological monuments (15 issues) dominates and largely on paper money (87%). Although the theme "Cientist Honour" is very restrictive, mathematicians, physics and inventors dominate issues. Outstanding people and leaders of medicine, public health sciences, arts and literature were well represented in different countries. With the exception of Charles Darwin, represented in paper money and coins of many countries, no other personality of Geosciences have been honored in the numismatics contents studied.

Figure 7. Examples of paper money using Geosciences themes. Above from left to right: Denmark indicating field of boulders; Argentina landscape of Ushuaia; Zimbabwe national monolith; Madagascar rapids region; Nigeria marine oil platform; Pakistan national mountain; Chile illustrating series of 5 cedulas with national landscapes; Suriname illustrating mining activity; Japan with classic image of Fuji Volcano; England with bust of naturalist Charles Darwin.

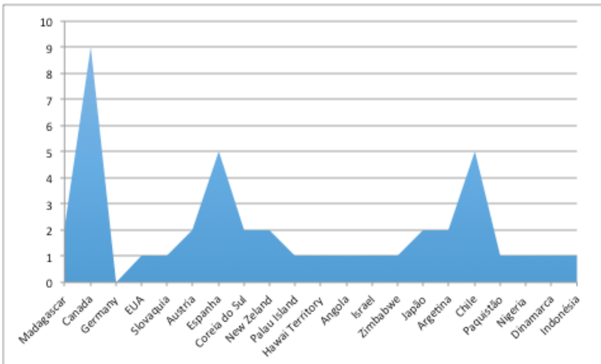

Figure 8. Distribution of money samples by country

In regard to the history of Brazilian money, the first commemorative emission dated from 1900 were 25 issues were identified theme related to Geoscience, in which National Fauna dominates (9 issues) followed by Scientists Honor (5 issues) (Barata 2015) and just 3 issues represented Geological Monuments as one issue of Iguaçu Falls (Fig. 5). While Brazil gets only one Geoscience issue, Latin American countries have already issued this themes as a systematic way, particularly Argentina and Chile, which together have issued more than 10 National Geoheritage and landscapes (Fig. 7).

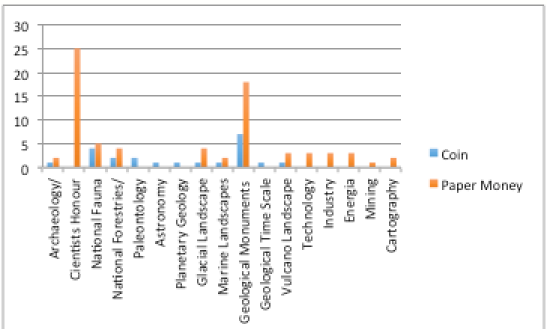

Figure 9. Themes on Geosciences found on the search

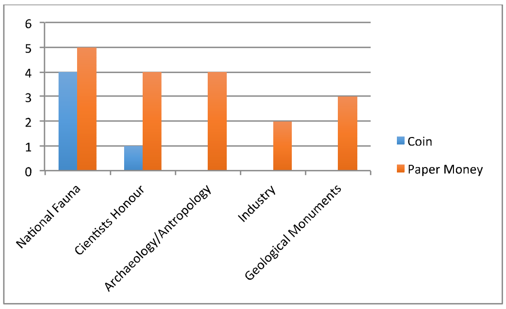

Figure 10. Themes on Geosciences found on Brazilian money (from 1900-2018 issues)

Moreover, it makes possible to point out fields for the analysis of the representations that coins and paper notes brings as fundamental element of construction process for a national identity (Castro et al. 2012).

6 Conclusions

The described approach using money as a didactic tool can be useful for Geology teaching in schools. This is a source that, literally, is in the hands of students and the general public. Money is a gateway to formal scientific content represents a useful tool for didactic activities.

As demonstrated above, in the formal Education system, different approaches using coins and paper money are possible for dealing with basic topics of History, Geology, Geography, Chemistry, Mathematics and Economy. The development of didactic activities with the use of coins and paper money requires first to consider interdisciplinarity and transversal approaches of Geosciences. The demand for original methods and practices enable to use the teacher's imagination for developing teaching strategies for promoting geoscientific knowledge.

Geoscientific contents can be approached using numismatic; coins and paper money allow an easy and efficient didactic transposition of scientific knowledge, because:

• They awake the power of accurate observation;
• They allow to develop meaningful learning;
• There is easy acquisition of related images and examples from the internet.

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HOW DO TEXTBOOK IMAGES IN K-8 US SCIENCE TEXTBOOKS SUPPORT LEARNING ABOUT SCALE, PROPORTION, AND QUANTITY?

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Abstract— Understanding the spatial, temporal, and numeric scales at which natural processes and events occur is important in geosciences. Science standards documents, like the *Next Generation Science Standards* in the USA emphasize important crosscutting concepts like *scale, proportion, and quantity* because they impact science learning across disciplines. Because textbooks remain an important driver of instructional practices in K-8 grade classrooms (5-14 yrs.), they need to support learners as they develop ideas about spatial, temporal, and numeric scale. We surveyed commonly used science textbooks dealing with Earth materials and processes and astronomy in the three most populous US states in grades K-8. Based upon research in cognitive science, we investigated how textbooks treat two meanings of scale: one as the magnitude or extent of an object or event, and the other as the relationship between objects or events. We coded textbook images for accuracy of treatment of spatial, temporal, and numeric scale using both definitions. We also coded for non-cognitive factors such as type of image. Pictures and diagrams are the most common image types in the textbooks surveyed. Scale is depicted more frequently in astronomy images than in those dealing with Earth materials and processes. Numeric scale is presented most accurately, though it is also portrayed the least frequently. Spatial and temporal scale are generally depicted more accurately in astronomy images than in ones for Earth materials and processes. The addition of referents to images for both spatial and temporal scale could aid students in their interpretations of the images.

Keywords— Scale, spatial, temporal, magnitude.

Thematic line— Geosciences and Natural Sciences for Basic Education.

1 Introduction

A sense of scale is important for all science disciplines, perhaps none more so than the geosciences. Systems and processes change with scale, from the very small and very short to the very large and very long. Mechanisms that operate at one scale do not necessarily operate in the same way at other scales. Spatial and temporal scales are frequently, but not always related. Large-scale Earth processes often occur over long time periods, but some small-scale changes, like carbon dissolution can have large-scale impacts.

Scale (spatial, temporal, and numeric) permeates the geosciences, and geoscientists must be able to mentally move back and forth across spatial and temporal scales as they go about their work. Geologic features that appear static at human scales may be undergoing deformation at larger spatial or longer temporal scales (Shipley et al. 2013). If understanding scale is important for geoscientists, then it must be part of Geoscience education at both compulsory and tertiary levels. Science education reform efforts across the globe emphasize the importance of the acquisition of key unifying concepts, like scale, that impact learning across science disciplines. In the USA, seven of these crosscutting concepts are identified, and *scale, proportion, and quantity* is one of them (National Research Council 2012).

1.1 Learning about Scale in Grades K-8 (ages 5-14 yrs.)

Extant research indicates that students of all ages have difficulty estimating spatial magnitude at scales that are outside daily human experience (Tretter et al. 2006, Miller & Brewer 2010, Jones et al. 2008). Similar difficulties are observed when estimating temporal magnitude (Trend 1998, Catley & Novick 2009, Cheek 2013, Delgado 2013, Jolley et al. 2013). In all these studies, students are often better at placing spatial or temporal events in relative order than they are at determining absolute placements. Number magnitude estimation studies show predictable patterns of increasing accuracy as students age (e.g. Siegler & Opfer 2003). While older students perform better on spatial and temporal scale estimation tasks than younger learners, some continue to have difficulty estimating unfamiliar scales into adulthood (e.g. Landy et al. 2016).

Science reform efforts with their associated standards documents and assessments have impacted science instruction in many countries. Curricular materials (often textbooks) which may or may not align well with those standards also influence instruction. Textbooks are especially important drivers of what is taught in science classrooms and how instruction is delivered for teachers who possess less subject matter content knowledge (Abd-El-Khalick et al. 2016), which is often the case for teachers of younger students. Textbook images (e.g., photographs, drawings, diagrams, maps, graphs, tables, and timelines) provide many of the examples of natural phenomena students see in the classroom (Kelly 2007). Because textbooks are important resources for K-8 (ages 5-14 yrs.) science teachers, it is important that they support student learning in science, including their learning of crosscutting concepts, like *scale, proportion, and quantity.*

How can curricular materials like textbooks support student learning about *scale, proportion, and quantity?* It can be argued that naming this as a single concept may complicate matters as this is really a series of interconnected ideas that involve multiple facets of spatial, temporal, and numeric reasoning. Research in cognitive science, while largely outside the scope of this paper, provides a framework in which to understand what is meant by *scale, proportion, and quantity* and what students in grades K-8 should be learning about these ideas.

1.2 Two Meanings of Scale

Despite its importance, there is scant research on how understanding of scale develops across the K-8 grade span within the context of geoscience education or other science disciplines, for that matter. One reason may be that the term *scale* is ill-defined, both by researchers and practitioners. For this paper we adopt two meanings of *scale* grounded in psychological literature and explicated in Cheek, LaDue, & Shipley (2017). Both meanings are consistent with how geoscientists use scale. The first meaning refers to the spatial, temporal, or numeric *magnitude* of objects or events and can be measured in standard or nonstandard units. Magnitude can also be described with context-dependent terms such as large, small, short, or long. These descriptors are unlikely to be problematic for domain experts, but could be for learners who may not realize that large-scale flooding does not denote the same spatial scale as large-scale glaciation.

A second meaning of scale refers to the spatial, temporal, or numeric *relationship* between objects or events. Scale as a relationship includes formal proportional mathematical relationships, as would be found in mapping. It also includes informal descriptors such as larger, smaller, shorter, or longer. Young children can identify relative scalar relationships, i.e. *The ball is bigger than the toy car.* As they move through the K-8 grade span (ages 5-14 yrs.), students are expected to learn to use proportional reasoning to quantify scalar relationships and develop a "feel for quantity" using a range of spatial, temporal, and numeric magnitude units (National Research Council 2012, p. 90).

In this paper we report on preliminary results from a portion of a larger, ongoing research project investigating the treatment of spatial, temporal, and numeric scale in US science standards documents and grades K-8 (ages 5-14 yrs.) science textbooks. Here we provide descriptive analysis to answer the following question: *How do K-8 science textbook images for astronomy and Earth materials and processes depict information about spatial, temporal, and numeric scale as magnitude and a relationship?*

2 Methods

To answer our research question we analyzed textbook images dealing with Earth materials, surface and tectonic processes and astronomy in the most recent editions of Kindergarten through 8th grade science textbooks (ages 5-14 yrs.) used in California, Florida, and Texas, the three most populous US states. We developed an initial coding frame based on definitions of spatial, temporal, and numeric scale as described in Cheek et al. (2017) and used content analysis (Bernard & Ryan 2010) to code textbook images. Table 1 lists coding categories and examples of images coded for each category.

Table 1. Examples of Images Coded Accurate, Confusing/Ambiguous, or Misrepresentation

Coding Category	**Example Image**
Accurate Spatial Relationship	Topographic map with scale
Confusing/Ambiguous Spatial Relationship	Partial Sun and Earth; because Sun is partially visible relative sizes are ambiguous
Misrepresentation Spatial Relationship	4 Earths in orbit around Sun at solstices and equinoxes; All Earths are same diameter as Sun
Accurate Spatial Magnitude	Sand dunes with grain sizes labeled in mm
Confusing/Ambiguous Spatial Magnitude	Related images of sediments sorted by size but no indication if images are at the same level of magnification
Misrepresentation Spatial Magnitude	Saturn and Io; distance between them is too small
Accurate Temporal Relationship	Seafloor spreading showing older crust farther from mid-ocean ridge
Confusing/Ambiguous Temporal Relationship	Debris flow with caption that says materials can move "quickly"
Misrepresentation Temporal Relationship	None found
Accurate Temporal Magnitude	Devonian Sea with caption that says 380 Ma
Confusing/Ambiguous Temporal Magnitude	Steel and paper clips; caption says they last a "long time"
Misrepresentation Temporal Magnitude	Timeline not to scale
Accurate Numeric Relationship	None found
Confusing/Ambiguous Numeric Relationship	None found
Misrepresentation Numeric Relationship	None found
Accurate Numeric Magnitude	Table listing number of moons of Jupiter
Confusing/Ambiguous Numeric Magnitude	Development of a rift valley; caption says "numerous" cracks develop
Misrepresentation Numeric Magnitude	None found

We also coded for type of image (e.g., photograph, drawing, map, table graph, or timeline) and the presence or absence of non-cognitive factors (e.g., captions, arrows, a scale referent, and whether the image was mentioned in the text). Data was analyzed by grade bands: K-2 (ages 5-8), 3-5 (ages 8-11), and 6-8 (ages 11-14). Because US textbook publishers are currently in the process of developing textbooks aligned with the *Next Generation Science Standards,* we did not analyze textbooks by series or author. Our aim was not to identify "better" or "worse" texts. Rather, our intent was to determine more broadly how spatial, temporal, and numeric scale is represented in textbooks currently in wide use. We believe this information can provide guidance to textbook developers and adopters.

Images that appeared multiple times in the same grade-level textbook were only counted once, and we did not code images on review pages or those that were part of embedded investigations. Images showing change over time (e.g., tidal range, shadow length, mountain building) were counted as a single image since they referred to a single event, albeit at multiple points in time. Textbooks at lower grade levels do not distinguish topics as clearly as texts for older students do, making some images difficult to categorize topically. Images about seasons that focused on the reason for seasons were coded with astronomy, while those focusing on weather differences across seasons were not. Images dealing with water as a resource were coded with Earth materials, while ones dealing with the water cycle were not.

Each author coded a subset of the data and then met to discuss coding. Differences were reconciled via discussion and the coding frame was revised as needed. Initial intercoder agreement prior to discussion using Cohen's Kappa was 0.8, which can be interpreted as either good (Fleiss 1981) or substantial (Landis & Koch 1977) agreement. Data analysis is ongoing. Therefore, results in this paper represent preliminary findings and are reported descriptively.

3 Results

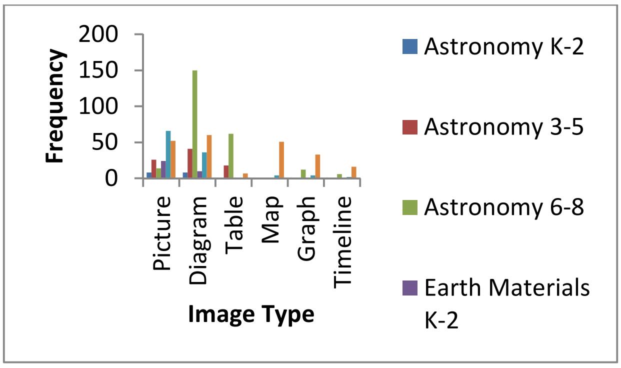
Table 2. Mean Number of Images and Percentage Depicting Scale by Topic Area

Grade Band	Astronomy		Earth Materials and Processes	
	Mean Images per Page	Images Depicting Scale	Mean Images per Page	Images Depicting Scale
K-2 (5-8 yrs.)	1.1	18%	1.6	10%
3-5 (8-11 yrs.)	1.3	27%	1.6	19%
6-8 (11-14 yrs.)	1.4	29%	1.4	16%

Units of instruction in astronomy and Earth materials and processes across grade bands contain on average 1+ images per page (See Table 2), with little variability in the total number of images in the texts. There is greater variability in the percentage of images that depict some aspect of scale (spatial, temporal, or numeric) across grade bands and topic areas. Astronomy images at grades 3-5 and 6-8 depict scale in more than 25% of images. At all grade bands, astronomy images are more likely to portray scale than images of Earth materials and processes at the same grade band.

Pictures and diagrams are the dominant images in the textbooks investigated (Fig. 1). As a general statement, pictures are more common in Earth materials and processes chapters than they are in astronomy chapters at the same grade band. Conversely, diagrams occur more than twice as often in grades 6-8 astronomy chapters as they do in ones dealing with Earth materials and processes. Tables, maps, graphs, and timelines are uncommon at lower grade levels. They are also far more common in chapters on Earth materials and processes than they are in astronomy chapters.

Figure 1. Image Type by Frequency



Accuracy of scale representation differs considerably (Table 3) across topic areas and grade bands. When, images showing numeric scale are included, accuracy of representation is high. Temporal scale is depicted more accurately in astronomy images than is the case in Earth materials and processes. Accuracy in images portraying spatial scale is highly variable. Spatial scale as magnitude is shown more accurately than scale as a relationship for both astronomy and Earth materials and processes images. There is insufficient variability in accuracy for temporal or numeric scale images in astronomy to make claims about relative accuracy. There is no discernable pattern in the accuracy of temporal scale as magnitude vs. as a relationship for Earth materials and processes. In aggregate, the textbook images reviewed accurately depicted scale with 90% or greater accuracy approximately 35% of the time.

4 Discussion

While data analysis in the current study is ongoing, preliminary results reported in this paper suggest that scale is depicted in K-8 science textbook chapters dealing with astronomy and Earth materials and processes fairly infrequently, at least in the ones surveyed for this study. This is surprising given the fact that many astronomical and geologic processes and events take place at spatial, temporal, and numeric scales that are unfamiliar to K-8 learners.

Table 3. Accuracy of Representation of Scale as Magnitude and a Relationship by Subject Area

Subject Area	Coding Category	Grades K-2 (5-8 yrs.)		Grades 3-5 (8-11 yrs.)		Grades 6-8 (11-14 yrs.)	
		Total Images	Percent Accurate	Total Images	Percent Accurate	Total Images	Percent Accurate
Astronomy	Spatial Rel.	10	70	46	36.9	69	47.8
	Spatial Mag.	5	80	46	73.9	65	90.8
	Temp. Rel.	5	100	12	100	6	100
	Temp. Mag.	2	100	16	100	30	96.7
	Numeric Rel.	0	---	0	---	0	---
	Numeric Mag.	0	---	15	100	33	100
Ea	Spatial Rel.	3	67	10	70	44	95.5

	Spatial Mag.	19	31.6	44	52.2	73	86.3
	Temp. Rel.	9	55.6	41	29.3	64	79.7
	Temp. Mag.	6	33.3	24	54.2	51	84.3
	Numeric Rel.	2	100	0	---	4	100
	Numeric Mag.	5	80	7	100	34	91.2

Images that include scalar information like maps and timelines are less common than pictures or diagrams. Geoscientists routinely add scale referents to photographs, but such referents were largely absent in the textbook images we reviewed. We think they should be included. This is especially important because captions on many pictures and drawings used descriptors such as “large,” or “a very long time,” whose meanings vary across science disciplines. This is probably a nonissue for domain experts, but could be very significant for K-8 learners (5-14 yrs.).

Astronomy images showing temporal scale at these grade levels often include familiar timescales like day, month, and year, which could explain why temporal scale is portrayed more accurately in astronomy images than in Earth materials and processes. In the latter case, temporal information is often ambiguous or simply missing. The addition of temporal referents could be helpful.

We are surprised at the low accuracy for images showing spatial scale as a relationship, particularly as young children’s early understanding of spatial relationships is relative involving direct comparison between objects. It would seem important to capitalize upon these early notions about spatial scale by emphasizing relative spatial relationships more explicitly. Given what is known about learners’ difficulties understanding geologic and astronomical time, it seems equally important that textbook publishers pay attention to the need to portray temporal scale accurately.

It is unclear at present why numeric scale is depicted more accurately that either spatial or temporal, but it may be due to the types of images found in the textbooks surveyed.

4.1 Limitations and Future Directions

We surveyed the most widely used textbooks in the three most populous states in the USA, but they may not represent the broader market of K-8 science textbooks, either in the USA or across the globe. Textbook publishers in the USA are currently working to develop textbooks aligned with the newest science standards, so all of the texts surveyed for this study were produced prior to the development of those standards. It could be argued that it is unfair to judge them on the basis of constructs (crosscutting concepts) that didn’t exist at the time they were written. While acknowledging the point, we allege that the idea of unifying ideas or themes, which have included some mention of scale have been present in US standards documents since the 1990s. Furthermore scale is so integral to astronomy, Earth materials, and processes that one would fully expect to see textbook images accurately representing scale, even if crosscutting concepts or *scale, proportion, and quantity* were not mentioned.

An underlying assumption of this study is that if K-8 science learners have access to textbooks that accurately portray the spatial, temporal, and numeric scales of geoscience phenomena they will be more likely to acquire those concepts. That assumption is untested by this study. We have only investigated and coded the images themselves. We did not survey students to determine how they interpret the images. This is an important next step. With the increasing popularity of digital textbooks in compulsory education, it will also be useful to investigate whether digital images that can be manipulated help students develop greater understanding of scale.

5 Conclusion

Scale as both magnitude and a relationship is important for geoscientists. Astronomical and geologic spatial, temporal, and numeric scales are often outside the bounds of human experience. Practicing geoscientists must be able to work at unfamiliar scales and move back and forth across scales. Scale is also identified as a key unifying construct, or crosscutting concept, in the most recent US science standards (NGSS Lead States 2013). Textbooks remain integral components of K-8 science classrooms in the USA. It is essential that images in those textbooks represent spatial, temporal, and numeric scales accurately.

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OVERVIEW OF ASTRONOMY TEACHING IN BRAZIL: DIFFICULTIES AND ADVANCES IN THE LOCAL LEVEL: COXIM [STATE OF MATO GROSSO DO SUL]

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Abstract— Astronomy is a science that currently deals with studying the celestial bodies and phenomena among them physical, chemical and biological. However, in Antiquity it was of great use to agriculture for establishing a calendar for the organization of time, and also of great importance for the great maritime navigations in the discovery of new geographical regions. This science received significant advances from the Middle age, but its consolidation occurred in the late nineteenth and early twentieth century due to technological advances. Researches point to a great difficulty in relation to the Teaching and Learning of this science in Basic Education, especially in the second cycle of elementary education. These problems, according to the researchers, are related to the initial formation of the science teacher, the conceptual errors present in textbooks and the spontaneous conceptions that students carry throughout their school life, both in Basic Education and graduation. Possibly the origin of these difficulties is related to the initial formation of teachers. Researches point out that astronomy content is often not addressed in the license courses and when this discipline is offered, it is in an optional form. Although Astronomy is one of the oldest sciences of Humanity, it is verified that when students leave the Basic Education, do not have sufficient knowledge of this discipline. The difficulties are the most varied since the design of the seasons of the year with the distance of the Earth from the Sun until the understanding that the human being does not inhabit the surface of the planet Earth. In this sense, the present work aims to identify the main causes of such difficulties and the possible solutions proposed by different specialists, in an attempt to visualize alternatives to soften the problem in a local context. A bibliographic review was carried out in articles published in specialized journals in Science and Astronomy Teaching. The selection of articles for the foundation of this work considered those published in the last 15 years, willing to verify how these researches are contributing to the teaching of Astronomy topics in Basic Education, as well as the proposals to reduce the difficulties inherent.

Keywords— Teaching Astronomy, Science Teaching, Basic Education.

Thematic line— Geosciences and Natural Sciences for Basic School.

1 Introduction

This work presents a bibliographical review focusing on the teaching of Astronomy in Brazil, particularly in relation to Basic Education (Elementary School). Its objective is to seek theoretical basis for the development of a research and elaboration of a teaching sequence to work on astronomy topics with students from the Fundamental Education of schools in the municipality of Coxim, in the state of Mato Grosso do Sul. The study aimed to verify the student's significant learning through the elaboration of a comic book addressing two Astronomy topics: Solar System and Earth System.

Astronomy is a science that allows the contextualization of Physics' concepts; moreover, given its interdisciplinary character, it is a captivating science for students of Elementary Education, motivating them in the search for explanations of natural phenomena, transforming them into reality researchers, with the possibility of content deepening in other areas of knowledge, Oliveira & Langhi (2011).

Studies of the origin, formation and evolution of the Universe have gained momentum as a consequence of the knowledge acquired over the past fifty years, mainly because of space missions. The new discoveries brought a concern to the elementary school teachers: - how to approach this subject in the classroom, given its high degree of complexity and abstraction? According to Longhini & Menezes (2010), the great concern is regarding teaching-learning activities that can provide conditions for understanding natural phenomena, such as long-term ones, which can only be observed in a distant future.

For Pellenz (2015), astronomy is an essentially interdisciplinary science, because it deals with the origin of life on our planet, planetary evolution, celestial movement, laws governing the universe and with the possibility of talking with Mathematics, Chemistry, Biology and Geography, amplifying human knowledge in relation to the exploration of space and time. This science still enables the student's intellectual development through direct observations of constellations, planets and stars, by understanding that they are at different distances from the Earth (on an astronomical scale - much larger than those students are used to dealing in their daily life), but also by the knowledge of the main astronomical events that have occurred throughout history.

According to Ferreira & Meglhioratti (2011) it is imperative that the study of Astronomy be approached in Elementary Education, in the discipline of Sciences, for a good formation of men in the present world, since the stars accompany Humanity from its beginnings, in a constant search for evidences of its origins, nature and characteristics. The authors understand that it is through Astronomy that men can understand the Universe, in spite of its extreme complexity, because it allows an understanding of the place it occupies in space, as well as a conception of nature's phenomena. It also enables man to have a good perception of life on Earth and to search for new information about and beyond the atmosphere, as people from different cultures did, from simple ones to those with great technological advances. Although it is a subject that arouses great interest in students, its teaching still faces serious difficulties.

1.1 Brief report on the Astronomy History

Researches have pointed out that since Antiquity, the Universe causes enormous fascination in Humanity, whether by simply observing the stars or searching for explanations on its origin and the laws that govern it. This enchantment for the sky combined with the practical necessity of having to organize time and agriculture by the regularity of the movement of the Moon, to predict the periods of cold and heat by the appearance of certain stars in the sky, etc., promoted the study of Astronomy. Thus, this science made possible the organization of the most varied social activities such as sea voyages, new geographic discoveries, time management and the establishment of a calendar (Bartelmebs 2012).

According to Costa et al. (2016), the Chinese, Babylonians, Assyrians, and Egyptians were the first people to present written records about the Universe, dating back more than 3000 BC. From the Middle age, especially in the Renaissance, astronomy has seen significant advances, but it was not until the late nineteenth century, at the beginning of the twentieth century, that this science was consolidated and benefited from the enormous scientific progress and the corresponding technological evolution. Nowadays, astronomy is concerned with the study of celestial phenomena, including physical, chemical and biological.

The celestial phenomena also represented a superstitious way of seeing the sky, through explanations associated with beliefs and divinities, characteristics of each social group, even being considered as a world inhabited by monsters and heroes (Oliveira et al. 2007).

Although Astronomy is one of the oldest sciences studied by Humanity and being directly linked to its daily life, it is verified that the students leaving Basic Education do not have knowledge about a great number of topics of this science, which is not understood by the population in general (Martins & Langhi 2012).

In this way, Astronomy has been the object of study of several researches, from its teaching in the fundamental cycle, undergraduate and continuing training courses, with the purpose of amplifying the understanding of the Universe and the quality of teaching-learning. According to Oliveira et al. (2007), the school has the fundamental role of spreading celestial phenomena, as well as historical research, because it is understood that astronomy has made possible various changes in society throughout its evolution. It is understood, therefore, that as the school is responsible to promote the teaching and learning of the topics of Astronomy, so this process may be carried out in a correct and meaningful way, but the researches still indicate that in Brazil several difficulties are found in the approach of this science in the classroom.

So, the aim of this work is to verify the progress of the research related to Astronomy Teaching in Basic Education, with the possibility of its use from the development of new techniques to approach this science, in order to promote a meaningful learning for the students, especially in a local context, in view of the existing regional diversity in Brazil's immense territory.

2 Methodology

As a way of ascertaining the panorama of the astronomy teaching in Brazil, a search for scientific articles was made, based on the orientations of Rosa (2013) for the accomplishment of a documentary research: definition of the key words, definition of the scope, selection of the research corpus and analysis of the documents.

For the definition of the keywords, it was sought, in the field of interest of this research, terms and expressions related to the Teaching of Astronomy in Brazil. Thus, the following words and expressions were selected: Astronomy, Astronomy Teaching, Science Teaching, Astronomy History, Astronomy in Elementary School; that is, words capable of guiding the selection of documents to constitute the corpus of this research.

To define the scope of the research, articles published in scientific journals in the last 15 years were selected, aiming to establish a picture of how the Astronomy Teaching in Brazil, mainly in Elementary School, is presented. With the possession of the selected articles, the title, the summary and the conclusion of each one was read.

Among the documents researched, were selected those that contemplated the objective of this research. In this step, only the fields selected for the survey were read.

Through the documents thus collected, the articles were read, seeking information related to the purpose of the present study. Then, a synthesis was made with the main contributions of each read article, establishing the basis of this research. Finally, a description of the discussion that the authors promoted regarding the proposed theme was made, verifying the results obtained with their research.

3 Results and discussion

3.1 Astronomy in Basic Education: difficulties encountered at national and local level, Coxim [MS] Brazil

There are several researches that point out the difficulties in the teaching and learning of Astronomy, both for students and teachers.

Conceptual errors in textbooks, problems in the initial formation of elementary school teachers, the spontaneous conceptions brought by students in both Basic Education and Graduation are among the main difficulties encountered at the national level and also at the local level – on the regions of the large Brazilian territory. In

Coxim [MS] it was possible to verify that such difficulties are present in all the schools of the municipality.

Langhi & Nardi (2005) point out that the alternative conception is one of the difficulties to approach Astronomy in the classroom. These concepts are acquired by local life and culture. They also point to a great lack of teachers to work on this content. In the municipality of Coxim, as in most municipalities in the state of Mato Grosso do Sul, such lack is very felt.

Regarding the conceptual errors present in the textbooks, Langhi & Nardi (2007) understand that this problem is even greater, since the textbook is almost always the only material available for consultation of the teacher. There is an unforgivable lack of care with the terminologies used in the didactic texts and also serious conceptual errors in some topics. Among the most cited are: occurrence of the seasons as a consequence of the extremely elliptical orbit of the Earth and explanation of the phases of the Moon due to the occurrence of eclipses caused by the formation of Earth's shadow on the surface of the Moon.

Langui & Nardi (2007) observed that in relation to the cardinal points an important concept appears in the textbooks incorrectly, when they affirm that the Sun always rises exactly in the east point and sets in the west point, but this only occurs in two days of the year.

They also agree, Ferreira and Meglhioratti (2011), that the teaching of Astronomy and its approach in the classroom run into many difficulties, associated mainly with the training of teachers who work with this content. These teachers are, for the most part, graduated in Geography and Sciences, and did not have this discipline in their graduation courses. They also point to a lack of available resources in schools and to the conceptual and illustrative distortions in textbooks.

Langhi & Nardi (2005) also presented the main alternative conceptions that are more reinforced, which may be due to the conceptual errors present in textbooks: association of the presence of the Moon only in the night sky; existence of stars among the planets of the Solar System, as well as the occurrence of the seasons of the year by the distancing of the Sun from the Earth.

According to Dias and Rita (2008), although Astronomy arouses the curiosity of people of any age group, the majority of students of Elementary and Middle School finishes their studies without the knowledge related to their formation. Like other authors, they agree that the conceptual errors present in textbooks and the misconceptions of science teachers constitute a barrier in the elaboration of experiments in the classroom, not counting the disintegration of the teaching career that constitutes an aggravating factor for the teaching of astronomy.

Pedrochi and Neves (2005) indicate that Astronomy is a subject that arouses interest among teachers and students. However, this content is relegated to the background in physics and even science curricula, both in major and graduation courses; and when this discipline is offered, it is in the elective form. As to previous concepts brought by academics, the authors point out that these may constitute a resistance to change for those addressed in the graduation course classrooms.

More recent researches such as Gonzatti et al. (2013) confirm the same difficulties and still indicate that the topics of Astronomy are treated superficially in the schools of Basic Education, with the aggravating of carrying conceptual errors present in the didactic books. In a study carried out with Basic Education teachers, the authors verified that these professionals find difficulties in the development of their practices in the classroom regarding the Astronomy approach because, in the context of the research, none of the participants had any specific training in graduation in order to allow them to work with property the content of Astronomy. Most of these teachers were Biology graduates and approached Physics.

In Brazil there is a great difficulty regarding to science education, mainly in the Physics discipline, which contributes to the decrease year by year of the demand for training in this area, according to Morret and Souza (2010).

According to Costa et al. (2016), even though Astronomy is recognized as being of great importance in Basic Education, its approach is made in a simple way. The authors point to two main causes: conceptual errors in textbooks and absence of astronomy teaching during initial teacher training. They also indicate that astronomy is only treated according to the topics presented in the textbook and that are transmitted in an uncritical way, with no scientific terms and with the presence of alternative conceptions. They point out that the deficiency in the initial training of teachers in the area of Natural Sciences makes it difficult to meet the expectations of students in Basic Education.

An analysis of how to work astronomy in the classroom was carried out by Peixoto and Ramos (2011). Due to the fact that this science is multidisciplinary and to arouse the curiosity of many people, the authors pointed out difficulties in their approach, such as: lack of specific teacher training in this subject, conceptual errors in textbooks and lack of supporting material to teachers.

Marrone & Trevisan (2009) pointed out that Astronomy has been treated only as a chapter of Physics in High School, and that this content is not always addressed in the classroom. In the times in which it is worked, it is limited to Kepler's Laws and Universal Gravitation. In an analysis of published articles from 1989 to 2009, the authors found that the explanation for astronomical phenomena had declined over time and that most of them were concerned only with the themes: Universe, Earth, Sun, Cosmology and Gravitation.

Ferreira & Meghilratti (2011) indicate that one of the difficulties in teaching astronomy is related to the scarcity of theoretical-practical courses available for teachers to be able to update themselves. Such a lack leads the teacher to feel insecure to approach the content of the discipline, and to search for materials that - as has already been detected - usually present unforgivable conceptual errors, reinforcing their alternative conceptions.

Gonzatti et al. (2013), in their research related to the teaching of astronomy also showed difficulties in the teaching-learning process of the corresponding content. They pointed to problems in the specific training of teachers forcing them to work on topics that they do not master or that they avoid dealing with in the classroom even though they are on the teaching level. They also consider that another difficulty is in relation to the abstraction of content. Another aspect that hinders the approach of this science is the religious question, because there is an obstacle in approaching the creation of the Universe without bumping into biblical aspects.

One of the great current problems regarding the teaching of astronomy, according to Lopes (2017) is about graduation and postgraduate courses. In these, the content of Astronomy is offered as optional subjects, being that only in some degree courses this discipline is obligatory, not to mention that in some courses it is not even offered. The author also points out that the lack of documents on astronomy makes it difficult to disseminate this science, even though it is present in our ancestors' day-to-day lives (as well as in our own daily life). Astronomy is a science recognized as of great importance to mankind, which can serve as a stimulus for its learning and for other contents. In short, the author believes that even though the Universe has been admired by man since Antiquity, the discipline that deals with his study, Astronomy, has two obstacles to his teaching-learning: disinterest on the part of the students due to the teachers' training; and the insecurity of teachers in approaching this theme in the classroom.

In a paper on the alternative conceptions of high school students about the phases of the Moon, Iachel et al. (2008) found that the confusion between the concepts of the phenomenon of Moon phases and moon eclipses is frequent between the various levels of Formal Education, from Elementary to High School; and also, by teachers at these levels of training. These phenomena were attributed to the fact that clouds covered part of the Moon; planets that cast a shadow on the moon; the Sun shades the Moon and the Moon has a white face and a black face, and as it rotates, these faces change places. The authors believe that the difficulty presented by the students may be due to the non-observance of nature, and that it would be up to the teacher to give an incentive to this practice.

Although Astronomy is one of the oldest sciences in Humanity, there is still a great lack of knowledge about it in Brazil, not only by students, but also by the general population as a result of a deficient process of teacher training for the teaching of this science. One of the difficulties may be related to the low quality of information present in textbooks, especially those of Elementary Teaching, when they reinforce the spontaneous conceptions of initial teacher training (Jesus, 2015).

3.2 Advances in the Teaching of Astronomy in Basic Education

According to Gonzatti et al. (2013), the Teaching of Astronomy has been the subject of research in the area of Science Teaching for some years. However, there is still a considerable distance between the results pointed out in the researches and what is done in the classroom.

Ferreira & Meglhioratti (2011) reinforce the idea that despite the difficulties pointed out in the approach of astronomy in the classroom, its content represents a subject of great interest to students in general. In this sense, they indicate that an improvement in teacher didactics through continuing training courses would be a considerable alternative to perceive an advance in theory and practice by teachers. Another alternative would be the use of new technologies to work astronomy in an interdisciplinary way aiming to promote a more meaningful learning of nature, as well as the provision of conditions to correct the spontaneous conceptions of teachers.

Gonzatti et al. (2013) also point to the need to intensify continuing education courses, and to review the essential issues of teacher education in order to provide knowledge about astronomy topics so that science can be addressed more effectively in Elementary Science classes.

According to Costa et al. (2016), the insertion of Astronomy in the courses of initial teacher training will enable a dissemination of knowledge about the Universe with the possibility of contributing to a convivial change of students, based on scientifically correct concepts. Thus, the authors understand that continuing education courses, through research for the Teaching of Astronomy, can contribute to this science being approached in a classroom with more ownership.

Regarding the textbook, Langhi & Nardi (2007) believe that one way to mitigate the issue of the conceptual errors that appear in these would be the correct inclusion of astronomy topics, both in initial formation and in continuing formation, with the purpose of preparing the teacher for a critical reading of teaching materials in general.

Based on the work of the last five years, Lopes (2017) indicates that there has been an increase in research related to teacher training in astronomy teaching, pointing out to how important it is to work with this science through an interconnection with the students' daily lives. It indicates that not only the research has had an increase of published works, but that extension projects are also being developed with the same purpose of the research.

According to Dias & Rita (2008), the inclusion of Astronomy content in high school can promote a worthier formation of the student and a less fragmented view of knowledge, considering its interdisciplinary character and its ability to articulate with other disciplines.

Bartelmebs & Moraes (2012) propose as possible alternatives for the teaching of Astronomy, nocturnal observations, records, satellite monitoring for a period of one month, work in research groups and elaboration of reports as a way of knowledge. The authors argue that from the earliest years, children should be encouraged to take a critical reading of their reality, and Astronomy leads to this, when it challenges the student to see the world reaching new horizons. Understanding the phenomena of the sky widens the worldview and reality, because with each new learning, a change takes place in the cognitive structure of the students, modifying its understanding and reading of reality, in a possibility to see which was not seen before.

According to Martins & Langhi (2012), one of the ways of working astronomy in the early years would be through the use of comic strips (HQ) due to the fact that they have been influencing several generations, due to their popular format and easy to read. They consider that the use of HQ as a potential strategy for science education is pertinent and effective due to its ease of reading and leisure promotion. The HQ can facilitate the development of skills and competences in the students, to provide examples and to indicate concepts related to teaching and approach in the classroom and how to make a relationship with the daily in the elaboration of the plot.

According to Martinez and Ferreira (2011), the children have a curiosity for knowledge, but when advancing in their studies one perceives themselves a lack of interest in the disciplines of natural sciences. In relation to Astronomy teaching, the situation is more complicated because it is not part of the daily routine of the student, not to mention that the great obstacle is the difficulty that the student has of being situated within the space, identifying dimensions and connections. Thus, the authors point out that through differentiated methods such as board games, charts, building a celestial map, and even an astrolabe, students can be motivated by the teaching of astronomy.

Bartelmebs (2012) points to a need for methodological changes in the practices of science teachers in view of the teaching of astronomy in the initial years of student training, since some subjects are privileged and astronomy is second maybe due to the poor training of teachers who did not have the opportunity to access their content during graduation, or because of the rigidity of the traditional content offered by the School, or because they think that content is of great importance for the children's age group. The author points to the inclusion of Astronomy as a discipline in the initial teacher training of the initial years, and studies show that most are unaware of this science and work in the classroom with concepts brought from their basic education.

For Morett and Souza (2010), a way of reversing this situation of astronomy teaching and learning, would be the motivation of the students of the Elementary School for science and one of the ways would be the work through play activities that could, therefore, the interest in astronomy. They also believe that the introduction of Astronomy in the early grades of High School would enable the student to have a more complete knowledge of the planet Earth, leading them to build a theoretical basis and prior knowledge about topics covered in Astronomy.

Marrone Jr and Trevisan (2009) consider that to improve the teaching of Astronomy in Basic Education it would be fundamental to include this discipline in an autonomous way, with the provision of adequate didactic material and easy access to the teacher. They also indicate that the publications in the form of an article of researchers in the field of astronomy teaching could be used by teachers as a didactic resource.

4 Conclusion

The research indicates that there are several difficulties with regard to the teaching and learning of Astronomy in Basic Education – in Brazil in general as well as in its different regions (according to the context of each). In Coxim [MS] the existing difficulties follow the pattern that is perceived in most of the Brazilian regions. There are deficiencies in several stages of the process: from the didactic material that presents conceptual errors to the formation of science teachers, who in the great majority still retain spontaneous conceptions brought throughout school life. It is understood that the development of more research in the field of Astronomy teaching could provide subsidies to enable elementary school teachers, and thus, ease the difficulties regarding the approach of this science in the classroom. With these works students would have the possibility to acquire scientifically correct knowledge about the Solar System and the Earth System, with probability of making use of these in other areas of knowledge. In this sense it is understood that the elaboration of a teaching sequence to approach the fundamental concepts of Astronomy - Solar System and Earth System - can contribute to a more meaningful learning of this science.

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THE ENVIRONMENT OF SCHOOL IN THE MEDIUM TECHNICAL EDUCATION IN CHEMISTRY: A PROPOSAL FOR THE ARTICULATION OF KNOWLEDGE BY THE GEOSCIENCES

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Abstract— The present work proposes to explore the school environment in the promotion of didactic-pedagogical articulations, from a group of students of the 1st year of the technical course in Chemistry. These articulations with the students, elaborated by the professor of Chemistry, included the development of three visits to natural areas within the school itself to provide data collection, followed by the elaboration of researches from materials and data collected in the field, using documents and digital geoscientific databases available on the Internet. Qualitative evaluation is used, based on the comparative diagnostic check before and after the students 'research, which provided significant improvements in knowledge construction and in the interaction between the students' knowledge. It was possible to develop a contextualized, collaborative and integration of contents, through Geosciences.

Keywords— Chemistry Education, Geocience, Field trips.

Thematic line— Geosciences and Natural Sciences for Basic Educacion

1 Introduction

In the official documents of Brazilian national education, by the Law of Guidelines and Bases of Brazilian National Education, it is stressed the need of teaching units, to promote in basic education, the development of learning capacity, through articulation of knowledge and skills, stimulating the construction of intellectual autonomy and critical thinking in students (Brasil 1996).

Gimeno Sacristán & Pérez Gómez (2000) propose that it is necessary to rethink the teaching-learning processes, so that the purpose of educating citizens to intervene relatively autonomously and rationally in social exchanges, orient and configure the educational practices.

For Vasconcelos et al. (2003), in order to achieve the objectives of the formation of autonomy and critical thinking by the students, it requires that the teachers provide moments that confront their previous concepts with scientific concepts, assume their central role in building their own knowledge. The same authors emphasize the need of teachers to diversify their teaching methodologies, assuming a role of intermediaries that accompany and model students learning through the rational use of new technologies and group work, providing a learning in order to confronting individual positions and cooperation among subjects.

The contextualization in teaching through environmental practices approach has been configured as promising, providing greater and better meanings in teaching, and providing an appropriate environment for the development of multiple skills by students.

Marques & Praia (2009) in discussing possible contributions to improvements in science teaching emphasize the practices related outside the classroom as potentially relevant to provide better understandings and uses of Sciences, appreciation of the natural environment. The authors characterize some contributions that can generate the practice of this type of didactic articulation, pointing out improvements in students' understanding of the development of scientific knowledge, the context of uncertainties and unpredictability related to geosciences, as well as promoting an integrative perspective of knowledge, which can contribute to an ethical and responsible formation of the students, towards with environment.

In this line, DeFelice et al. (2014) point out advantages in the teaching-learning process when using incursions to the local environment, through a pedagogical proposal aimed at sub-presented high school students who worked in an urban school in New York through a research in environmental sciences, that was guid by a multidisciplinary committee formed by park employees, students of geosciences and university professors. The students were able during one week, to act as environmental researchers using a park located in the region of the school. These students, in groups, selected topics related to biology and geosciences, to research on the environmental factors related to the soil compaction phenomena and eutrophication of lake waters, both present in the park, as a way of articulating the curriculum by experiences in geosciences from the local environment. Got greater scientific identification and engagement of the students, who sought to record data and provide solutions, were provided for solving the environmental problems punctuated in the environment in the park.

Esteves et al. (2013) using the organizational model of Orion (1993), made field visits together with a group of 280 students subdivided into 6 groups, under the guidance of teachers. These groups visited different places in the northern region of Portugal and showed results from that field visits to natural environments can be seen as an effective way to evaluate the knowledge built by the students in the classroom, evidenced by the production of reports, inventories and resolution of questionnaires applied before and after field visits. It also shows comparative abilities, the development of some scientific procedures and the conceptual exposition, together with an improvement in the awareness of the need to preserve geodiversity, specifically related to the region around the school.

Semken et al. (2017) after elaborating a review of theories and methods of research in teaching of geosciences that using the place around the school (PBE), published in journals and textbooks of geosciences or environmental education recently related levels and situated in different places, regions and cultures, underline the transdisciplinary character of this model of place-based teaching. The authors divided the research into five parts, elaborating a review related to the theoretical structure for the EBP in the teaching of geosciences, analyzing the factors used in formatting curricula, evaluating the significant impacts on learning, and giving some examples regarding the use of PEB in different places and cultures, as well as providing guidance on the use in research, practice and evaluation in the teaching of geosciences by this method.

In this perspective, it is proposed that students' interaction with the environment, specially using the local environment of the school, from the elaboration of a scientific research, together with a group of 38 students from the 1st series of the technical education in Chemistry integrated to high school, of a public educational institution, located in the São Paulo municipality of Itapira. This research will be developed during 2 months of the Experimental Chemistry Topics (TQE) in 2017.

This research uses the proposal based on scientific research, in which the TQE' teacher acts as a teacher and researcher of their practices, seeking to enable students to carry out research using the environment of the school itself to build knowledge and skills provided by the practice of field visits.

The objectives of this research are to enable students to construct scientific knowledge about the terrestrial environment present in the school area, interrelating them with concepts worked in the classroom, as well as develop skills aimed at critical and reflexive observation, through insertions in the environment next school.

2 Methodology

Using the assumptions of Marques & Praia (2009), it is proposed to explore the environment of the school, to promote didactic excursions for field visits, together with a group of 38 students of the 1st grade of technical education in Chemistry integrated to the medium, brazilian public school in the São Paulo municipality of Itapira. The teacher who will also act as a researcher will mediate external and internal research activities to the classroom, from visits to a rocky outcrop located inside the school area, so that students identify the rocky, mineral and chemical composition of this outcrop, as well as, to build possible relations between knowledge, from this scientific research.

The activities will be developed during classes TQE, comprising 6 weeks and totaling 18 hours of 50 minute class.

In the first week a dissertation questionnaire will be applied so that the students respond individually to questions that focus on the establishment of relations and interactions of contents in Chemistry and Geography, according to the course's curriculum (São Paulo 2016). The questions elaborated by the professor-researcher are based on definitions of rocks and minerals, the genetic classification used for rocks, the types of chemical bonds established between components elements of rock forming minerals and chemical elements most commonly found in the earth's crust.

In the second week students in groups of 4 to 5 individuals will make two field visits in an area with a rocky outcrop located inside the school itself to collect and record data and information about the rock present in this area.

Over the next three weeks, group students will develop research activities from documents, databases and maps available on electronic websites of national and international teaching and research institutions, in order to identify the type of rock present in the outcrop, its classification, mineral and chemical composition, using the data and samples collected in the field visits.

In the sixth and final week, the initial questionnaire will be reapplied, to verify the knowledge acquired by the students, from the research development.

The methodology used to evaluate and categorize students' answers in the dissertationary questionnaires before and after the project will be based on the qualitative analysis of Flick (2009).

3 Results and discussion

3.1. The Field trips

In the verification of the groups annotations, referring to the first field visit (Fig. 1), teacher found that all groups pointed out some caracteristics for the outcrop rock, relating the presence of light and dark lines, cracks, bright spots and folds. In addition, most of the groups pointed out the presence of dark patches caused by the deposition of water, besides the presence of soil and vegetation, in some points protruding from the rock.

Figure 1. Students during the first visit to the outcrop (Source: Authors)

The following week, after the teacher's guidance on the use of the GPS application for mobile phones: GPS Status, students downloaded this application in at least 2 members' cell phones in each group and moved to the same location of the previous visit (Fig. 2), did collect and recording data regarding the latitude and longitude of the outcrop site.

Figure 2. Students during the second visit to the outcrop (Source: Authors)

During the verification of the geographic coordinates, there was a debate between the groups regarding the coordinates of the area and they agreed on the latitude and longitude of that point, registering 22º26'47 "S for latitude and 46º50'19" W for longitude.

We agree with Campos et al. (2011), when these authors argue that different skills such as observation, expression, communication, manipulation, questioning and debates, directly contribute to the formation and development of the students. Providing also important moments of knowledge building among students.

Silva & Carneiro (2012) also corroborate the demarcation on the use of technologies in teaching, pointing out that:

> Geotechnologies can and should be used in educational activities, such as didactic tools adapted by the teacher according to their objectives and their mastery of the content, and can make classes more attractive and, at the same time, contribute to more formation of the students (Silva & Carneiro 2012, p.340).

In this context, the insertion of the technology to provide the georeferencing of the area with the students, culminated in the development of a new experience by the students, since they manifested themselves to the teacher, who they never practiced this activity.

When we analyzing Marques & Praia (2009), they point other educational implications are related to thoughtful observation, cooperative work, decision-making, as well as the probabilistic aspect, emanating from the elaborate and consensual. This results they were obted with latitude and longitude register between the groups, from the study object: rock outcrop.

2.2. Investigative research from the field visits

Over the next three weeks, the groups attempted to identify the possible types of rocks present in the outcrop area, using the data and information recorded in the field visits and the bibliographic sources for consultation, from of IPT (2013) and the virtual museum Heinz Ebert, available respectively in the electronic sites http://www.preventionweb.net/applications/hfa/lgsat/en/image/href/3118 and http: //www.rc.unesp .br / museudpm / banco / index.html. The students agreed that it was a metamorphic type rock, punctuating gneisses and migmatites present from Amparo Complex, belonging to the Andrelândia Group, according to the geological map of the municipality.

However, when asked by the teacher to identify whether the rock present in the outcrop was a gneiss or migmatite, three groups pointed to the rock as a migmatite and the other six groups pointed to the rock as gneiss, also identifying their respective mineral compositions and the aproximate chemical formulas of the minerals in the white board (Fig. 3).

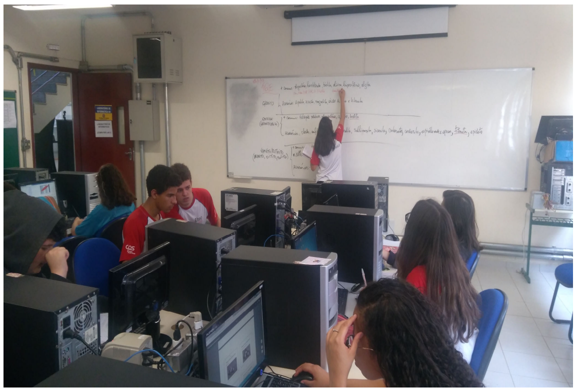

Figure 3. Students identifying and characterizing the rock outcrop samples (Source: The authors)

On the basis of these findings, teacher proposed to the groups another field visit to the outcrop (Fig.4), which culminated in a broader record of the rock characteristics present in this area, highlighting the prevalence of white lines with dark bands, and later on, the students characterized as the presence of leucosomes in the metamorphosed rock structure, as well as granite rock sections, which after students were searching and comparing with digital images available in the Heinz Ebert Virtual Museum, they agreed that the rock is a migmatite.

Figure 4. Students with teacher during a visit (Source: Authors)

To complement the approaches, teacher provided samples of the minerals of his own collection, at the beginning of the fifth week of the research work (Fig. 5). The students had direct contact with samples of quartz, feldspar, biotite and epidoto which are minerals commonly found in the composition of migmatites, as well as samples of accessory minerals apatite, garnet, zircon and muscovite.

Figure 5. Students manipulating mineral samples (Source: Authors)

The students also searched the possible types of intramolecular chemical bonds, which may occur between the components of minerals present in the rocks, pointing to covalent and ionic bonds, after consulting the textbook (Santos & Mól 2015).

In this way, the teacher based on Wicander & Monroe (2009), complemented that there are also the metallic and van der Waals, existing in elements that make up crystalline reticles of minerals, in addition to those pointed by the students.

Regarding the attempts of interpretations of data recorded and collected in the field, by the students, as well as the propositions of these in explaining the composition of the outcrop rock, characterizes a probabilistic dimension of the activities outside the classroom, recognized and pointed out by Marques & Praia (2009).

The research activities allowed students to take the center of the teaching and learning process, and teacher to promote and orient the interactions experienced in the didactic-pedagogical process. Since teacher, who also assumes the role of researcher in the activities, tried to establish search for the build knowledge in order to students, through the orientations that he made to the groups. Taking students to develop autonomy and cooperation in their own teaching processes, which are also highlighted in the proposals of Marques and Praia (2009).

2.3. The application of the questionnaire

In the sixth and final week, teacher reapplied the questionnaire individually to the students, organizing the questions (Q) with the answers in before (RA) and answers after the project (RD), in order to compare with the results obtained with the development of the activities by the students, which were

Q1. What are rocks?

RA.1: (31%) Solid materials that may have minerals; (36%) Materials formed from magma; (18%) Materials consisting of sediments; (3%) Matrices formed by the movement of tectonic plates; (3%) These are minerals.

RD.1: (97%) Natural solid aggregates having one or more minerals in their composition; (3%) Materials formed in chemical processes.

Q2. What genetic classification is commonly used for rocks?

RA.2: (45%) They do not know; (18%) Sedimentary, metamorphic and igneous; (18%) Igneous; (8%) Metamorphic and sedimentary; (8%) Igneous and sedimentary; (3%) Sedimentary.

RD.2: (97%) Natural solid aggregates having one or more minerals in their composition; (3%) Materials formed by chemical processes.

Q3. What are minerals?

RA.3: (33%) Materials released by rocks / sediments; (25%) Do not know; (15%) Soil material, microorganisms; (5%) These are types of rocks.

RD.3: (100%) Crystalline solid natural compounds, are found in rocks or pure, have defined chemical composition, with small variations.

Q4. What types of intramolecular chemical bonds can occur between the elements that make up the minerals?

RA.4: (78%) They do not know; (11%) Ionic; (9%) Ionic and covalent; (2%) Metallic.

RD.4: D (89%) Ionic, covalent, metallic and van der Waals; (5%) Ionic and covalent; (6%) Do not know.

Q5. What are the chemical elements most found in the earth's crust?

RA.5: (18%) Al, Ca, Fe, O, Mg; (81%) Other (Au, Ag, Ni, Cu, Pt, Sn, P, Zn).

RD.5: (92%) O, Na, K, Si, Fe, Ca, Al, Mg; (8%) Others (For example: S, C).

In addition, the teacher applied two other essay questions that were not applied to the students prior to the works, which were research materials by the students throughout the investigations. These issues were:

Q6. What is the name and the classification of the rock of the area visited?

(79%) Migmatite and metamorphic rocks; (10%) Granite and igneous, (3%) Gneiss and metamorphic, (8%) did not know.

Q7. What are the uses of this type of rock by society at present?

(96%) Used in production of crushed stone, asphalt, or in the manufacture of sinks, tables or partitions (4%) They did not know.

2.4. Analysis of questionnaire responses

When comparing the answers of the questionnaires, before and after the project, there is a better understanding of contents, evidenced by their more elaborate answers.

Regarding questions 1 and 2, the majority of students after the investigations, ie 97% and 89% respectively, related the rocks to natural materials formed by one or more minerals and that the classification for the rocks is closed to the three types: igneous, metamorphic and sedimentary.

Regarding the definition of minerals and the types of chemical bonds present in minerals, referring to questions 3 and 4, respectively, all students commented that they are pure crystalline chemical compounds found in rock, with chemical composition with few variations, and 89% opted that ionic, covalent, metallic and van der Waals bonds can be found in the composition of the chemical structures of the minerals.

With regard to the most abundant types of elements in the earth's crust, it was evident that the research activities used to survey the molecular chemical formulas of the possible minerals that could constitute the visited outcrop as well as the investigations from the contents of the digital sites were preponderant for 92% of the students to point out elements such as O, Si, Fe, Al, K, Ca and Mg as constituents most found in the earth's crust, altering the students' perceptions after the investigative activities.

Notoriously, the research activities contributed significantly to the construction of this knowledge, in addition to those that were articulated to seek relations for the complementary questions, since most of the students managed to weave adequate responses to the type and classification of the rock present in the outcrop (79%), and (96%) made notes on the use of migmatite as materials also used in basic industries such as asphalt and gravel. It should be noted, then, that they related the use of gneiss as being the same for migmatite.

4 Final considerations

The proposal of scientific research from the school environment provided to a significant evolution in the appropriation, construction and interaction of knowledge in Chemistry, Geography and Geology by the students participating in the research.

The involvement and collaboration between students in this type of investigative educational approach was notorious, since the search to identify the types of natural materials present in the outcropping was very expressive.

Another important factor in relation to students 'involvement was the didactic practices based on the use of technological resources, configuring themselves as a developer of skills in the search and build cientific knowledge, increasing the students' competence, mainly regarding the use GPS applications and digital scientific data sources.

The use of the didactic book made it possible to check for conceptual errors in the books which can lead to the development of reflection and critical sense by the students.

We agree with Marques & Praia (2009) that there are significant improvements in students' learning and comprehension in relation to content worked and articulated by activities outside the classroom. The natural physical environment, besides stimulating the formation of specific attitudes and abilities with the students, proporting better constructions of the knowledge by the students.

We acknowledge that there were many opportunities to articulate other contents in Chemistry, Geography Geology and from other areas, but we have tried to limit the investigations, in order to beginning of works of this nature with this group of students, waiting to evolve complex works in the in the future, together with this group.

Notoriously, the articulation of common knowledge and practices of the teaching of Geosciences, allowed articulations between contents of different areas, provided the contextualization and interactions between knowledge, that commonly articulated in schools, in a watertight way and without meaning for students.

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THERE ARE NO ROCKS IN THE AMAZON! THE PHYSICAL LANDSCAPE OF THE AMAZON REGION AS SEEN THROUGH THE EYES OF LOCAL SCHOOL STUDENTS

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Abstract— This study aimed to investigate the knowledge of 9th grade students regarding the physical landscape of the Brazilian Amazon. The research was carried out with 25 students from the Center for Education which is located in the city of Manaus, Brazil, and belongs to the network of full time public state schools. The research was conducted by questionnaires. The results indicated the students know little about the physical landscape elements, rocks, relief and soil. There is a need to create education strategies so that the scientific production related to the Amazon physical landscape reaches basic education. That knowledge produced in research institutes should be available and dialogue in a recurrent way with the students, respecting the characteristics and the purposes of this level of education.

Keywords— Teaching of Geosciences, basic education, Amazon.

Thematic line— Geosciences and Natural Sciences for Basic Education.

1 Introduction

The objective of this work was to investigate the knowledge of elementary school students regarding the physical landscape aspects of the Brazilian Amazon.

The Brazilian Amazon is a region that encompasses the states of Pará, Amazonas, Acre, Rondônia and part of Maranhão, Tocantins, Mato Grosso, Roraima and Amapá. It is a vast world of water and forests, composed by several ecosystems that interact in time and space. The knowledge of the natural elements is strategic for the development of the region.

The understanding of the geology, relief, climate, soil, hydrography and vegetation characteristics of the Brazilian Amazon landscape, as well as the factors that originated them and the processes of interdependence between them are studied in the discipline Geography in Elementary Teaching II.

The research was carried out at the Full Time Education Center which is locate in the city of Manaus and belongs to the school network of the State of Amazonas, Brazil. The choice of a school in the city of Manaus for this study was due to the fact that the capital city of the State of Amazonas was set up as an urban center that was structured in the inner part of the Amazon forest on the left bank of the Rio Negro, constituting what Becker (1995) called "urbanized forest". Manaus is the Amazonian capital with greater expressiveness and regional influence. The 9th grade class was chosen because they are in the final stage of elementary education and can take advantage of all the learning they have had in this stage.

This article is derived from the PhD project developed at the Graduate Program in Teaching and History of Earth Sciences of UNICAMP by Marcela Mafra. The objective of the doctoral project is to investigate the students' perception of elementary education in relation to the physical landscape elements of the Brazilian Amazon.

2 Methodology

This research is characterized as a case study, with a descriptive approach in which 25 students aged 14-17 participated, and more than 80% of respondents were 14 years old. The students were studying the 9th Year of Basic Education in a Full Time Education Center, located in the South-Central Zone of the city of Manaus, State of Amazon, Brazil.

This school was selected because it is a partner of the State University of Amazonas in the development of projects aimed at initiating teaching. The students were chosen through simple random sampling.

Questionnaires were used to perform the research. All questionnaires were identified with alphanumeric codes from A1 to A25. For the application of questionnaires, there was the initial contact with the manager and the pedagogue and a short presentation on the project as well as on the Certificate of Presentation for Ethical Appraisal (CAAE) approved under n. 62764116.2.0000.5404 and the authorization of SEDUC issued by Oficio n. 4086/2016-GS/SEDUC AM.

The questionnaire was divided into two parts:

a) First Part: To identify what the students knew about the physical elements of the Brazilian Amazon, the words relief, climate, vegetation, rocks, soils and hydrography were arranged in a table and explained that they should register next to each word all they knew about these terms for the Amazon.

These data were tabulated and analyzed using descriptive statistics;

b) Second Part: After the free registrations, a question was posed which answer involved the relationship between several physical elements: Why does it rain a lot in the Amazon? What do you know about the Amazon?

The questionnaire open question data were classified through the Content Analysis proposed by Bardin (2016), which consists of a set of communication analysis techniques that uses systematic procedures and objectives to describe the content of messages.

Based on the Content Analysis, the descriptive treatment of the registered information of the students participating in the research and the Categorical Analysis, which is an operation of classification of constitutive elements by differentiation, were performed. Then the results were regrouping according to the gender (analogy), with the previously defined criteria. That is, they consist in delimiting into categories, elements of meaning, contained in the answers.

3 Results and Discussion

The data presented in figure 01 show the expressive number of students who did not record any information with respect to the physical landscape elements of the Amazon region, especially rocks, soils, relief and vegetation. Related to rocks, Almeida (2015) states that the "unpopularity" of the geological knowledge may be related to several factors being one the fact that most people are more interested in living beings than inert ones.

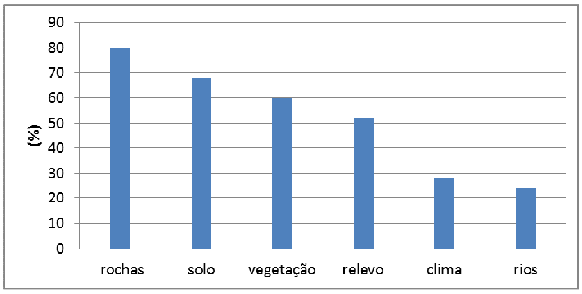

Figure 1. Number of blank records of students referring to physical elements

It is believed that the high blank number in relation to the vegetation, which is the most striking aspect of the region, may be related to what was perceived by Freitas & Ferraz (2009) who identified students do not perceive the urban forests as portions of the forest and have the feeling that they know little or nothing about the natural rainforest.

Looking at the various parts of the questionnaire we highlight the following observations.

In relation to the term "rock", 80% did not make any record about the rocks of the Amazon, indicating a possible unknown, allied to that 8% assure that there are no rocks in the Amazon, 4% affirm that it is difficult to find rocks in the Amazon and 8% claim that rocks are stones.

In popular language rocks are considered as stones. Although students do not use the specialized terminology, the concept is correct. However, in conceptualizing, they did not describe any characteristic of the predominant rocks in the region. The statement of lack of rocks in the Amazon is due to the context where they live within this immense region, since it is not at all easy to see outcrops of rocks in Manaus.

As far as soil is concerned, only 32% of the students did some registration, of these, 20% only state soil is the equivalent of land, 8% say soil is fertile and 4% describe soil as acid and with low fertility..

The vegetation of the region is described as predominantly of tropical-Amazonian forest, diversified, with fruit trees. There is only one record that pointed out that although the state has a dense forest, the city of Manaus does not have much vegetation due to the predominance of built areas.

More than half of the students did not make any records regarding the relief, 24% defined the term relief as a set of forms, represented by plateau, plain, lowland and mountain, 12% characterize the Amazon relief as being predominant of lowland and another 12% said that in the relief of the region predominate the plateau and the plain.

The climatic and hydrographic aspects were the ones that had more records, more than 70% of the students described the characteristics of the Amazon relative to these two elements.

Regarding the climatic characteristics, 48% of the students highlighted the high temperature and humidity of the region, which is consistent with the remarkable characteristic of the Equatorial Climate that has average annual temperatures between 22° and 28° C. The remaining 24% only conceptualized the term climate and cited the zonal climates, but with regard to the various aspects that characterize and determine the climate of the Amazon region there were no records.

The Amazonian rivers show large flow, differing in their coloring due to the geological and geomorphological structure of the spring sites, the morphology of the river beds and the suspended material. Sioli (1985) classified the Amazonian rivers in relation to color in white water rivers (muddy water), clear water rivers and black water rivers. In describing the characteristics of the Amazonian rivers, 28% of the students registered the names of the rivers of the Amazon Basin, especially the Amazonas, Negro and Solimões rivers, 24% highlighted the magnitude of the Amazon River, 8% called attention to the fact that the rivers have characteristics of having their fresh water suitable for consumption, and 8% did not mention specific characteristics of rivers in the Amazon and conceptualized the river element only, and the other 8% recorded river use by riverside dwellers and its use as a way of transporting people and goods in the region.

3.1 Interrelation between the natural physical elements of the Brazilian Amazon

In the Amazon rainfall is significant throughout the year. Even in the "dry" months, rainfall is high compared to precipitation in other areas. The students were asked "Why does it rain a lot in the Amazon?" and 32% did not respond and the other 68% attributed the high rainfall to the factors: 12% stated the geographic location is responsible for the higher incidence of solar rays because they will contribute to generate intense evaporation, 16% believe the moisture from the Atlantic Ocean that travels from east contributes significantly, 16% highlight the role of forest evapotranspiration, 16% attribute high precipitation to the process of evaporation of rivers and among the other 8% say that it does not rain much in the region.

Interestingly the student A14 said: "a tree releases a lot of water per day, thousands of them release much more, as it happens here. There are flying rivers with thousands of drops of water "and the A16 student who points out that it rains a lot because" the moisture that comes from the Atlantic Ocean and gets loaded in our region, then travels to the south and southeast. "

Nobre (2014) points out that tropical forests are much more than an agglomeration of trees, passive repository of biodiversity or simple carbon stock. For the author, the living technology of the forests and the dynamics of interaction with the environment gives them power over other landscape elements, including the climate. It is notorius in most of students' responses that they recognize the role of forests in climate conditioning and in the process of rainfall formation.

Another question asked was "What do you know about the Brazilian Amazon?". About 90% of the students responded to this questioning. The responses were analyzed in order to identify which physical elements were investigated.

In describing the Amazon, most of them do it from the point of view of the majestic forest predominantly, some still highlight the following attributes: "lung of the world", very large, rich in plant diversity. Another aspect recorded is the hydrography of the region, especially the fact that it is the largest and longest river in the world. It is evident that the students present the Amazon of the superlatives.

What is striking is that relief, geology and soil are not described in any answer.

In a similar research on environmental perception, Freitas (2013) verified the representations of the students of the distance learning course (Curso Regular de Educação a Distância do Colégio Militar de Manaus) of the poles of Tefé and Tabatinga with respect to the Amazon. He found that in the universe of these students, who come from several Brazilian states and live in these localities due to the transfer of their parents, the representation of the Amazon is related to the forest, indigenous population and social problems. Silva (2017), in a research study with high school students in the city of Manaus, states that the absence of regional geography in the school curriculum makes it impossible for students to have a holistic view about the Amazon, making them incorporate a vision formulated by media.

These observations resulting from research with Amazonian and non-Amazonian students are supported by Tuan (1980), who emphasizes that the visitor and the native perceive very different aspects of the same place. The visitor's perception is reduced to composing pictures, because the visitor judges by appearance and beauty, while the perception of the native is complex derived from his immersion in the totality of his environment. In the current study, it is perceived that the view of the native students of the Amazon is similar to the view of the students coming from other states, recently arrived from other regions of Brazil.

This may be related to the lack of a discipline that addresses the specificities of the region, the scarcity of didactic-pedagogical materials related to the Amazonian contents, the poor contextualization in classes and the fact that the research was carried out in a school located in the urban area of Manaus, a regional, highly urbanized, industrial, poorly forested metropolis that differs totally from the widely publicized image by mass media.

Thus, if the Amazon, especially with respect to its physical-natural aspects is little discussed in the classroom, if the student's place of living is urban and if this student travels little within the state of Amazonas and Amazon region, the student's perception is directly influenced by images and information disseminated by mass media that always give more prominence to the forest.

4 Conclusion

In this article, we sought to learn about the social representations built by the students about the Amazon in terms of their physical aspects.

The analysis of the data allows to affirm that the students who participated in the research presented difficulties in describing the characteristics of the region, mainly with respect to geology, relief and soil. This is clear in two moments in the first part of the questionnaire when they should have recorded all the information that they knew about these elements and they did not do it. This is evident in Figure 01 which shows the high percentage of blank answers. Even those students who responded to the questions made conceptual errors or showed difficulty systematizing ideas. The second moment is when the students were asked to explain why it rains a lot in the Amazon and no answer pointed out the contribution of relief in this process. In the question which students were asked to describe the Amazon there was also no mention about the rocks, relief and soil. They only described the Amazon was from the forest and the water courses perspectives.

It is necessary to reflect on what are the obstacles for the knowledge produced on these elements to reach the school. Almeida et. al. (2015) point out there are difficulties in disseminating specific geological knowledge since work on a local scale is generally developed in academic circles and textbooks adopted in schools use more global examples and geological illustrations, which are important but do not always bring the specific contribution the teacher wants or needs.

In a research with teachers, Roque Ascenção (2004) states that there are teachers who disregard working with the physical aspects of the landscape because they consider some elements very abstract, such as relief.

With regard to climate, students demonstrated knowledge by explaining the factors that contribute to high rainfall in the region resulting, which result from the combination of several factors. Some of these factors were described by students, such as geographic location, river evaporation process, ocean moisture transported to the region by winds from east, and the role of the forest in this process through intense evapotranspiration. Hydrography and vegetation were also described by students, but without much familiarity and without being based on scientific concepts.

Finally, it is important to emphasize that it is necessary to create mechanisms so that the knowledge produced on the Amazon in research institutes and institutions of higher education reach basic education and become content in a recurrent way with the students, respecting the characteristics and the purposes of this level of education.

This research provides information about students' previous knowledge on Amazon and can be useful for the elaboration of teaching strategies and didactic subjects focused on the contents of the physical geography of the Amazon.

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Thematic Line

Geosciences in Higher Education

ACADEMIC MONITORING: REPORT OF THE ACTIVITIES DEVELOPED IN DISCIPLINE OF FUNDAMENTALS OF GEOLOGY

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Abstract—The present article will discuss the experience in activities developed in the Academic Monitoring, during the year 2017 in the course of Geography of the State University of Mato Grosso do Sul which presents in its curriculum of the 1st year, the discipline Fundamentals of Geology. The main objective was to collaborate with the discipline in a didactic way using laboratory materials, fossil replicas kits, rocks and minerals, among other tools needed to analyze characteristics of lithology and approach to geosciences in Higher Education. Above all, the result of this work has had important effects for the Geography course, for the academic monitor, for the teacher and for future work to be developed in the pedagogical field.

Keywords—Higher Education, Geosciences, Academic Monitoring.

Thematic line—Geosciences in Higher Education.

1 Introduction

The course of Geography of the State University of Mato Grosso do Sul, University Unit of Jardim, presents in its curricular curriculum the discipline Fundamentals of Geology, taught in the 1st year of the course. The Institutional Monitoring Program provides the student who is approved in the course, the opportunity to act as a monitor the following year, assisting other academics in the accomplishment of discipline activities and content setting.

The teaching of Geosciences is an essential part of the degree course in Geography, in the disciplines of the physical area, whose theme is focused on the preparation of future teachers of basic education in the disciplines of Science and Geography. According to Carneiro et al. (2004), the classrooms during the work with geoscience contents should allow the students to visit and investigate the geodiversity of the place where they live and with which teachers and students relate. According to Alencar et al. (2012) to know the origin, the processes of formation and interactions with the biotic beings, the geological heritage gains value, justifying the efforts for its conservation.

Since the first semesters of the degree course in Geography the academics are directed to the development of actions that aim to develop important skills for the future teacher profession, such as seminars, fieldwork, laboratory activities, participation in different levels of congresses. It is worth mentioning the University's incentive to promoter search initiation, search for investigative knowledge and, in addition, to incorporate the epistemic process Severino (2013).

In this context, the academic monitor has the function of assisting the discipline that is willing to work together with the teacher, attending in particular to doubts, practical activities in the laboratory and fieldwork whose sharing of knowledge among academics reinforces the course community. There are many positive aspects of a monitor's task, especially personal, academic and professional growth. The present work was developed for 9 months during the year 2017 (between February 22 and December 6), which various activities were developed by monitoring the discipline of Fundamentals of Geology. Given the relevance of some actions carried out during the monitoring, the ones that had the greatest contribution to the discipline of Geology: Paleontology Workshop; Production of mockups on Earth's convection currents and dynamics of Tectonic plates and Rocks and Mineral Workshops.

2 The monitoring

Fundamentals of Geology is an important discipline of the Geography course because it introduces valuable concepts of Geosciences for the understanding of the origin, evolution and constant transformation of the planet. The contents worked involve the reading of natural aspects of all Earth systems, studies of physical maps, chronostratigraphic and geological tables, classification of lithological materials, as well as several topics that seek to bring the student closer to the surrounding geoscience.

2.2 Materials and methods

Throughout the academic year of 2017, the activities developed in the monitoring were designed and executed according to the necessity of increase and enhancement of the content taught in class (Tab. 1). The activities of the CEPEMA - USP is an acronym for Center for Research in the Environment of the University of São Paulo through the project CAP is an acronym for Researcher Apprentice Center were also implemented, which has been working since 2013 on the activities of various areas of the natural sciences, for schools in the Metropolitan Region of Baixada Santista and which, in turn, supports the expansion of scientific literacy. CEPEMA's Geosciences activities were previously adapted to the local reality, as well as the level of deepening, use of equipment and local geological context.

Initially, the theme focused on the origins of life on the planet was deepened by the teaching workshop with the use of kits of replicas of fossils produced by the Museum of Geosciences of the University of São Paulo. Each student randomly chose two replicas of fossils (Figure 1) and according to the information contained in the identification plates of each one, answered the investigative questionnaire with comparison and identification of the age of the fossils observed next to the geological table.

The second major activity (Fig. 2) was the convective currents of the interior of the Earth based on the concepts presented in Christopherson (2012). In the laboratory the process was exemplified by moving water molecules with different temperatures (hot and cold) using a glass box (approximately 40 cm^3) with water at room temperature, 200 ml of heated water, 200 ml of cooled water, red and blue colorants for temperature differentiation and two *Erlenmeyers* for submersion of the cooled water and the heated water under the main vessel.

Third proposed activity involved the production of three-dimensional models with representation of the dynamics of tectonic plates in different geological contexts (Figure 3). Were made as vertical clipping diagram blocks of the surface layers of the planet, with emphasis on the result of movements tectonic plates under the earth's relief. The mockups with better quality and representative ness were designed for schools in the region.

Fourth major activity carried out by the monitoring, entitled Workshop of Rocks and Minerals, contemplated all the processes studied during the academic year in the discipline, making use of important bibliographies (Christopherson, 2012; Grotzinger and Jordan, 2013; Popp, 2010; Teixeira et al., 2008). During the activity, the students randomly selected three rock samples (Figure 4) and analyzed their main characteristics (hardness, porosity, coloration, cleavage, classification, weight and density). Using magnifying glasses, scales, sharp objects of hard material for hardness evaluation, and fundamental communication and collective cooperation, each student fully responded to the questionnaire proposed in the activity. The preparation of didactic materials accompanies the development of teacher education, essentially using the capacity to deal with theoretical, methodological and reflexive aspects that stimulate research and enrich education Santos (2014).

3 The analysis

In view of the results obtained from the 01 Paleontology workshop, it was possible to provide positive points about the students' involvement, the practice attracted the attention of many, having an effective participation of them, for the discipline since Paleontology is a new subject and that allows numerous didactic approaches of the content. In this sense, the involvement and participation were the main notes of the monitor.

The theme discussed in workshop 02 on convective currents is a very abstract concept for academics recently enrolled in the university. Many have not even had contact with this content in basic education, in addition to other limitations such as a very long period out of school and have now returned to complete their degree. In addition to these limiters, we have identified difficulties in correlating important concepts related to the internal dynamics of the planet, such as layer density, layer position, heat propagation. After the realization of the workshop, the understanding of movement of masses of heat and cold became somewhat clearer in the context of Geology, according to the participating students, it changed the view of the academic before the possibilities of presenting a complex subject, since the presentation of a practical methodology ended the anonymity of the theme.

Table1. Short description of each activity in chronological order

Order	Activities	Description
1ª	Paleontology Workshop	Exhibition of fossil replicas, for observation and various practical activities.
2ª	Experiment convection currents of the Earth	Experiment in laboratory, simulation of a process that takes place inside the Earth, energy in movement. Earth's convection currents.
3ª	Mockups – Dynamics of tectonic plates	Representation of the movements between tectonic plates, their limits, convergent, divergent and transforming and transformations in the earth's crust
4ª	Rocks and Minerals Workshop	Sort, organize, and describe rocks and minerals from their characteristics.

Figure1. Scenes from the workshop on fossils. a) Academic selection of fossil samples and replicates; b) analysis activity of the fossil material

Figure 2. Scenes of activity on convection currents. a) Involvement of academics in the preparation of the experiment; b) final result of the experiment

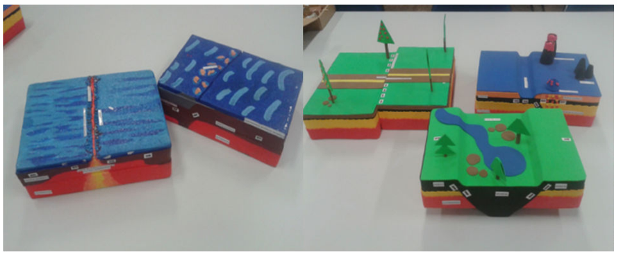

Figure 3. Final products of the activity related to the dynamics of tectonic plates, representation model

Figure 4. Workshop scenes on rocks and minerals. a) Selection of samples from different geological and mineral groups; b) Lithologic laboratory collection.

For activity 03, the tectonics content approach was introduced cautiously so that few doubts would arise during the preparation of the models, however the final results of the works were not entirely satisfactory, since the students' greatest difficulty was to represent the characteristics from the lithosphere of the micro scale (block diagram images) to the macro scale (styrofoam model), this made the graphical representations very confused and untrue to reality. On the other hand, some models obtained positive results in their representations of the geological formations, the students who triggered the doubts in extra - class moments, were the ones that obtained better results in the end. For the monitor, every effort to elaborate the proposal, select images of representation and organize the groups, was valid and extremely important in the training as an educator, because it required dedication to discipline and enough knowledge to the content besides being able to deal with the difficulties of the students.

For the activity 04 Workshop of Rocks and Minerals, the fundamental analysis that was done of the practice was approach of the students with the discipline, since the subject of the Geology approached during all school year and all introduction to Rocks and Minerals had been worked in room of the workshop effectively contributed to the knowledge of the content. The students participating in the workshop exceeded the expectations of the instructor, as they were able to develop the recognition of the different classifications of rocks and minerals, a fundamental proposal of the workshop.

4 Conclusion

The observation that is made from the subjects involved in the activities, academics, teacher and student-monitor, corroborates with the statement of Manosso and Basso (2009), "*the knowledge about how the Earth works can cause a real modification in the relations that each person has with the environment, as well as the way they see the world around them*."

The production of knowledge and the sharing of experiences in monitoring can give the academic a broad involvement with the teaching activity and bring it closer to the professional reality. Direct contact with the teacher generates important information exchange for the academic monitor in order to guide their professional and intellectual future. In addition to all expectations in contributing to the discipline, it is possible to identify the willingness to solve various problems that all the daily texts of the University can promote. In view of the results observed and discussed during the academic year, we conclude that the materials and the applications of these materials contributed positively to the discipline of Fundamentals of Geology. In addition, many people have benefited, since the final products of the third activity, or mockups were donated to schools in the area of the city garden.

In spite of all the efforts of monitoring, performing different activities that will help the teacher and the future teachers with an example of practical actions for the contents listed, there is a great barrier to be overcome by the academics, which is the personal motivation to seek the knowledge of the students. content and more complex concepts of Geography and Geosciences present throughout the course.

Acknowledgements

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CASE STUDY: UNICAMP UNDERGRAD STUDENTS GEOSCIENTIFIC KNOWLEDGE

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Abstract— Geology and its basic contents are dispersed among some disciplines in Brazilian compulsory education. At higher education some students choose courses that require a consolidated understanding of these concepts. This is the case of civil engineering and biological sciences, which have in their basic curriculum a geology discipline. The professors who teach these subjects in these courses generally have the expectation of being able to deepen the contents in order to apply the concepts of geosciences to the respective areas. However, after the application of questionnaires at the beginning of the academic semester, it was possible to note that the necessary basic geoscientific information is little assimilated by the students. Subjects such as geologic time, rock cycle, absolute and relative time do not seem to be clear to these students. Only the theme of plate tectonics has shown more concise and correct results in the analyzed groups.

Keywords— Inventory, concepts, Geoscience, Geology, indirect approach.

Thematic line— Geosciences in Higher Education.

1 Introduction

Higher education must involve specific contents of each area and their comprehension and deepening depend, in general, on the content already addressed and assimilated by students in their previous years (compulsory education). Deficiencies in teaching geoscientific contents and its importance in the formation of citizens with greater critical capacity and a "safer, healthier and more sustainable" society have already been pointed out (Carneiro 2008).

For those who teach classes in higher education, there is always a doubt (in a first contact with the group of students) about how much they know about the contents of high school and how much should be remembered / reinforced in their classes. A practical step to sort this out is to apply a questionnaire at the beginning of the semester, as a way of ascertaining the knowledge acquired in previous years.

Biology and civil engineering are two different courses that require that geoscience concepts are well understood for adequate development of specific classes. For civil engineering, geology knowledge is the background for geotechnical engineering (soil mechanics, rock mechanics and earthworks). Geological basic concepts are also important for Biology courses. Geoscientific contents such as development of life on Earth and the planetary changes throughout history are essential issues for the correct understanding of paleontology contents.

Furegatti & Abreu (2011) evaluated how much geoscientific knowledge had been assimilated by first year undergraduate students in compulsory education. They applied a questionnaire with direct questions like "Did you learn about rock types?". These authors pointed out that content like "minerals", "rocks origin", "soil origin", "geological time", "wind and coastal processes" should be reinforced in their geology classes for civil engineering undergraduate courses. Other contents like "plate tectonics", "current climate and climatic zones", "hydrological cycle", "groundwater", "relief formation" and "river evolution" were better understood by the students. However, an application of questionnaires with direct questions does not detect how much of the geosciences concepts have been assimilated by the students. These questions just detected if the student remembers or not having dealt with the subject at some point.

The current paper presents the results of a questionnaire applied to biological sciences and civil engineering undergraduate students from University of Campinas (Unicamp), in São Paulo state, Brazil. This questionnaire is composed of questions that bring different geoscientific contents in an indirect way and that were elaborated specifically for the contents related to the geosciences.

2 Materials and Methods

The questions included in the questionnaire were taken from the Inventory of Concepts of Geosciences (GCI). This Inventory was proposed, tested and validated by Libarkin and Anderson (2005). It was originally prepared in English language and is available in its 3.0 version, at: https://geocognitionresearchlaboratory.wordpress.com/research-in-the-grl/research-related-to-understanding/. It consists in a list of 73 multiple-choice questions evaluated and validated to test the understanding of topics related to plate tectonics, geologic time, relative and absolute time, among others.

Libarkin & Anderson (2005) recommend choosing only 15 to 20 questions (out of 73) for each test. At first, 18 questions out of the 73 GCI questions were considered of interest for testing Brazilian compulsory education. As the tests were applied at the end of the first class, some subjects had already been dealt with during the class (for instance the inner structure of the Earth), which reduced the group of questions to be applied to only ten questions.

Throughout the translation process to Portuguese language difficulties on how to effectively translate some words were identified. For example, in GCI question 2 the word "tempo" means "climate" and "time" in Portuguese, but this difficulty could be overcome by using the word "clima" for "climate".

GCI question 47 was eliminated because the translation did not really make sense in Portuguese.

Thus, the questionnaire applied was composed of the following 8 questions (with the correct answer):

- Which of the following can be caused by wind? (Answers: Waves and Erosion)
- Which of the following can directly affect erosion rates? (Answers: Rock type and Climate)
- Which of the following best describes mountains? (Answer: Old mountains have gentler slopes than young mountains because old mountains have been wearing down longer)
- Which of the following statements about the age of rocks is most likely true? (Answer: Rocks found on continents are generally older than rocks found in the ocean)
- If you could travel back in time to when the Earth first formed as a planet, what would the Earth look like? (Answer: The Earth would be mostly covered with molten rock)
- How far do you think continents move in a single year? (Answer: A few inches)
- A scientist collects all of the fossils ever discovered into one room. This room now contains: (Answer: Fossils of a few of the plants and animals that ever lived)
- If you could travel millions of years into the future, how big would the planet Earth be? (Answer: Same size as today)

The questionnaire was applied to 74 civil engineering students (freshman year) and to 25 biology students (fourth year) at the beginning of the semester. The students had 20 minutes to answer the questions and did not identify themselves. Questions related to individual study background were also applied.

Most of the questions had only one correct answer. Question #1 had two correct alternatives and question #2 had three correct alternatives. For this study only answers in which all the correct alternatives were pointed out were considered as "correct".

3 Results

3.1 Sample Characterization

Civil engineering students who answered the questionnaire attended mostly private elementary schools (62%) and public high schools (55%). Most of them studied in the state of São Paulo (89%) and took pre-college preparatory courses (66%).

Biology students who answered the questionnaire attended elementary and high school in public schools (68% and 56%, respectively). Most of them studied in the state of São Paulo (85%) and took pre-college preparatory courses (56%).

3.2 Conception retated to geosciences themes

The results were divided by course and are presented in figures 1 and 2. As shown in these figures performance of both courses are very similar. It has been found that correct answers varied between 32% and 88% for biology students (questions 4 and 6 respectively) and between 47% and 85% for civil engineering students (questions 2 and 6 respectively).

The averages for correct answers are presented in table 1, considering the two courses together (civil engineering and biology). For most of the questions (6 out of 8) there was more than 50% accuracy in both courses. Accuracy percentages above 75% would represent a good index of geoscience contents internalization. This result may reveal that these contents have not been well understood by students in compulsory education, or the students were not sufficiently motivated to answer the questionnaire seriously.

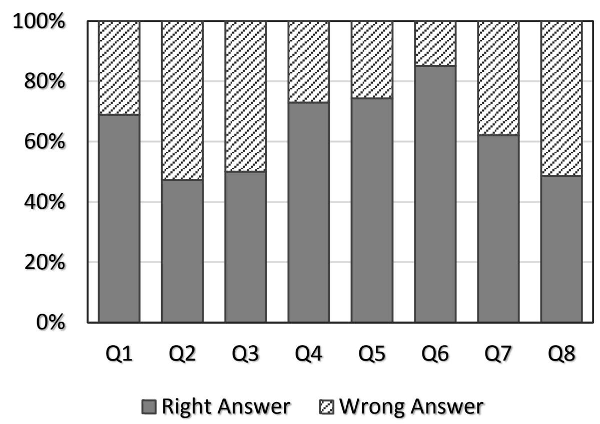

Figure 1. Questionnaire results for the civil engineering course

Both groups achieved highest 'hit rates' on the same question – plate tectonics. High school geography classes in Brazil explore this subject (plate tectonics). In addition, this questions had a more direct formulation, similar to the one in college admission exams, when compared to the other questions, that generally demanded reflection, abstraction and interconnection of contents, not having answers easily found in textbooks and / or provided by teachers in the classroom. For these reasons, low scores were expected and they are in line with the results obtained.

Both groups had a poor performance in question 2 and this should be attributed to problems in the formulation of the response alternatives, which were only realized after the questionnaire was applied. At first only one answer had been defined as corrected for this question. Later on it was realized that, depending on the interpretation given to the question, there could be more than one correct answer. Data analysis was performed based on only one correct answer and this possibly diminished the average of correct answers of both courses.

Differences in performance (comparing biology and civil engineer students) were noted only on questions 4 and 7. The reasons for a significant difference in question 4 are not clear. The related subject requires knowledge about rock cycle and other factors involved in their formation; a type of knowledge that is not directly addressed in compulsory education.

Table 1. Correct answers for both courses.

Question	Correct Answers (average)
1	62%
2	42%
3	53%
4	52%
5	71%
6	87%
7	73%
8	44%

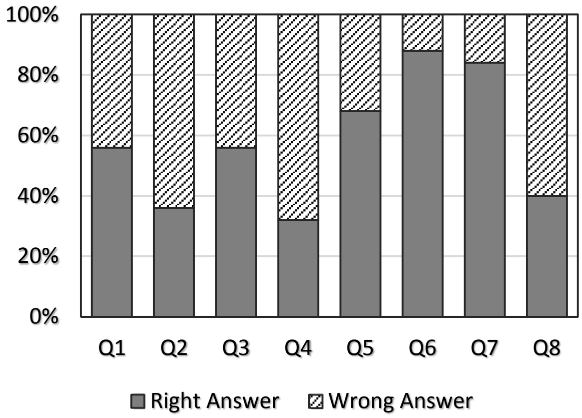

Figure 2. Questionnaire results for the biology course

Regarding question 7, it is believed that the best performance of the biology class reflects a better understanding of the diversity of life (origin and evolution of life) in this undergraduate course. Nevertheless, it should be noted that these students had not yet taken paleontology classes when they answered the questionnaire.

4 Final considerations

The application of questionnaires such as the GCI seems to be a promising way to evaluate the students' understanding of the basic geosciences concepts and to be able to compare the responses of students with diverse school background and varied interests.

All the GCI questions used present basic geoscientific contents that should have been well understood and assimilated by students during high school. The survey results showed that this had not happened. In the short term basic geoscientific content needs to be reinforced during the undergraduate courses. In the long term effort should be placed on enhancing teaching strategies for geosciences throughout compulsory education.

The authors intend to continue to apply versions of the GCI in the coming years to other classes of undergraduate students, in order to improve the data collected so far and to initiate a broader research for the diagnosis of geosciences teaching in elementary and high school education in Brazil.

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DIDACTIC ENVIRONMENTS FOR TEACHING: DEVELOPING ABILITIES IN GEOLOGICAL 3D VISUALIZATION

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Abstract— Any geologist or student of Geology should be able to identify the geometric arrangement of units (the geological structures) within a solid mass of rock. The process involves visualization, orientation and establishment of relationships. This article focus on the construction of spatial reasoning in the teaching-learning process. It explores the theme from recent developments, seeking to identify alternatives, examples and new ideas to improve teaching-learning of Geology. Visualization covers a set of abilities related to the construction of spatial reasoning. 3D visualization assumes a critical role in the Geosciences, since representations are frequent in this field of Science. Visualization of structures also requires building arguments about temporal relationships; these elements allow to interpret the geological history of a given region. Human knowledge is essentially interdisciplinary; since Geology is an interpretive and historical science, the development of qualities of 3D vision in students helps solving different types of problems, which are not exclusive to Geosciences. Visualization abilities help constructing a broader view of the world in which we live.

Keywords— Teaching-learning, visualization, spatial thinking, Geology, Geosciences.

Thematic line— Geosciences in Higher Education.

1 Introduction

Geosciences teaching involves the reconstitution and interpretation of features observed in three-dimensional space. Therefore, this special circumstance requires students to develop spatial abilities. The daily practice of Earth Sciences requires participation of all human senses, especially when a professional geoscientist carries out fieldwork. Vision, essential for the most activities of geoscientific research, encompasses more than a mere ability to see; it includes the ability to manipulate, represent, and reason in a three-dimensional way.

During fieldwork, a geologist uses vision to locate himself and to recognize details, colors and brightness of the studied place; hearing helps to feel movements of water and wind, sounds of birds and other animals, while touch allows one to sense the texture of rocks and sediments. Sensations of thermal comfort/discomfort (cold-heat, wet-dry etc.) are linked to touch. Smell, by its turn, helps to explore the aromas of rocks and vegetation, the smell of damp clay, smells of a contamination, organic fumes and decaying materials etc. The palate accompanies the olfactory perception for appreciation of the materials we examine, such as clays, salts and other materials. Learning, in this case, requires caution when testing them (Carneiro 2015).

Spatial abilities are unevenly distributed among people (Kastens et al. 2009); each person has a greater or lesser facility to acquire them. Developing such skills is the responsibility of schools and formal education, by means of instruction and practice. Kastens et al. (2009) emphasize that formal education does not recognize the unequal needs of students, failing to build a full awareness of the space challenge. Since the natural world is dynamic and complex, many phenomena are described using simplified models and visual representations. A great part of the communication involves texts and images, whose complexity may hinder understanding. It is therefore necessary that teachers be fluent, effective and able to develop visual pedagogical content, in order to teach the student to “read” models and representations.

This article examines paths for construction of spatial reasoning in the teaching-learning process of Geosciences, seeking to identify alternatives and ideas for teaching-learning Geology.

Since human knowledge has an interdisciplinary character and Geology is an interpretive and historical science, such qualities can provide a better understanding of the problems the society is experiencing in the present.

2 3D visualizing as a condition for learning science

Learning science by students involves a personal construction and production of mental models. These should be as close as possible to scientific or historical models (Gilbert 2005). The modes of representation can be concrete (three-dimensional), verbal (a description of the features and the relationships between them), symbolic (equations and mathematical expressions), visual (graphics, diagrams and 2D animations) or gestural (movements of the body or a part of it). As a way of covering the different categories, Gilbert (2005) proposes the concept of metacognition in visualization.

Metacognition is an environment or a set of interrelated constructs pertaining to cognition about cognition (Gilbert 2005). A metacognitive learner is one who understands the tasks of monitoring, integrating, and expanding his/her own learning. Spatial intelligence is the ability to accurately perceive the physical world by making transformations and modifications over a visual experience, even in the absence of physical stimuli.

Visualization plays a central role in learning, especially in science (Gilbert 2005); students need to learn how to navigate within – and between – different modes of representation. In order to do so, the meta-visual capacity must be expanded in order to reduce the difficulty of carrying out the activities. Visualization involves the formation of a mental image; this requires the capacity of to imagine an object and, at the same time, to make it mentally visible to the eyes. When presenting examples of a phenomenon, simplifications may aid to build a visualization (visual perception) of what happens at the macro level (Gilbert 2005).

Descriptions and/or simplifications of phenomena are models, which play a central role in the dissemination and acceptance of knowledge. Models also play a central role in science education, since they provide the basis for predictions about scientific explanations. Complexity and uncertainty of records of natural processes can be envisioned using a type of thinking that is greatly benefited by taking into account the kind of interpretive and historical reasoning that characterizes Earth Sciences (Frodeman 1995). The relationship between visualization and thinking involves:

(A) to apply a reasoning associated with the generation of new images to recombine elements of existing images (visual analogy);
(B) to develop a skill, such as a visual perception, which defines the nature of the physical movement involved in the exercise of the task (observation);
(C) to produce verbal descriptions of a preexisting image, employing creativity and the reinterpretation of meanings.

When meta-skills are poorly developed – a common situation in high school students – there is a serious prejudice to learning. Gilbert (2005) also states that to stimulate visual interpretation, students should invest in the ability: (A) to make a transition between modes and submodes (3D to 2D); (B) to mentally change perspective; (C) to perform a representation in themselves (as if they were in front of a mirror). For developing meta-visualization skills, students must know the conventions of representation (Gilbert 2005), as well as the limitations and scope of each mode or sub-mode, which involves the skills of:

- **spatial visualization**: ability to understand a 3D representation of a 2D representation;
- **visual orientation**: ability to imagine if a 3D representation may change, and in what way, if viewed from a different perspective;
- **spatial relationships**: ability to visualize reflection and inversion effects.

Good practices should start with simpler shapes and use a variety of modes of representation to maximize the shapes' outline, their limits, shadows and patterns, as well as vary shading degrees and color usage. Among other approaches, Gilbert (2005) proposes the use of stereodiagrams, teaching planes, rotation and reflection.

The three-dimensional visualization externalizes thoughts that facilitate, among other human activities: memorization, information processing and collaboration (Tversky 2005); its purpose is to communicate spatial relationships. The communication elements that may be used include icons, morphograms, graphs, route maps and mechanical diagrams that suggest asymmetric relationships. Cognitive design follows the principle of congruence, because the structure and content of visualization must correspond to the desired mental structure and content. Another principle of cognitive design is apprehension: the structure and content of visualization must be perceived fast, and accurately understood.

Mental models are the internalized representation of concepts and ideas (Rapp 2005), which facilitate the construction of models about scientific information and lend themselves to the use of visualizations as educational methodology. Generally, the difficulty of defining mental models is related not to direct observation of abstract concepts, but to abstract descriptions of memories. This kind of dynamic representation changes all the time. Mental models represent perceptual and conceptual features of the external world, but they are not a replica of that world. Tversky (2005) divides the diagrams into: (a) narrative diagrams, such as those seen in textbooks. Spatial and conceptual relationships predominate in narrative diagrams, as well as the structures and structural processes illustrating parts of a system; and (b) process diagrams, which mark changes over time.

Rapp (2005) recalls that visualization in learning should not be viewed as a panacea, since poor or weak visualizations are no better than poor reading. Among the factors that influence learning, Rapp (2005) states:

a) *Cognitive commitment*: By integrating new information with previous knowledge, stronger links are built, which increase the likelihood of their storage. The deeper the information processing, the greater the probability of later reminding it. The process triggers motivation of cognitive activity at deep levels.
b) *Interactivity*: Mental models are interactive; their success depends on the degree of control that the students have about the pace or direction of the lessons and their active involvement with the situation.
c) *Multimedia learning*: it can be useful in specific circumstances and environments, as representations are not always effective insofar as they can cause interference and confusion

3 Geosciences and visualization skills

The ability to visualize geological structures within solid rock masses depends on the learner to develop, or to construct, a visual penetrative ability (Kastens et al. 2009, Kuiper 2008). Computer use may help or hinder (Oppenheimer 1997) the attainment of many skills (Schlische & Ackermann 1998, Wells 2002), but research on this subject has little advance in Brazil.

3.1 Geology as a visual science

Geology is a markedly visual science. Therefore, in this field visualization is essential in undergraduate courses (Reynolds et al. 2005). Students need to develop three-dimensional thinking skills during the course of Geology because they are continually challenged to visualize and construct relief shapes or three-dimensional images from, for example, two-dimensional topographic maps or geometric arrays of survey data; an effort is required to learn the three-dimensional nature of geological structures.

Solving certain mathematical problems is common in geological-structural problems, especially because field geologists are not satisfied with merely visual judgments. It has been frequent in Geology the use of trigonometric formulas, supported in trigonometric and logarithmic tables and the use of special tables for fieldwork (Badgley 1959, Ragan 1973, 2009, Harker 2009). The use of methods requiring ruler, scale and protractor is required, for example, in the graphical determination of the actual position of exposed sedimentary strata in natural or artificial sections such as road crossings.

Spatial ability is “an important component of intellectual ability”; it is generally defined as the “skill in representing, transforming, generating and remembering symbolic, non-linguistic information” (Linn & Petersen 1985, p.1.482). Spatial ability is a cognitive factor related to high performance in science and mathematics. Black (2005) evaluated, using multiple choice questions of Earth Sciences, misunderstandings and conceptual difficulties in undergraduate courses of applied natural sciences. The research was done in conjunction with departments of Geosciences, Chemistry, Physics and Biology of the University of the North American Midwest. The author verified that mental rotation is the spatial ability most associated with misconceptions, suggesting that this may be the type of skill directly related to low performance in tests on concepts of Earth Sciences, as well as problems of scale and difficulty to transform 2D images into 3D. He admits that the neglect of educators in valuing space skills is related to a history of association with practical rather than academic skills. It is possible that many educators have assumed that nothing can be done to improve spatial skills. The author relates the misconceptions in Earth Sciences with conceptual difficulties and spatial abilities, concluding that the study suggests an opportunity to improve the understanding of Earth Science concepts from the development of curricula and interventions that focus on the spatial aspect of the concepts.

3.2 Stereology and 3D visualization

In general, a geological model consists of three parts or aspects: (1) a model that describes the geometry and properties of several units and /or lithological domains at various scales; (2) a structural model that describes the geometry and properties of a geological arrangement or a deformation zone (Munier 2004). The third element (3) that integrates the model is the fracture arrays and/or other structures within the lithological units:

> However, fractures and small deformation zones are too small to be deterministically described and therefore must be statistically described in terms of the various distributions and their relationships (Munier 2004, p.6).

The models operate as bridges between scientific theory and the world of experiences, making abstractions visible by means of simplified representations. In order to construct a 3D geological model, it is necessary to have an adequate sample of three-dimensional data (Pollard & Fletcher 2005). The quality of a model is a direct function of the quality and quantity of field data. The difficulty increases if the data are poorly distributed or insufficient (Wu et al. 2005). The development of geological interpretations can explore the three-dimensional environment from sketch, to enhance a 3D representation of rock formations (Groshong, Jr. 2006).

The Geosciences educator should help learners to develop skills that enable them to understand models as well as to solve problems related to space. Kastens et al. (2009) enumerate fundamental skills for professional geoscientists, such as:

a) Developing **temporal thinking**, that is, internalizing the vastness of time and recognizing the brevity of human history, in addition to thinking time on a geological scale, where a low frequency of high impact events dominate.
b) Designing the Earth as a **complex system**, which exhibits concomitant and non-linear interactions, as well as multiple stable states, formed by multiple mechanical, chemical, biological and anthropogenic processes.
c) Stimulating **learning in the field**, in situations in which the observation of Earth, oceans, atmosphere or planets plays a fundamental role. Field experience is essential in this training (Carneiro et al. 1993, Compiani & Carneiro 1993), as it contributes to the development of a “professional vision”. Fieldwork stimulates the learner to see features useful to his/her practical life and to acquire capacity of critical thinking.
d) Students need to translate the raw material of nature into **words, signs, and symbols** that geoscientists routinely use to capture and communicate observations.

Finally, Kastens et al. (2009) state that students need to deal with spatial tasks by building spatial reasoning, which greatly contributes to the acquisition, representation, manipulation, and exploration of objects, processes, or phenomena, in space.

4 Teaching Strategies

Different types of visualization skills are valued for developing visualization among undergraduate students; therefore, introduction of specific curricular materials is expected. Constructivist strategies can lead the student to assimilate new knowledge through association with concepts that he/she has previously constructed (Reynolds et al. 2005). The creation of didactic strategies is based on simple tasks such as three-dimensional modeling workshops of geological structures produced with recyclable materials such as cardboard boxes, fabrics, paints and other materials (Andrade 2015) towards using new technologies with devices and equipments such as virtual reality, augmented reality and computer aided design (CAD).

Wells (2002) has developed a series of stereoscopic diagrams for the study of earthquakes and earthquakes in various parts of the globe that allow a spatial visualization of the distribution and incidence of hypocenters. At the same time, the diagrams provide the student with an understanding of the large amount of data involved in the construction of seismic databases. The ability to penetrate any structure is known as *penetrative visualization*.

4.1 Stereographic projection and 3D modeling

Teaching-learning of Structural Geology seeks to improve students' ability to visualize structures in space, an essential requirement for understanding rock arrangements and their spatial distribution, as presented in maps. Stereographic projection techniques are a decisive teaching-learning resource, as long as they offer the student the possibility of acquiring spatial abilities to visualize a structure (Miguel 2018, Carneiro et al. 2018) or the configuration of the layers of a rock exposure. Blenkinsop (1999) warns that many students simply apply rules to solve exercises using stereographic projection without understanding the operations or the fundamental principles of projection. The author recognizes two groups of problems:

- *Learning problems*, related to lack of confidence and confusion in the attitudes recorded by a compass (direction, dip, plunge), poor visualization and lack of interest caused by frustration with learning itself, despite the initial enthusiasm.
- *Teaching problems*, associated with an introduction without any appreciation of the usefulness and importance of the technique, and a mere application of rules, which are incapable of solving complex problems.

Peskins & Ballard (1999) report the growing application of stereographic environments in other areas, as the use of magnetic resonance and tomography. These technologies allow a visualization of oil reservoir rocks in stereographic viewing theaters, creating a 3D illusion that permits visual interactions, combining vibrant images and convincing presentations. Such a promising environment can have a new impact on the production of science.

Visualization has grown in importance since new improved applications are developed, using experimental apparatus, projection systems and computational capacity. Mezzomo (2007) produced a 3D model of a volcanic-sedimentary succession, outcroping in a border area of Paraná Basin, comprehending geological units ranging from Devonian to Cretaceous. The model, produced in three different scales, is based on many sources of information: geological and geophysical maps, satellite images, interpreted alignments, well profiles, Laser Scanner (LIDAR, Light Detection And Ranging) data, outcrop data and digital elevation models.

4.2 Computer-aided design (CAD)

Texts in Portuguese on Computer Aided Design (CAD) are scarce in Geology. Jacobson (2001a, 2001b) provides examples of the use of CAD to solve exercises in Structural Geology, such as structural contour lines, depth and thickness of layers, three-point problem and determination of the real angle of dip from apparent dips. Exercises that use CAD in two and three dimensions hold identity with manual resolutions (Carneiro & Carvalho 2008, 2012).

Chiozza (2017) presents the solution of two hypothetical problems, in which the student can represent, measure and analyze the geometry of geological structures in a CAD environment. The AutoCADfromdesktop program offered free of charge for teachers, students and schools has been chosen for Windows and Mac OS platforms. AutoCAD allows one to represent geological situations, adding accuracy and facilitating the process of technical drawing. Many problems solved by manual drawing techniques, descriptive geometry, and trigonometry are treated in 3D space using real spatial relationships and relative positions. More realistic approaches do reduce the abstraction of graphical representations involving projections. The technique does not require calculations, since the results are obtained by direct measurement. The author recommends not to abandon the traditional treatment by manual methods, as it provides the student with concrete measurement and scaling experiences. In computer environments, this is more difficult. The 3D modeling contributes to the construction of the concept that geological structures have volume and help in the learning process to see beyond the surface of the outcrop (Chiozza 2017).

Problem solving in a CAD environment requires familiarity with basic program functions, including creation of simple objects such as lines and texts, as well as manipulation of objects (Jacobson 2001a, 2001b, Chiozza 2017). It is necessary to study the creation of layers, color control and types of lines, master the movement of an object from one layer to another and know techniques of manipulation of the graphic area, coordinate systems, control of viewing angles. The function of programs is to process vector-type images, but they also allow you to insert photo-type or bitmap-format files to be used as the basis for scanning. Inserted data is organized into layers or layers, sorting information according to different colors and attributes, such as line thicknesses, solid colors, gradations of tones or textures.

4.3 Virtual Reality (RV)

Virtual reality can be concealed as a "mirror" of physical reality, in which the individual exists in three dimensions. He/she has the sensation of real time and the ability to interact with the world around him/her (Valerio Netto 2002). Virtual Reality (VR) is an "advanced user interface" for accessing applications running on the computer, providing real-time visualization, movement and user interaction in three-dimensional computer generated environments. The sense of vision is usually preponderant in applications of virtual reality, but the other senses, like touch, hearing etc. can also be used to enrich the user experience (Kirner & Siscoutto 2007).

Using interactive visualization training, Reynolds (2005) used Quick Time Virtual Reality (QTVR) images available on the internet, applying them to two groups of students from a large university in the southwestern USA in courses in which the discipline of Introductory Geology was required and in a course of Structural Geology for undergraduate students in Geology.

The exercises were applied in a virtual way. Later the students went to the field to locate the features and to navigate in a topographic map. They produced a geological mapping and determined orientations using topographic profiling. In the evaluation of results Reynolds (2005) observed a significant improvement of the spatial visualization, geospatial measurements and the use of topographic maps. The author concludes that virtual visualization helps students to better describe a topography, to understand the geometry of the geological structures and to locate in the field. The authors report that lowering costs in the digital area has brought benefits, such as increased visualization software capacity, citing the example of Geowall, a 3D stereographic projection system that narrows the gap and serves as a bridge between 2D representations and 3D objects (Reynolds 2005).

4.4 Augmented Reality (AR)

Augmented Reality (AR) may be defined in several ways:

(A) AR is the enrichment of the real environment with virtual objects, using some technological device, working in real time;

(B) AR is a real world improvement with computer-generated texts, images and virtual objects (Kirner & Siscoutto 2007);

(C) AR is the mixture of real and virtual worlds at some point of reality/continuous virtuality, which connects completely real environments to completely virtual environments (Milgran 1994 apud Kirner & Siscoutto 2007);

(D) AR is a system that supplements the real world with virtual objects generated by computer, seeming to coexist in the same space and presenting the following properties:

a. AR combines real and virtual objects in the real environment;

b. AR performs interactively in real time;

c. AR aligns real and virtual objects to each other; it applies to all senses, including hearing, touch, strength and smell (Azuma 2001, Kirner & Siscoutto 2007).

5 Final Remarks

This article synthesizes several recent contributions for 3D visualization teaching techniques and identifies a lack of research in this field in Brazil. Many contributions from the specialized literature enhance that teachers of basic education often do not realize the need of stimulation of students to develop 3D visualization as early as possible. Those who enter into higher education may transfer such deficiencies to the academic environments.

As new technological resources for processing of digital data evolve, more resources are available to enhance the ability of penetrative visualization, resulting from studies about 3D visualization applications. If spatial reasoning skills are fundamental for Science learning, spatial envisioning plays a critical role in Geosciences because representations, part of the routine of a geoscientist, become a professional task for many, if not all, geologists. We have collected examples of teaching strategies that help teachers and students to develop 3D vision qualities. 3D modeling, stereographic projection, CAD, Virtual Reality and Augmented Reality can help them to solve a variety of problems and enable them to form a broader view of the world in which they live.

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DIMENSIONS OF KNOWLEDGE FOR GEOSCIENCE AND ENVIRONMENTAL EDUCATORS

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Abstract— This article aims to investigate the pedagogical practices in undergraduate teaching licensure in Geosciences and Environmental Education (LiGEA) of a public university in the State of São Paulo, Brazil. Teacher training in this area is unprecedented in Brazil and is the only undergraduate course in the country. The research used theory of university pedagogy and geosciences education to analyze the teachers' practices. The theoretical framework is based on the categorization of pedagogical practices and faculty knowledge dimensions. The research made use of several data collection methods. Semi-structured follow-up interviews were carried out with nine faculty members. The interviews were designed to generate in-depth profiles of teachers' views of teaching, with open questions considering the categories of knowledge. The questions were organized into three categories with 16 questions about the professional dimension, 34 on the pedagogical dimension and 12 on the organizational dimension. Documents relating to classroom practices (guidelines and syllabus), creation of the course, and the political pedagogical program were analyzed. Categorization pointed to a framework where traditional/teacher-centered practices are predominant, but some of them attempt innovation in the teaching of geosciences and reflection on the importance of pedagogical knowledge and professional development in the institution.

Keywords—Teaching knowledge, Higher education, Pedagogical practices on Geoscience teaching.

Thematic line— Geosciences in Higher Education.

1 Introduction

This article analyzes pedagogical practices in the Geosciences and Environmental Education (LiGEA) teaching degree with the purpose of understanding the particularities of Geosciences teaching.

The purpose of the research is to articulated teaching and learning processes and it presents the driving questions: what pedagogical practices characterize the teaching at LiGEA? What difficulties do the faculty have in pedagogical approaches? Which institutional actions promote faculty professional development?

1.1. Teaching Degree in Geosciences and Environmental Education (LiGEA)

The undergraduate course began in 2004. It is a four-year night course designed to provide a teaching degree in Geosciences and Environmental Education, with 3,435 hours (courses and internships). Forty students enroll in the course each year and they present a great diversity compared to geology students (age, gender, first-generation college students, less academic preparation in high school, little financial support from their families), and some students with first degrees in different areas come back to university to get a teaching degree.

Faculty is basically formed by geologists, with various specialties and different levels of experience (Figure 1). A few have additional training in pedagogy. The focus of the present research is to identify the teaching practices most appropriate for teacher training in Geosciences and Environmental Education.

2 Methodology - Understanding Teaching Practices

The research comprised a case study of one course and used several techniques such as interviews and bibliographic and documentary research. Faculty were interviewed with a focus on: thinking about the teaching practices in the individual and institutional context and identifying difficulties of their pedagogical practices. Nine volunteers from different geoscience specialties, responsible for teaching various disciplines composed the corpus of the research. The interviews lasted from one to two hours and were held in the teachers' offices.

Semi-structured interviews were applied to identify teacher knowledge. The questions were organized into three categories suggested by Pimenta (1999), Tardif (2002) and Zabalza (2004): 16 questions about the professional dimension, 34 on the pedagogical dimension and 12 on the organizational dimension.

2.2 Dimensions of Teaching Knowledge

The data were analyzed according to the categorization of teaching knowledge (Pimenta 1999, Tardif 2002, Zabalza 2004).

The three dimensions of teaching education considered were:

- Professional dimension: the bases of the professional formation (initial or continuous) and the professional requirements;
- Personal dimension: the understanding of the circumstances of the work and the phenomena that af-

fect those involved with the profession and the mechanisms to deal with them over the career;

- Organizational dimension: in which the conditions of work feasibility and the standards to be achieved in the professional performance are established.

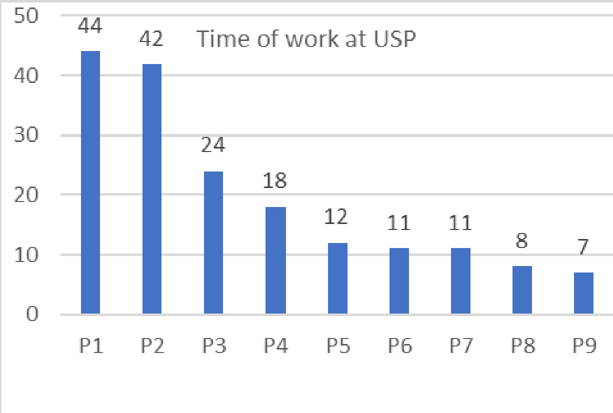

Figure 1: Research subjects

We first discussed the concept of teachers' practices, second, the categories of the three dimensions of knowledge, using Textual Discourse Analysis (Moraes & Galliazi, 2000), and finally the pedagogical practices. Textual discourse analysis considers the importance of subjectivity, that is, the knowledge, experiences, contexts and worldviews of the subjects involved in the research. It consists of a research procedure that allows the reconstruction of meaning through three moments: unitarization, categorization and communication.

To preserve the privacy of the teachers participating in the research, as well as to respect the relationship of trust that was established during the interviews, all subjects were called Teacher, followed by a letter of the alphabet from A to I. Names of disciplines and terminology that could identify a particular teacher are not mentioned.

3 Categorization of pedagogical practices

3.1. Concept of pedagogic practice

The concept of pedagogic practice is important to understand how the faculty develop and organize their syllabus, assignments and assessment in each course. Concepts of pedagogical practice are presented in the following ways:

- *"It is an organized way of transmitting to the student the knowledge of that discipline."*
- *"My pedagogical practice can be summarized as follows: content plus discussion."*
- *"It is the exercise I do in the classroom, concerned about what is going on with the students and trying to fit into various realities. It is the daily learning in the classroom."*
- *"Use some audiovisual tools with different themes of the technological part to get the knowledge to people who do not know that type of information."*
- *"It is the way to convey knowledge."*

The teachers' statements reveal a certain conceptual fragility; they refer to predominantly intuitive and self-taught practices. Through their experience in teaching, they try to change, adapt or better develop strategies in classroom. That is, they seek to adapt their practices to the needs and challenges encountered during their professional activity, but without a theoretical framework that supports the attempts to improve them.

3.2. Characteristics of teaching

- Traditional/teacher-centered

In teacher-centered education, students put all their focus on the teacher, the classroom remains orderly and students are quiet. There are more lectures than discussions, and this approach is focused on the technical dimension of the teaching-learning process, dissociated from the political-social dimensions of practices. Traditional teaching delivers large volumes of content in a limited time and provides few opportunities for student-instructor interaction and communication.

- Transitional/teacher-guided

Transitional/teacher-guided lessons, although instructor-driven, provide a few opportunities for student input or brief discussion. The teacher presents concepts, making some connections to the real world or other disciplines and students may make observations, but there are limited opportunities to assess the procedure or test predictions, estimations or hypotheses. Teacher and students ask questions of each other, but answers and wait time are limited. Students interact with each other through short exchanges or guided activities.

- Transitional/student-influenced

In a transitional/student-influenced classroom instructors implement some elements of active learning and they still are the dominant voice and thinker in the classroom, but student voices are now heard. Students talk to each other and to the instructor, and there are efforts to engage student minds (Budd et al. 2013).

Transitional instructors are distinguished from traditional instructors by design of their lesson, deliberate efforts to have students interact with each other, and the development of student–teacher interactions.

- Student-Centered Classroom

In this student-centered classroom, the instructor uses several active learning activities and multiple strategies to engage students in an increasingly multifaceted learning community. Students are explicitly charged with constructing their own understanding of the content. Instructors require students to explore before content is introduced, to activate their preexisting knowledge and conceptualizations, to work with and interpret data, and to communicate with each other and the instructor (Budd et al. 2013).

A major difference between teacher-centered and transitional classrooms is student involvement in the classroom. In the student-centered classroom the largest differences relate to lesson design and student–teacher interactions as the instructor implements a role for themselves as the ‘‘guide on the side’’ (Sawada et al. 2002) rather than as the source of all learning.

Some practices in the present research were identified as more teacher-centered with respect to classroom management, as these examples show:

> “My first classes were full of content, they were heavy. I went into the room and [I] started to talk like a machine gun for two hours…, talking, talking, talking…., because I thought I had that time and I needed to take advantage of that time with the students. So that was it, I was a machine gun and at the end of class I was exhausted. I looked at the students' faces and said, "My God, what am I doing with them?” (Teacher G 2016).

> “I teach a typical lecture, transmission of contents, but also some discussion. I try to stimulate students to go beyond what I was teaching, because I think the concepts we transmit are all in the books. So, I think they would not need me. I try to facilitate learning, but it is difficult sometimes. It requires previous preparation from the students, they need to open the book and read. If nobody reads, there is no discussion and the whole chain is damaged”. (Teacher E 2016).

However, some practices seek to break with traditional teaching, with teachers reporting that they try to develop practices to motivate students in the classroom.

> “I do not have an individual method developed. I teach the way I was taught. My classes are extremely full of contents, but I teach with as much enthusiasm and empathy as possible.” (Teacher H 2016).

> “I divide the course in 2 modules. At the end of each module I separate students into groups and each of them prepare a lesson with the concepts we have learned in the module. I have taken books to the classroom. To prepare the lesson they read the book and review the concepts. If they did not read previously, they have time to read in class and they learn with the discussion in groups” (Teacher E 2016).

> “I always try to introduce more and more practices in the classroom. I try to introduce new things, to renew, to update. Motivation is related precisely to practical activities because they put their hands-on and see something different, and I think it works. Practical activities with samples, videos, animations, games, etc.” (Teacher B 2016).

Analyzing the interviews, we could say that the teacher’s practices consist of passive rather than active learning, with few guidelines to the students, and the affective domain is not considered, and there is little diversity of pedagogical methods. Assessment is summative rather than formative, course design is poor, content is excessive and there is conceptual fragility in the pedagogical background.

We have analyzed the categories of teaching knowledge considering three dimensions: pedagogical knowledge, personal knowledge and organizational knowledge. In this paper we will present the pedagogical and organizational dimensions.

Pedagogical knowledge refers to the educational science of didactic approaches and the social practice of education, which includes tackling real problems in the practice of the trainees and teachers (Pimenta 1999).

To Tardif (2000) pedagogical knowledge refers to knowledge of the discipline or field (language, earth sciences, humanities, biological sciences). Such stores of knowledge, produced and accumulated by society throughout history, are administered and accessed by the scientific community and they should be made available through educational institutions. The author considers too how institutions manage socially produced knowledge that must be transmitted to the students (disciplinary knowledge). Organizational approaches are presented in the form of school programs (objectives, contents, methods) that teachers must learn and apply.

To understand the pedagogical and didactic dimension present in the discourse of the faculty, the following question drove the research: *what theoretical base of pedagogic knowledge is present in the educational practices in the LiGEA?*

It is notable that the pedagogical theories related to teacher training are still fragile. Some concepts present in the teachers’ discourse are not supported by educational background. Others presented misconceptions related to pedagogical knowledge as well as the relation of pedagogical knowledge with teaching practice.

Regarding teacher training, two teachers stated that they attended pedagogical courses during their undergraduate career and two others stated that they had taken part in the Postgraduate Training Internship. However, what was observed are intuitive and self-taught practices by teachers who seek to alter or complement their experience, and to find new methods for teaching, evaluation, etc. In other words, these teachers seek to adapt their practices to the needs and challenges encountered during their professional action, but without a theoretical framework that supports their attempts to improve practice. On the other hand, they bring a dynamic of restlessness through the perception of the practice itself, which is reflected upon and evaluated, but not systematically, pointing towards some change. The teaching performance in the teaching degree course was responsible for promoting such change in the practices of some teachers, who did not perceive the need for change in the geology course.

One of the problems addressed is that pedagogical knowledge is not part of the geologists’ initial training and therefore, the practices strongly reflect a focus on the transmission of technical knowledge. This is based on the separation between theory and practice, and on the academic transmission of knowledge, brought into a normative and disciplinary curriculum. The focus of training is on the normative model based on the acquisition of fragmented content and skills (Pimenta & Anastasiou 2002). Teaching is conceptualized in relation to applied science and the teacher plays the role of technician who highlights the applications of scientific knowledge produced by others and converted into rules of practice (Pérez Goméz 1992).

Other aspects of pedagogical practice were also considered, such as syllabus organization, learning goals, content and assignment proposal, student profile, design and application of lessons, organization and presentation of materials in a learner-oriented setting, and student-instructor interaction.

Faced with these questions it was observed that in relation to the establishment and organization of class content, most follow the institutional syllabus of the discipline as guide, not preparing a more detailed guide to orient students. This is not sufficient to support student understanding. When teachers realize that the menu is not adequate, they try to modify it by proposing to the Graduation Committee changes that best suit the contents given. This practice is common and refers to a dynamic curriculum. Assessment and grades basically consists of an evaluation of content.

At present, the idea of training is closely linked to short-term academic learning and long-term professional performance, with absolute dependence on the barely-discussed demands of the labor market. Personal enrichment and improved quality of life tend to be ignored, as if they were irrelevant to the university's purpose (Zabalza 2004, p. 43).

This disassociation of the technical dimensions of the teaching-learning process from the political-social dimensions (Candau 2014, p.14) and content teaching is still present in the institution, as exemplified in the following excerpt:

> "In the didactics course I had the opportunity to know how teaching, how to stimulate a palette, how important is to have a good diction, to stand in front of a student without getting your hands in the pocket, the importance of do not have an accent and speak low, and do not facing the blackboard, which hinders the passage of information. Nowadays, I try to minimize this with the use of advanced technological materials, using movies, posing questions and do not spend much of the psychological limit of assimilation of the 20 minutes" (Teacher F 2016).

However, there are some experimental practices in geosciences instruction that seek to break with traditional teaching. Some teachers report that they seek to develop practices to motivate students in the classroom. In the selected excerpts of the interviews we see teachers who look for alternatives to the traditional classes.

These activities consider procedural knowledge, including techniques related to geologic research, such as observation and interpretation of landscape evolution and bedrock geology, as well as the preparation of didactic collections and use of multiple means (graphs, maps, cross-sections) to represent phenomena, that allow the reconstitution of aspects studied in the field. They also involve the learning of field techniques such as observation, description, data collection and sampling (soil, rock, water) and mapping of sedimentary, igneous and metamorphic terrains. In addition, activities include visits to rock exposures or geological situations of interest (parks, mines, landslides, civil constructions) associated with land use, such as dams, roads and tunnels in the surroundings of São Paulo, complementing the diversity of geologic knowledge necessary for pedagogical effectiveness.

Fieldwork is not restricted to visiting a specific place, but requires a long process of development, reflection and systematization of the data collected. Through fieldwork we can develop multiple geoscientific skills and practices, such as observation, perception, interpretation, use of images, creation of collections, registration, experimentation and problematization.

There is a concern, therefore, that teacher training should include field lessons as a component of elementary and secondary education. At these levels of education there is an emphasis on preparation for these activities (pre-field, field and post-field), discussing their importance in teaching Science, History and Geography, participatory and interdisciplinary teaching methodologies that involve the study of the environment, and emphasis on the local context. They are also important in the development of didactic sequences, from the accomplishment of field work in places with historical, geoscientific and environmental relevance.

The laboratory classes are important for the pedagogic planning process and, in this context, the dimensions that guide the choice of the place to be studied or visited. Additionally, the main phenomena and geoscientific topics addressed in the place are valued, as are the techniques of observation, recording, interpretation and analysis developed in the field; the availability and use of diverse sources of information, historical, maps, etc. Such activities provide the training of autonomous, creative and reflective teachers who combine local research and effective teaching (IGc/PPP 2015). Regarding objectives of lab classes, Teacher B points out that

> "it is to go out of the classroom, to train the observation and to expand to another scale, a landscape scale, to see samples in place and to encourage the future teachers to use outdoor activities with their own students and have contact with the essence of the geological field work."(Teacher B)

Conceptual learning objectives are presented more clearly in the syllabus but do not make clear to the students the expectations for learning. In several courses analyzed it was not possible to verify the presence of procedural and attitudinal objectives.

The organizational dimension was also considered in the present research.

Aspects more clearly related to contractual conditions, selection and promotion systems, incentives, hours, and obligations linked to professional development, etc.) are included by Zabalza (2004) in the organization dimension of knowledge. The question posed to understand this dimension was: *how does the teacher evaluate the Institute of Geosciences (IGc) as a place of work and teaching?*

The IGc was considered by the interviewed subjects as containing good infrastructure and resources, good didactic materials, such as collections of minerals and rocks and the museum of geosciences was a privileged space to learn. Classrooms, resources for learning in the field and laboratories were deemed suitable for research and teaching.

Issues related to management, student evaluations, distribution of classes and courses, charge and involvement with undergraduate education were pointed out as internal problems that deserve more attention. Other problems are related to political management by the dean of the institute and departments. They reported also political interference and management changes from the provost in the last years that directly affected teaching.

> "I think we have at IGc good material resources. I do not know if we have appropriate management, it's a bit amateurish. I think offices, laboratories and academic services should work until 11:00 p.m. for every student to have access. We know of the critical conditions of the university at this moment, but in the beginning of the licensure course it worked. So, you really must extend accessibility to everyone" (Teacher I, 2016).

> "Yes, there is external interferences in the teaching work, like CERT (Special Committee on Labor Regime). Sometimes they disturb more, other they interfere less, the periods alternate. Internally, I think there is an omission posture from the directors, not taking sides or defending the faculty. It's everyone for himself. There is a very strong individualized leadership and a corporatism culture present. (Teacher C, 2016).

> "Here (at IGc) a fundamentally conservative structure is present. And we have a very bad scenario, with decrease of the number of teachers and increase of the administrative charge. External and internal pression to increase numbers of research and publication of papers is on teachers' shoulders. The research proposal is always individual or in small groups. I take care of my individual professional responsibilities rather than the institutional concerns otherwise I will not be a CNPq scholar and I will not make money, I will not be able to do this or that without money" (Teacher F 2016).

4 Conclusions

The data analysis in the present research leads us to agree with Almeida (2015), who affirms that university teachers need to appropriate the pedagogical knowledge through individual or institutional processes of training and such knowledge should be properly valued in the professional career.

The complexity of teaching must overcome paradigms present in the design and implementation of the courses. The latter must be structured to facilitate teacher-student and student-student interaction, and relevant pedagogical theory must inform teaching guidelines (Almeida 2015). It is necessary to overcome the belief that only the domain of specific content or the high investigative capacity are sufficient to create good teachers. A deep understanding of pedagogy is important to produce good practices. More openness to interdisciplinarity in Earth Sciences and to complex thinking are also very important to facilitate the role of teachers today.

In relation to pedagogical knowledge some aspects can be presented:

a) Fragile teaching professional identity. The degree and graduate programs in Geology are oriented to the research and/or professional career and do not to teaching preparation.
b) Absence or superficiality of pedagogical knowledge.
c) Medium interest in or availability of teaching and learning development.
d) Absence of interdisciplinarity in teaching, integration of disciplines and research, restriction to the specific domains of Geology.
e) Predominance of cultural knowledge that values research over teaching and learning.

The teachers' interviews were fundamental to express the existing difficulties in teaching at the institution. While they understand the importance of pedagogical practices and try to improve them, they run into administrative demands, such as departmental politics, increasing pressure for publication, and devaluation of teaching. The emphasis on research and career development at the organizational level discourages participation in committees related to teaching and learning and inhibits initiatives that could lead to effective changes in pedagogical practices. Teachers perceive the current reality of Brazilian primary and secondary education, including difficulties presented by students regarding behavior, interest and motivation, as well socioeconomics problems. But they feel immobilized by lack of time and structure, and the absence of institutional support to seek change, improvement in pedagogy or even space to discuss their dilemmas, questions and solutions for higher education.

The LiGEA course is centered on the disciplinary dimension, on the methodological and con-conceptual structure of the contents, which, according to Pimenta et al. (2014), removes the necessary multidimensionality from teaching. The authors point out the political-pedagogical, ethical, psycho-pedagogical and didactic aspects as essential to be incorporated by the teacher of a specific area. Pedagogical and didactic parameters must be articulated alongside the logical-scientific elements of content knowledge. In addition, they affirm that the texture of content and its didactic transposition requires the continuous articulation between the educational principles, the pedagogical intentionality and the specificity of the given conditions.

Knowledge presented in the current course is restricted to the technical formation of the geologist, ignoring essential aspects of teaching training. From this perspective, it reinforces the position of future teachers as technicians who perform what was defined by specialists in their initial training, and who believe that the simplification of Earth Sciences concepts and logic is sufficient for fulfillment of a teacher's role.

The course contents reflect the culture of the institution, its concept of education, and its ideologies.

Equipping geoscientists with specialized knowledge of how to search for natural resources and understand Planet Earth as an integrated system is not enough to avoid the fragmentation of teaching. As Frodeman (2010) points out, understanding the history and epistemology of Geosciences, and considering the intrinsic forms of investigation in this field could be transformative and lead to the construction of new paradigms and new pedagogical practices.

Support and encouragement for participation in professional development should be a policy of the university, institutes and departments. However, higher education institutions do not offer these opportunities in a timely manner, with rare exceptions. Programs such as University Pedagogy (Pimenta & Almeida 2009), as well as experiences of research and implementation of isolated programs, as described by Cunha (2001, 2004) are examples of successful institutional initiatives but they are very restricted. Meanwhile, current practices and policies reinforce traditional and technical education but do not contribute to paradigm change.

Paths to change in the current framework require, first, a validation of undergraduate education, training policies and evaluation of teaching practices within the unit and the university, and spaces that promote reflection on teaching. Corrêa & Ribeiro (2013) point to the need to develop a culture of valuing teaching in the university, a process that can promote pedagogical capital and the formation of a pedagogical habitus in teachers' practices.

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HANDS-ON ACTIVITIES FOR GEOSCIENCE KNOWLEDGE CONSTRUCTION

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Abstract— Undergraduate incoming students need a better appropriation of knowledge and geoscience literacy. To this end, hands-on activities were elaborated and inserted in introductory classes. These activities improve the active participation and thinking of the students and enable a systemic and integrated vision of the Earth. These activities explore geologic concepts and processes such as Geologic time, Earth structure, seismic wave propagation and knowledge of the internal structure of the Earth, sand observation with stereoscopic microscope, the use of minerals as pigments, tectonics and Google Earth, magmatic differentiation, rock deformation, topographic maps and profiles, systemic vision of the planet. These hands-onactivities are dynamic and are combined with theoretical content that turned them efficient and motivational for the geoscience knowledge construction.

Keywords— Hands-on activities, Undergraduate course, Meaningful learning.

Thematic line— "Geoscience in Higher Education".

1 Introduction

Geoscientific literacy is essential for the incoming students of Geosciences and Environmental Education undergraduate course of IGc-USP. These students constitute a very heterogeneous group, both by the prior knowledge and by the age. Some just concluded High School, and are attending the first undergraduation course, others already act as teachers, but not always in the area of natural science or geography, and others are graduated in other subjects and seek to extend their knowledge in Geosciences.

The Dynamics of the Earth System I and II disciplines (1st and 2nd semesters of the 1st year) address the central concepts and geological processes with a systemic and integrated view of the planet. As introductory disciplines of the course, it is often necessary to deconstruct the previous knowledge of the incoming students, who have learned in a fragmented content way, incomplete and/or erroneous contents, during the Basic Education (Toledo 2005).

The motivational and didactic role of practical activities in teaching is widely proven (Chang & Weng 2002, Imbernon et al. 2009, Constante & Vasconcelos 2010, Holstermann et al. 2010). However, in university courses, classes are traditionally taught in an expository manner, with a dichotomy between theory and practice. Considering that the appropriation and meaningful learning of knowledge are facilitated when associated with playful and interactive activities, and through dynamically and integratively classes, we sought to invest in new ways of contributing to the teaching-learning processes. To this end, new pedagogical practices have been developed that allow the active participation and the students' reflection. This paper aims to present and discuss the insertion of these new practical activities merged with theoretical contents.

2 Hands-on activities

For a geoscience knowledge construction, the incoming students need a solid basis of geological concepts and processes. In order to promote this construction, hands-on activities were elaborated and introduced in the introductory classes. These activities explore, for example, Geologic time, Earth structure, seismic wave propagation and knowledge of the internal structure of the Earth, sand observation with stereoscopic microscope, the use of minerals as pigments, tectonics and Google Earth, magmatic differentiation, rock deformation, topographic maps and profiles, systemic vision of the planet. Here, only some of them are described and discussed.

2.1 Temporal and spatial scales

The temporal and spatial scales are essential to understand the formation, dynamics and Earth evolution. In order to promote a better understanding of the dynamic processes of the Earth, geologic time with billion years of duration should be linked with spatial scale, which has also a wide range since it varies from a few nanometers to million square kilometers. Besides, science fiction movies tend to distort the temporal and spatial reality and the real notion of scales is lost.

To resolve this difficulty, hands-on activities focus the construction of the geological time scale and the structure and dimensions of the Earth. In the first one, students indicate and place on a 5 meters graph paper Eons, Eras, Periods and main events that highlight the evolution of the planet, since its origin 4.56 billion years ago (Fig. 1). In the second activity, the inner layers of the Earth (6370 km), the ocean, atmospheric layers until 350 km of altitude (where is located the International Spatial Station) with their main characteristics are positioned in the inner courtyard of the Institute considering an equivalent 30 m scale. In both activities, the students illustrate with rock and fossil samples and photography. After overcoming their mathematical difficulties, they are surprised and well succeeded in seeing the different dimensions involved. The activities bring them closer to the reality mainly because they used to have an unspecific and reduced notion of these scales in the textbook illustrations.

2.2 Rock deformation

To get a systemic and integrated vision of the planet, it also necessary to explain and understand the mechanisms and processes that deform the rocks and create Earth structures.

This theme is generally approached through a simple passive transmission of content and an expository class. In order to promote a better approach with an active participation and reflection of the students, a new hands-on activity was applied. It focusses and investigates the change in patterns of different materials under compressive, tension and shear stresses. We chose materials that represent a good analog for rocks and may be easily reused: i) chalk samples and wax candle to study deformation and rupture; ii) marshmallows to demonstrate ductile deformation, simple and pure shearing, and stress-strain curve; and iii) solid paraffin mixed with gravel and airy solid paraffin to demonstrate that different material composition under same stress conditions result in different strain patterns. After each experience, the observations are discussed in class as well as the relationships between processes and corresponding geological structures (Fig. 1).

2.3 Magmatic differenciation and fractional crystallization

The understanding of the magmatic differentiation by fractional crystallization is very abstract and difficult for the students in the first year of undergraduate course. The simple explanation of the Bowen's reaction series is not sufficient. Therefore, we elaborated a new hands-on activity adapted from Wirth (2003). Students use a set of different colored buttons. Each colored button represents a major cation from the chemical composition of an initial hypothetical magma. In order to simplify, anions are oxygen and are not represented in the exercise. The objective is to simulate the magmatic differentiation process by fractional crystallization, following the Bowen's reaction series steps and watching out the magma's chemical composition evolution during the process (Fig. 1). In each step of the fractional crystallization, the buttons that correspond to the crystallized minerals are removed from the initial set. The number of buttons that remained into the magma after crystallization is counted and reported in a table. Then, the corresponding percentage of each element is calculated. Finally, the students generate x-y plots of Si, (Mg+Fe) and K contents *versus* the residual liquid fraction and discuss the chemical evolution of the magma. To complete the activity, another exercise is applied. In this one, the chemical analysis of real volcanic rocks related to Paraná Basin magmatism according to Piccirillo & Melfi (1988) data are examined. The students spot the samples in a map using the available geographic coordinates and Google Earth, classify the different rocks according to their SiO_2 content (felsic, intermediate, mafic, ultramafic), generate x-y plots that show the variation of MgO, CaO and K_2O content with SiO_2 and explain them, discuss in what minerals Mg and Ca may be incorporated and how may explain the difference between rock compositions. At the end of the activity, all the hypothesis and conclusions formulated by the students are discussed in the class.

2.4 Topographic maps and profile

There is a huge difference between what is a topographic map for geoscientists and what it represents for the incoming students. Only few have the idea of what it actually represents in space and how it is drawn. The appropriation of map knowledge as a tool can only occur from its construction, its use and application. In order to promote meaningful learning, an activity was elaborated in which the representation of the relief in a horizontal plane is carried out constructing a hypothetical model of mountain with play dough. This model is then sliced and the outline of each slice is sequentially drawn in a plane (a sheet of paper), which allows to explain the concepts of topographic contour lines and contour intervals (Fig. 1).

Knowing to read a map is to comprehend it and it is a necessary condition for use it. Then, the activity follows with the observation of a real topographic map and the identification of its main characteristics (scale, orientation, coordinates, contours, legend, etc.).

Finally, the activity ends with the construction of a topographic profile from (i) the vertical cut of the play dough model relating height to distance and (ii) a section mapped on a real topographic map.

2.5 "Earth system" game

The Earth System game was elaborated aiming to diversify the teaching-learning activities of the discipline and to promote a transposition of knowledge in a playful way. The game consists in a sortition of six words belonging to five different thematic categories addressed in disciplines: Processes of the internal dynamics of the Earth, Processes of the external dynamics of the Earth, Terrestrial Materials, Human Action and Geological Time. Then each group has to elaborate a one-page text explaining and relating in a coherent, logical and didactic way all the words.

Figure 1. Hands-on activities examples (clockwise from top: geological time scale, rock deformation, magmatic differentiation by fractional crystallization and topographic maps and profiles activities)

3 Discussion and final consideration

The introduction of new pedagogical practices, besides making the class more dynamic and less tiring for teachers and students, aroused more attention, greater involvement and collaborative dynamics and promoted a much more meaningful learning. These innovative and participatory activities included in introductory courses of the Degree in Geosciences and Environmental Education were also very motivating because according to Freire (1997): "to understand the theory it is necessary to experience it".

The practical activities became more investigative and gave the student greater autonomy and protagonism. Many concepts were addressed only after observations of practical activities, with the construction of knowledge begining from the student's observation and not from teacher’s explanation. The proposal of intercalating student investigation, conceptual explanation and synthesis phases promoted greater understanding among the students. Moreover, the realization of simple experiments and the development of a scientific reasoning proved to be effective in elucidating concepts in later activities.

In addition, these practical activities can serve as educational means and practices replicable and adaptable by students as future teachers.

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TEACHING-LEARNING OF GEOLOGY COMBINING DIGITAL AND MANUAL RESOURCES OF STEREOGRAPHIC PROJECTION

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Abstract — Computer programs that permit creation of simulations are a fundamental resource for teaching-learning of Structural Geology, since they offer a simple way to help understanding complex structural fabrics. This paper presents results of two complementary academic investigations focusing the stereographic projection program called Ester 2.1. The program applies current projection methods such as projection of planes and lines, statistical analysis, rose diagrams, rotations and conversion of notations. It also permits the production of tangent diagrams, which are an effective tool for studying conical and cylindrical folds. The first investigation has evaluated and validated the Ester 2.1 program, by means of restrictive analysis of comparative tests with structural data of different geological contexts. The results obtained using Ester 2.1 were compared with other yielded by similar programs. The second research relies on didactic workshops offered for undergraduate and graduate students of the Institute of Geosciences of the University of Campinas in order to evaluate the Ester 2.1 program as a learning tool. The evaluation of such pedagogical utility has combined practical manual and computational stereographic projection activities, also extended to simulators and 3D-modelling programs. The results of both validation and didactic evaluation tests showed a good functioning of the program. The didactic workshops also demonstrated a potential to contribute to meaningful learning and to the development of spatial perception, but it requires the students to be previously motivated and guided under an effective way.

Keywords — Teaching-learning, 3D models, significant learning, computer assisted learning, Geology, Structural Geology.

Thematic Line — Geosciences Higher Education.

1 Introduction

Structural geology is essential for unraveling the geologic history of any given area or region within the Earth´s crust (Davis et al. 2011). The main objectives of Structural Geology are:

a) To understand the structural modifications or simply the deformational history of rocks and regions (Arthaud 1998);
b) To understand and to describe movements and strains that have controlled the development of any structure;
c) To interpret structures and structural systems in relation to mechanics, tectonics and geological history (Davis et al. 2011).

Stereographic projection helps manipulating and interpreting geological 3D data on a two-dimensional surface. This method is useful in Structural Geology mainly for studying and resolving geometric problems. There also relevant applications in Crystallography, Seismology and Geomagnetism.

Associated with practically every field of a geologist's career, Structural Geology is a fundamental discipline of undergraduate geology courses, whose understanding requires knowledge of rheology and high-level three-dimensional visualization skills. The idealizations of stress are particularly hard concepts for students to grasp, because it is difficult to watch the development of a progressive deformation. Simple two-dimensional programs are ideally suited for this type of visualization (Primm 2004). Teaching of Structural Geology generally includes practical exercises that apply the descriptive geometry to analyze geological problems. In general, problem solving requires manual activities, both in the field and in the classroom (Burger 2004), but computers allow designers to create drawings quickly and accurately (Jacobson 2001a, b).

Recent computer-based technologies have opened up new perspectives for science teaching and learning in general, in particular geology. The different ways of using the computer enabled the diversification of strategies in teaching. The full realization of the pedagogical potential of computers depends on sufficient educational and quality programs (Fiolhais & Trindade 2003).

Many programs for structural analysis is available; some of them require acquisition of commercial licenses, while others are available in the internet, free-of-charge.

The available tools ranges from the most elementary and simple stereographic projection packages to specialized programs that perform specific tasks such as geotechnical stability analysis (Grohmann 2010).

The stereographic projection belongs to the category of relatively low-cost applications because many programs are freely distributed, such as Stereonet (Roeller & Trepmann 2003-2008), Stereonet9 (Allmendinger

2017), Dips, QuickPlot and OpenStereo. The easy access makes the applications the most widely used.

The 2.1 version of the Ester system of stereographic projection for Structural Geology (Souza & Carneiro 2013) meets the concept of Free Software; it runs on Windows operating systems.

It can help a geologist to:

a) produce cyclograph or polar representations of planar and linear data;
b) represent the same data in a tangent diagram;
c) create rose diagrams;
d) develop statistical tests and fault analysis;
e) determine the main orientations of shortening and stretching tectonics.

2 Objectives

This article is the result of two complementary academic investigations in Structural Geology (Fig.1): the first one sought to evaluate and validate the Ester 2.1 system (Fig. 2), while the second evaluated the didactic-pedagogical utility of the program for teaching, using practical manual and computational activities.

The former version of Ester program was published in 1996 under the name Ester 1.0, as part of a technical-didactic book along with other unpublished programs: TRADE (Yamamoto & Pereira Jr. 1984) e TRADE-AP (Campanha & Yamamoto 1987). Running on MS-DOS operating systems, the program produces Schmidt-Lambert plots of planes and lines, using polar and cyclographic projections, counting and tracing of isofrequence curves, as well as calculating statistical parameters (Carneiro et al. 1996). The validation tests of the software consisted in evaluating the effectiveness and a meticulous study of the products that the program offers, involving:

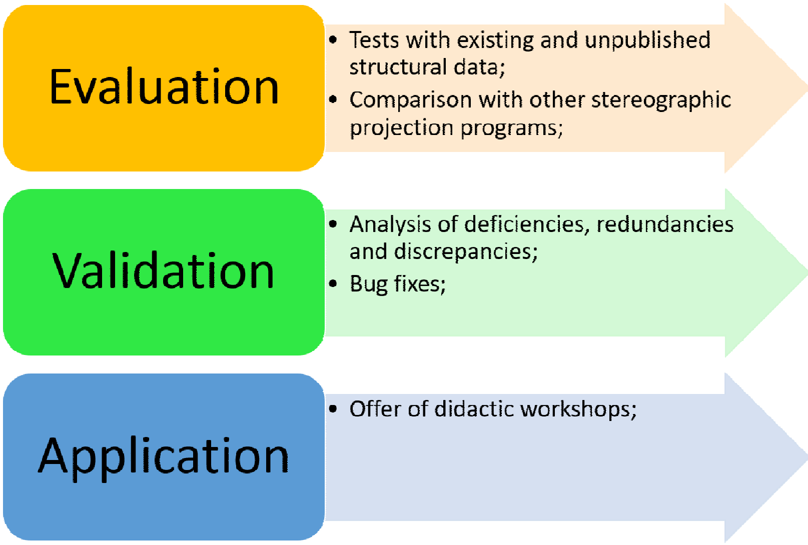

Figure 1. Flowchart of the activities

1) evaluation of the computational environment;
2) production of statistical analysis diagrams by insertion and processing of real data;
3) comparative examination of diagrams produced by Ester 2.1 and other programs.

The educational research comprised:

1) an elaboration of techniques aiming to reach an effective learning of the stereographic projection techniques;
2) a study of ways to develop three-dimensional visualization skills, since this can impede significant learning in Structural Geology;
3) the development of proposals of activities using

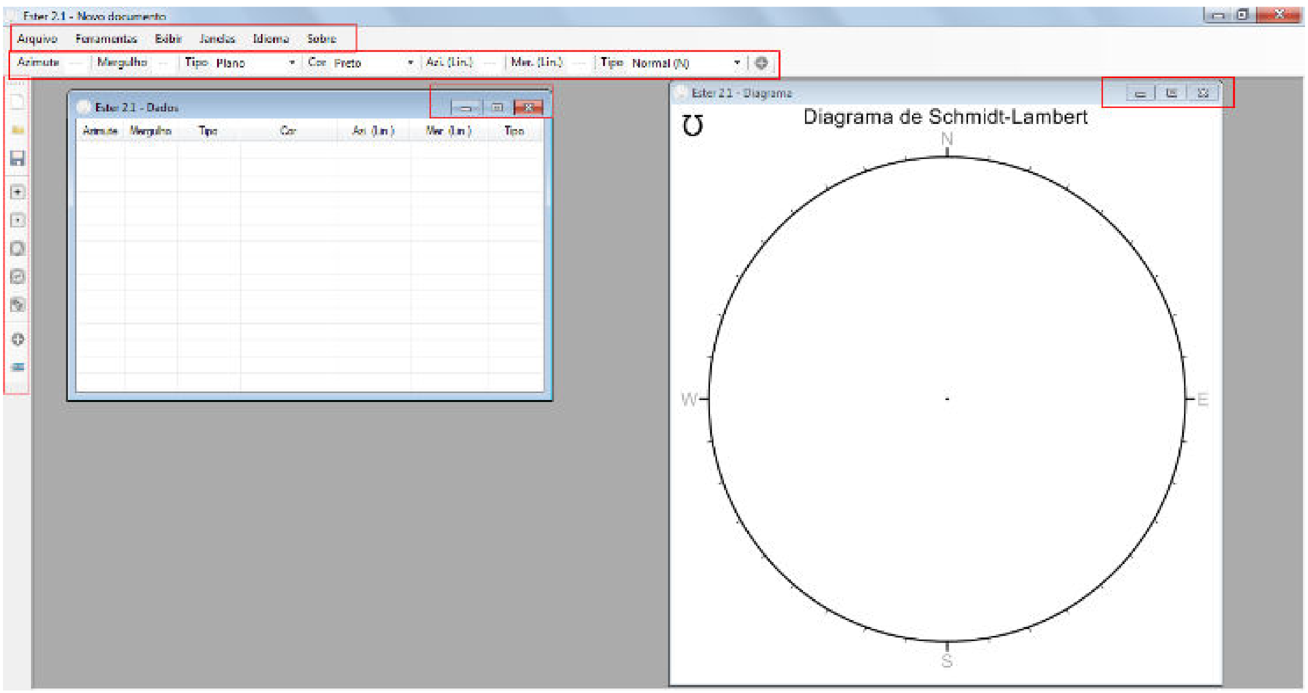

Figure 2. The Ester 2.1 environment

manual and virtual exercises, seeking to test possible complementarity of them;

4) An evaluation of the Ester 2.1 program by each user.

Since 2006, several projects carried out at the University of Campinas aimed to update these programs and to develop integrated systems of 3D visualization of geological structures (Mizuno & Carneiro 2007, 2008, Souza & Carneiro 2013). The current version includes the Tangent Diagram tool (Carneiro et al. 2018), which consists of a polar coordinate graph that provides useful vector solutions for several types of study, specially to distinguish between cylindrical and conical folds (Bengtson 1980).

3 Materials and Methods

The research started with a bibliographic study of Structural Geology, methods of stereographic projection, fieldwork techniques and data processing in Geology. The theoretical study included Geosciences teaching, and teaching and learning of stereographic projection techniques as well.

3.1 Evaluation and validation of Ester 2.1 program

The evaluation focused the latest available version, called Ester 2.1, to test the real use of the system and to optimize the functionalities (Fig. 3), with data retrieved from the literature or collected directly from fieldwork. We compared the resulting diagrams with others made with the same data range into other software to allow objective comparison.

The practical part involved insertion and processing of data from different sources: (a) data originally published by Carneiro 1996 (Fig. 4) and (b) unpublished data from a fieldtrip of the third author. The tests were rigorous, not only towards finding errors and bugs to correct, but also due to the objective of validating the current Ester 2.1 program. The authors have carefully enumerated, listed and subsequently corrected eventual deficiencies, redundancies or discrepancies between the produced diagrams.

3.2 Workshop of stereographic projection

The planning of a stereographic projection workshop in Geology relied on several studies involving Structural Geology, three-dimensional visualization and psychology. The resolution of problems and activities reconciles manually and in a computer program (Ester 2.1). The activities should facilitate learning and the enhancement and/or development of three-dimensional visualization skills.

The bibliographic study showed that a student must develop an extensive and high level spatial thinking to learn Structural Geology. Therefore, getting these capabilities is an important component of systematic training on Geology. Since stereographic projection has a decisive role for significant learning of Structural Geology, the first author followed the discipline of Geological Design, in the second semester of 2016, offered to classes of the second year of the Geology course. She sought to observe the main difficulties that the students present during the learning of the content of the discipline, in order to formulate the contents of the workshops,

The target audience of the workshops were under-

FAULTS PLANES	STRIATIONS ATTITUDES
100/ 35	160/ 19
120 /50	146 /32
142 /85	224/ 50
348 /50	314 /45
021/ 30	249/ 33
077 /30	150/ 08
054/ 40	340 /14
328 /80	255/ 52
320/ 80	240/ 40
140/ 80	204 /44
136/ 70	224 /38
060 VERT	206 /48
044 VERT	227 /50
040 VERT	216/ 52
052 VERT	242/ 54
Attitudes of faults and striations. Source: Torquato et al. 1996, p.112	

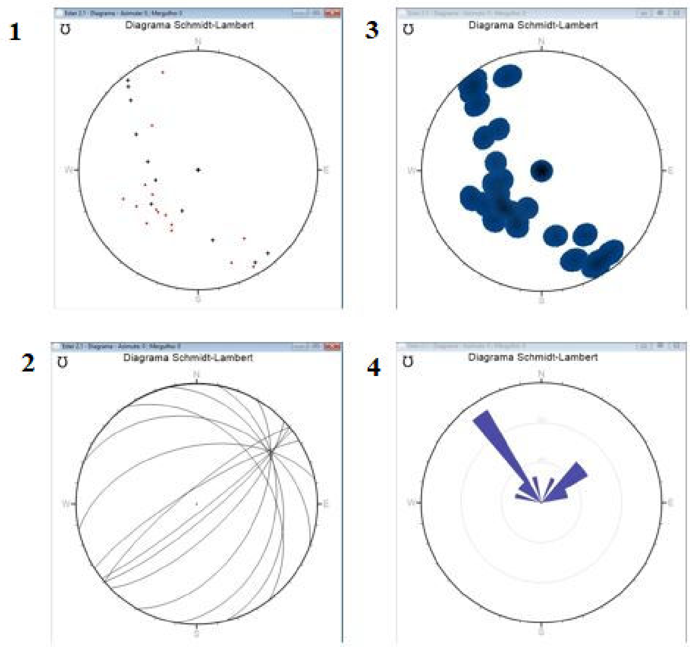

Figure 3. On the left, table with the data used. On the right, stereograms produced by Ester 2.1: (1) projection of lines (red) and planes (black), (2) cyclogram, (3) statistical control, (4) rose diagram

graduate and graduate students of the Institute of Geosciences of Unicamp who had already made the disciplines of Geological Design (GE-407) and Structural Geology (GE-603) or who had not yet studied them, but were interested in the content. The workshops have followed strictly some research premises and directions given by the university.

There were three didactic workshops: a short workshop with a duration of two hours and application of computational activity and two complete workshops lasting twelve hours, fragmented in three mornings, combining manual and computational activities.

In the short workshop, the participants worked with an exercise of statistical control and rose diagram. In the complete workshops, theoretical and practical activities to develop: projection of planes and lines, intersection of structures, measurement of angles between structures, real and apparent dips, rotations (using vertical, horizontal and oblique axis), statistical control, rose and tangent diagrams.

4 Results

The interface of the Ester 2.1 software is simple and easy to use, both the top and side toolbar are in Portuguese language (Fig. 2). The user should enter data in Clar format, but the program offers the “tools” function for conversion of notations. The user enters the data in the same environment in which he/she works on them, by the superior toolbar or the data entry tool, which allows an immersion of the user in the application throughout the use. One can also import and export files from Excel, Notepad, or from/to DIPS and Stereonet software. Still on the upper toolbar, one can choose what diagram he/she wants to generate, Schmidt-Lambert or Tangent.

The side toolbar offers data representation options, as follows:

a. projection of the pole of a plane;
b. projection of lines;
c. cyclographic projection;
d. rose diagram
e. statistical analysis (Fig. 2).

These functions run simultaneously, thus representing the structures by different colors for planar and linear structures in the same diagram (Fig. 3). It is possible to apply the Arthaud (1969), Aleksandrowski (1985) and Angelier (1979) methods, and to manage the windows of the environment Ester 2.1. The user can save the resulting diagrams in image files as .jpg, .tiff, .bmp and others.

4.1. Evaluation of the program

For the comparative tests, we choose two similar programs already recognized in the market: Stereonet9 (Allmendinger 2017) and OpenStereo (distributed under General Public License, Free Software Foundation 1999). The tests have revealed the good performance of the Ester 2.1 program, since the results are quite similar with the other programs.

There were few divergences: there are difference on production of rose diagram by Ester 2.1 only when compared to Stereonet9, leading to the conclusion that the anomaly given by the divergent software results from the use of a distinct way of grouping data in relation to the others. The results of contour analysis showed that only the Ester 2.1 program displays data of planes and lines in a single density and represent them with different colors.

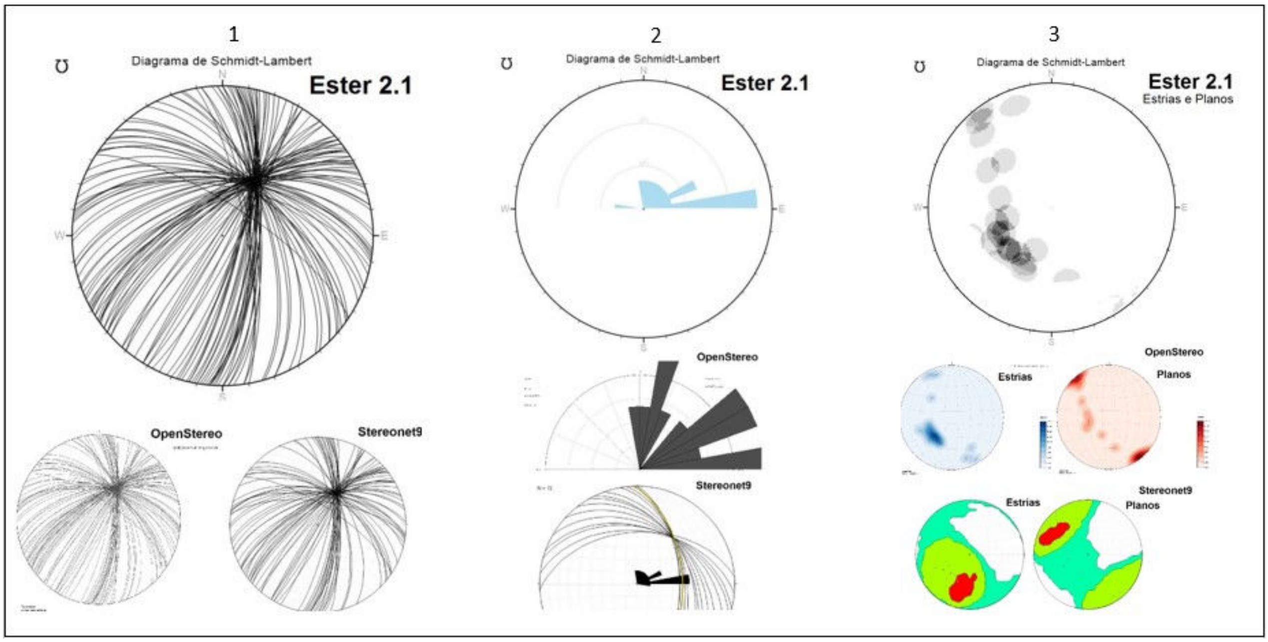

Figure 4. Results generated by the software Ester 2.1, Stereonet9 and OpenStereo, with the data of the Table contained in figure 3. (Carneiro et al. 2018)

In other software, it is necessary to create a diagram for each type of data (Fig. 4).

4.2. Evaluation of the didactic workshops

The need to diversify methods to combat school failure is particularly clear in the exact sciences. This has led to the increasing and diversified use of computers, which offer several possibilities to help solving failure problems in some disciplines. Recent computer-based technologies opened up new perspectives for science teaching and learning, particularly in Geology. The different ways of using computers introduced diversified teaching strategies. However, more educational and high quality programs are necessary to realize the pedagogical potential of computers (Fiolhais & Trindade 2003).

Each activity of the workshop began with a theoretical exposition about the content that would be worked, then an exercise was presented, referring to the exposed subject, after, opened a discussion for any doubts. Next, the resolution was made in paper diagram; new discussions were opened, this time about the exercise solved, then this same task was done in the Ester 2.1 program.

All the studied exercises about stereographic projection techniques present possible real situations or that need some effort beyond the mechanical use of the technique, just informing also in which field of Geology this situation is applied.

The first author observed when she followed the Geological Drawing discipline that many students simply memorize the techniques and read the exercises only to collect the data needed to solve the activity. In order to avoid the purely mechanical resolution, during the workshops, the participants were motivated to have a critical look on the procedure they had just performed and on the problem situation of the exercise. This helped to avoid merely a mechanical resolution and memorization of techniques, but was not enough: In some cases, the researcher noticed that few participants insist to memorize, not to really learn. After a week without performing the techniques, that is, at the second or third workshop session, the participant did not remember how he did the two basic techniques, the projection of plans and lines; he/she needs more practice to continue the activities.

The evaluation by users about the functionality of the program, for those who had the first contact with the Ester 2.1 software and with programs of stereographic projection, focused on the operational conditions of the program. For the participants who already had practical knowledge with stereographic projection programs the evaluation was more complete, with observations about the operational part and comparisons with other existing programs.

In general, participants found the program useful for working with structural situations that require the use of stereograms. They also considered useful the conversion and rotation tools. They acknowledged for being able to work with data of lines and plans in an unique stereogram and the insertion of data in the same environment.

5 Conclusions

The Ester 2.1 program showed, during the didactic workshops, its educational potential and good functioning. The software has passed a series of comparative tests, until all bugs were solved, some of them pointed out by the workshop participants. Ester 2.1 includes new features in relation to other available programs, which shows commitment to enrich the work of potential users. In higher education in Geology and other areas, Ester 2.1 appears as a strong ally in content transmission and learning of stereographic projection.

The connection between manual and computational activities is a key to arouse the student's interest, motivating him/her to learn by discovery and to withdraw the focus on memorization. During activities on computer environments, the program itself generated the results (the images); in this case, there was no concern with the execution and correctness of the task. The student had an opportunity to observe and reflect strictly on the results.

When doing paper diagrams, the participants concern about the correctness of the exercise. Instead of this, when the same exercise was done in Ester 2.1 program, they are obliged to create a mental image of the situation presented in the task, since it is necessary to fill data in tables, thus requiring an understanding of the situation problem by the person who manipulates the data.

The authors conclude that the combined use of computer programs and manual activities can assume a relevant didactic, motivating and investigative role for Structural Geology teaching.

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THE FIELD LEARNING ACTIVITIES AS TEACHING METHODOLOGY IN THE GEOSCIENCES

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Abstract— The objective of this work was to reflect on the role of the field learning activities as teaching methodology in the process of training students and professionals working in Geosciences, assuming that it is an indispensable procedure in training and teaching activities. The use of field learning activities in the process of training in the Geosciences area is replete with opportunities that generate learning, knowledge and experiences, increasing the perception and reflection of the reality that involves the participants. The efficiency of a field learning activities is based on the careful planning of activities, in the dominated of applied contents and techniques, and pre and post field evaluations, and during your realization should be provide moments for the reflection of theories, methods, procedures and techniques used. The preparation, organization and logistics involved in the development of field learning activities are synthesized in planning, so that their execution meets their didactic conceptions and methodological approach, allowing that the participant to work with different competences and abilities. As important as the realization of the field learning activities is the report of the activities developed, where the student registers his experiences and understanding of the treated theme. The production of the activity report should be encouraged in the format of scientific articles, providing students with the improvement of their abilities in the art of writing and research. Regardless of the format of the report to be submitted after the field activity, it is important that the teacher provide subsidies for the student to prepare the report. The use of Gowin's "V" diagram is suggested as a tool to guide the elaboration of the field report in a reflexive way, interconnecting concepts and theories worked in the classroom and/or researches with the questions and observations obtained during the field learning activities.

Keywords— Geosciences teaching, field learning activity planning, field learning activity report, Gowin's V diagram.

Thematic line— Geosciences in Higher Education.

1 Introduction

The field learning activities represents the moment of direct contact with reality, knowing it through techniques of observation and interpretation, instrumentalized or not (Venturi 2005).

The field learning activities can help geographers and other professionals from diverse areas of knowledge, such as physicists, chemists, biologists, historians, philosophers, and others interested in teaching Earth Sciences, to develop new didactic approaches, promote reflection and favor the learning of the suggested themes. According Carneiro et al. (2008), the field learning activities plays a relevant role in the formation of concepts and in the contextualization of knowledge. By providing direct contact with the environment, field activities enable the student to conceive the environment as a whole, not fragmented, and to perceive the interactions between phenomena, their relationships, and how these interactions occur (Justen-Zancanaro & Carneiro 2012).

This work seeks to reflect on the role of the field learning activities as a teaching methodology in the process of training students and professionals working in Geosciences, based on the assumption that it is an indispensable procedure in training and teaching activities.

2 Field learning activities as a teaching methodology in the Geosciences

The use of the field learning activities in the teaching of Geosciences as a practical activity aims at complementing the student's formation, both in obtaining scientific knowledge and in the generation of experience closer to the object of study and professional practices, articulating theory and practice and providing a better understanding of place and world (D'Aquino and Bonetti 2015).

The efficiency of a field learning activities is based on the careful planning of activities, in the dominated of applied contents and techniques, and pre and post field evaluations, and during your realization should be provide moments for the reflection of theories, methods, procedures and techniques used. The pre-field and post-field evaluations are carried out in such a way that there is a systematization of the information by the students, and enable the teacher to evaluate if the proposed objectives have been reached (Justen-Zancanaro & Carneiro 2012).

However, among the main problems encountered in its realization, we can cite the poor planning of the necessary time for the activities and insufficiency of expositive classes before field activity (Hawley 1996), the large number of participants (students) in the activity, often above the ideal so that everyone can participate in a satisfactory manner (Shackleton & Binnie 1996), as well as financial difficulties, lack of time for planning and the great responsibility that the teacher takes in taking students out of the school environment (Justen-Zancanaro & Carneiro 2012).

2.1 Fieldwork planning

The field learning activities allows to live the contents discussed in the classroom, often in an abstract way, understanding that this activity provides a perception and reflection of the reality that involves the participants.

According to Carneiro (2008, apud Justen-Zancanaro & Carneiro 2012) "the field is the place where all five human senses are required and participate in observation" in field practices in geology courses. The abstract and intellectual aspects of traditional classroom lessons are now being experienced by students through their perceptions.

> "(...) the vision, to look at the details of the place visited, its colors and sparkles (...); the audition, to perceive the passage of water in a stream, the noise of wind in the vegetation, the sound of animals and birds (...), the touch is not only for the geologist to perceive in the hands the roughness or softness of the roughness of a rock, but above all to feel the notion of natural environment. Direct contact with nature provides physical wear, but also the necessary sensation as cold-warm, wet-dry. The smell (...) we need it to take advantage of everything that exists to be noticed in the field, from the smell of rocks, the fragance of vegetation, the familiar smell of damp clay, exhaled by the action of certain bacteria, the unpleasant odors of eventual contaminations (...) the palate, which accompanies the olfactory perceptions, or can directly enter into the appreciation of the materials we examine, such as clayey sediments, evaporite salts and other materials; the latter are part of the same learning, because prudence teaches us to test them, all with great caution. This is perhaps the most difficult skill to be acquired in the field." (Carneiro 2008 apud Justen-Zancanaro & Carneiro 2012).

This activity should be planned and executed according to a theme, allowing the development of the abilities of observation, description and interpretation of natural and socio-spatial phenomena in the formation of professionals in the Geosciences area (Souza et al. 2008).

D'Aquino and Bonetti (2015) reinforce the need for planning by exemplifying the general steps for conducting a field learning activity of any discipline aimed at collecting data, which involves: a) the choice of study place, b) access check, c) transport logistics and instrumental preparation, d) preparation of the sampling plan, e) sample collection with student participation, f) maintenance of the equipments used when returning, g) assistance in the treatment and analysis of the data collected. The authors indicate the need to elaborate scripts and protocols as support material to the organization of the activity, facilitating, for example, the accomplishment of future activities and assisting in the standardization of data collection. Despite the intrinsic standardization of field way out, there is not possible to exclude the unique experience experienced by participants. Thus, the planning of field activity requires flexibility, since the dynamics of reality can be cause things not to occur exactly as planned and unforeseen can change the structurated and explanatory direction of the programmed content.

Carneiro et al. (2008), explaining the evolution of the field learning activities in introductory geological disciplines Sciences of Earth System I and II in Unicamp over ten continuous years, also reinforce the need for detailed planning of the field activities, considering the didactic conception and the intended methodological approach, as well as the theme of each activity, in order to develop in students the creativity, the ability to observe and understand natural processes, the capacity to analyze and integrate different types of information and cyclic thinking ability.

Compiani & Carneiro (1993, apud Scortegagna & Negrão 2005) proposed that five types of field learning activities can be established, according to the intended objectives, didactic vision in the teaching and learning process, questioning of scientific models, student-teacher interaction and the logic of adopted learning, classified as illustrative, inductive, motivating, trainer and investigative. To this list, Scortegagna and Negrão (2005) added more one type, the autonomous field activity. These six types of the autonomous field learning activities are briefly described below and, although addressed in the context of geological excursions, can easily be expanded to field activities of other disciplines.

- *Ilustrative*: the most traditional, is centered on the teacher, who shows and reinforces the concepts worked in the classroom, and the student is mere spectator;
- *Inductive*: establishes a guide to the observation and interpretation of a determined problem based on a script of activities that demands prior knowledge of the subject matter, the process values the scientific methods and the logical reasoning of the students;
- *Motivating*: arouses interest in a specific aspect or problem presented, does not require prior knowledge and the experience of each participant and their questions are valued;
- *Training*: aims to train abilities, such as the use of specific instruments and the collection of samples and measurements, requires prior knowledge and focuses on the technique and/or procedures;
- *Investigative*: the student elaborates the hypotheses of the research and structures the sequence of observation, interpretation and validation, discusses his reflections and conclusions, the student is the focus and values his prior knowledge, considering that he is able to develop abilities in the theoretical field;
- *Autonomous*: awakens the investigative spirit and prepares the student for the future professional reality, where the student goes to the field alone and the teacher guides him through discussions and exchange of experiences.

When the teacher is preparing and updating the protocols and guides of the field activity, according to the theme and objectives to be achieved, he can be combine some of the field activity types described above throughout the development of the activity, whenever possible and viable, aiming enrich the learning process of the participants, and allowing them to work with different competences and abilities in the same field way out.

2.2 The field learning activity report

The field activity will be characterized as a constructive and meaningful learning process for the student when assessments are made before, during and after the activities, compatible with the methodology proposed for the field activity (Justen-Zancanaro & Carneiro 2012).

As important as the realization of the field activity it is your report, where the student registers their experiences and understanding of the treated theme. This report can take a variety of forms, from the traditional descriptive report of activities to the more elaborate text in the format of academic work, and may also include the production of posters and seminars to complement the activity.

The production of the field activity report should be encouraged in the format of scientific articles, providing students with the improvement of their abilities in the art of writing and research. The elaboration of the report can be developed throughout the stages of the field activity, i.e., pre-field, field and post-field activities, arousing interest in the subject matter covered in field activity and enabling the construction of a conceptual base between the content discussed in the classroom with those experienced in the field activity.

In addition to the traditional format of the field activity report, usually adopted, the search and use of other formats in their preparation should be encouraged, such as the format used in the production of scientific article, with abstract, keywords, introduction, methods, results and discussion, conclusion, and references. This approach enables students do develop important abilities, such as the use of formal, clear and objective language; the use of appropriate words to express your ideas and observations, including the use of technical terms; exposure of content in logical sequence of sentences and paragraphs, chaining subjects; encourage the search for supplementary information through a bibliographic review; among others.

Regardless of the format of the report to be submitted after the field activity, it is important that the teacher provides subsidies for the student to prepare the field activity report. Here we propose the use of a heuristic tool for this purpose, the Gowin's "V" diagram (Fig. 1). This tool has been succesfully adapted for other purposes in classroom, such as in experimental works in the teaching of Geology (Fonseca et al. 2005) and in the process of research in Geography (Santos 2005).

Gowin's "V" diagram initially emerges as a set of five questions for the analysis of the knowledge production process and evolves into a more complex structure, the "V" diagram, capable of embracing in greater detail the constituent elements of investigation process (Santos 2005).

Fonseca et al. (2005) synthesize the constitution of Gowin's "V" diagram:

> "The form chosen in V was not random. Its vertex points to the events and objects that constitute the basis of knowledge.
>
> The left part of the V corresponds to the conceptual part of the research, the constructions that have developed over time whose basic elements are concepts, principles and theories. The right side of V is constructed according to the research that is carried out at the moment, it is basically the methodological part of the research, in which notes are taken of the transformations and observations that occur, annotations are written, tables and graphs are built, and the results are registered. In the center of the V, there is positioned the central question, which guides an entire investigation and involves, conceptually the other intervening elements." (Fonseca et al. 2005).

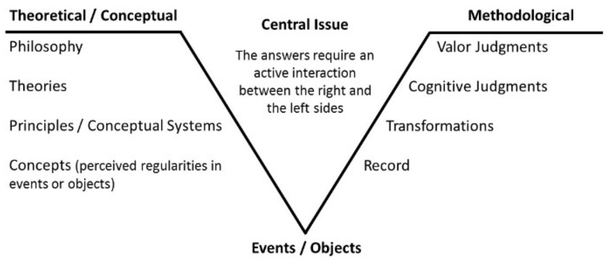

Figure 1. Gowin's V diagram (Fonseca et al. 2005)

Santos (2005) clarifies that the V diagram in its original form is used to "unpack" knowledge already produced and materialized in a written work that presents research results, and that can be adapted to other academic activities. Based on the changes proposed by the author, we propose the use of diagram V in the preparation of field activity reports, starting from the premise that some elements of the original diagram will need adaptations and others may be used in their original form, provided that understand what elements of the report are analogous.

Central Issue: originally refers to the basic questions of the research. In the field activity report, it is refers to the objective of the activity carried out in the field.

Philosophy: related to the philosophy that motivates the practices of a researcher. Although it is not a requirement in the preparation of the field activity reports, it is interesting to know the philosophies underlying the theme of the activity and what approach the author will give to his text.

Theories, Principles and Concepts: intrinsically linked elements, from which emerge the theoretical reference used in the presentation and discussion of the activities carried out, contextualized in the text of the report.

Events / Objects: it is the problem identified. In the field activity it is related to the issues raised during the activity, considering the objective of the activity.

Record: are the observations on the problem, still in the raw state. It is the set of information obtained in the field, without major interpretations.

Transformations: it deals with the type of treatment given to the records, complementing the field records with the contents worked in the classroom and/or obtained in bibliographical research, transforming the field data into scientific information, within the limitations of each field activity.

Cognitive Judgements: in it original use relates to the answers to the central question, whereas in the field activity report it refers to the objective of the activity carried out.

Valor Judgements: originally declares the value, the importance of the knowledge produced. Already in the field activity shows the importance of the activity developed and the knowledge acquired.

The Gowin's V diagram constitute an important didactic tool, that allow to guide the elaboration of the field activity report in a reflexive way, interconnecting concepts and theories worked in the classroom and/or researched with the questions and observations obtained during the field activity.

3 Conclusion

The use of the field activity in the process of training in the Geosciences area is replete with opportunities that generate learning, knowledge and experiences, increasing the perception and reflection of the reality in which the participants find themselves involved. After defining the thematic and objectives of the field activity, it is portanto to aknowledge that the development of the activities requires preparation, organization and logistics, i.e., planning, so that the execution meets its didactic conceptions and methodological approach, allowing the participant to develop different competences and abilities.

The field activity is considered as complete when the final report is prepared and delivered, document where the student registers his experiences and understanding of the subject matter, especially when he/she is encouraged to format it as a scientific article to improve his/her abilities in the art of writing and research. To this finality, Gowin's V diagram is an important didactic tool that can be used in its elaboration.

Finally, without a pretension to exhaust the subject, we seek to foment a discussion about the use of the field activity as an indispensable methodological method in the formation and teaching Geosciences activities.

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Thematic Line

History of Natural Sciences

RICARDO KRONE [1861-1917]: A NATURALIST ON THE FRONTIER OF KNOWLEDGE

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Abstract— This work is a critical analysis of the writings of Ricardo Krone, a German naturalist who lived in Brazil between 1884 and 1917. Krone was an enthusiast of studies on the natural and cultural environment of the Vale do Ribeira in the State of São Paulo and wrote numerous articles in specialized magazines. Three of them, which are objects of analysis in this work, deal with the abundance of caves in the area known as Vale do Ribeira. These publications of Krone were of great value for the creation of the conservation units in São Paulo, such as the State and Tourist Park of Alto Ribeira (Parque Estadual e Turístico do Alto Ribeira-PETAR), where are located many of the caves reported by Krone. Exalting the importance of the caves and their surroundings, Krone formulated a theory in which he showed the relations existing between the elements that composed the landscape as being totally integrated to the underground environment of the caves. Krone believed that the caves of the Alto Ribeira could contain remnants of the Pleistocene fauna that would contribute enormously to the Brazilian natural history. He maintained contact with important scientific institutions such as the Comissão Geográfica e Geológica de São Paulo, where he promoted the need to preserve the caves of the Alto Ribeira.

Keywords— Alto Ribeira, cave, speleology, history, knowledge.

Thematic line— History of Natural Sciences.

1 Introduction

This text intends to use the writings of Ricardo Krone in which he describes the natural attributes of the caves of the Alto Ribeira region, as an example of knowledge production aimed at the conservation of the environment.

Krone is presented here as an open-minded researcher who understands the world as an integrated system. It is intended to demonstrate that its activities corresponded to the time when construction of the national cultural and natural heritage began, starting from the strengthening of the scientific and cultural institutions in formation in Brazil in the late nineteenth and early twentieth centuries.

Due to a comprehensive, systematic and universalizing formation typical of his time, it can be said that Krone's textual contributions are disseminated in several newsletters, magazines and technical books of the most diverse areas of knowledge. In the context in which Krone carried out his research, there was already a tendency towards scientific and technical specializations in Brazil.

Of the publications available with texts written by Krone, only those in which he treats about the caves will be considered. This choice emphasizes Krone's contribution to public conservation policies in relation to the Alto Ribeira caves in the State of São Paulo.

In the three publications mentioned, Krone devoted himself to describing the results of his expeditions to the Alto Ribeira region. From this, Krone created reports containing descriptions, photographs, measurements, experiments, collections of mineral specimens and animals from 41 caves. In his numerous lectures given in various scientific and technical institutions, Krone disclosed his thesis on conservation of the caves of the Alto Ribeira.

2 Critical analysis of Ricardo Krone's writings

2.1 Brief biography

Ricardo Krone (Sigismund Ernst Richard Krone) was a naturalist born in Dresden, Germany. He studied Geographical Engineering at the Technical School of Upper Saxony. In 1884, at the age of 23, he came to Brazil to work as a land surveyor at Estrada de Ferro Sorocabana Company.

With the end of the contract, he moved to the south of the State of São Paulo, in the Vale do Ribeira region. He settled in the city of Iguape where he lived until 1917 and was able to exercise all his intellectual capacity by divulging a great variety of cultural and natural aspects of that region.

In addition to his good social relations with the riverside community, Krone has produced countless researches for national and international museums, research agencies, and has collaborated with numerous researchers in archeology, ethnography, paleontology, speleology, geology, geography, zoology, botany, among other specialties.

It is probable that during his formation Krone read the texts of scholars of karstic and speleological phenomena. In his descriptions he is able to articulate several emerging themes – many of these later consecrated – in the conjectures about the caves of the Alto Ribeira.

2.2 *The pragmatic empiricism-inductivism of Ricardo Krone*

The theme of this item is related to Krone's purpose in highlighting the paleontological potential of the Alto Ribeira caves, following what Lund did in the caves of Minas Gerais

> "It is known that our knowledge of Brazilian post-pliocene fauna is based almost entirely on the results obtained by teachers Lund and Reinhardt, in the first half of the last century, in caves of the Rio das Velhas Valley, in the State of Minas Gerais. Considering that in the middle Ribeira de Iguape Valley there is a vast area formed by gigantic limestone mountains that are excessively rich in caves, it can be presumed that a methodical research of this region can contribute to the knowledge of Brazilian paleontology." (Krone 1909, p. 141)

This statement is crucial to what will be demonstrated about Krone's work in the course of this article. However, he acknowledged that his hypothesis about the paleontological potential of the Alto Ribeira could be counteracted by the geomorphological processes in the carbonate rocks in that region.

> "According to a small tributary stream of the Monjolinho River bordering the Arataca Hill, there is a valley composed of steep bare rock walls, as well as the blocks of rock that formed the old roof of caves that gave way to the valleys due to the erosion that the destroyed. This is a strong evidence that one should not expect to draw from this great paleontological wealth." (Krone 1898, p. 489-490)

Despite distrust of fossil abundance, Krone believed that the paleontological potential should be the main attribute to be considered for the environmental conservation of the region's caves. With this goal in mind, Krone developed and disseminated an explanatory theory to emphasize the importance and foster conservationist perceptions of Alto Ribeira caves.

The methodological option of Krone was based on a singular analysis of the Monjolinho Cave located in one of the headwaters of the Pilões river, tributary of the Ribeira de Iguape river.

From the analysis he made of Monjolinho Cave (Fig. 1), Krone developed a series of inferences for the correlations between physical, chemical and biotic elements, besides making a considerable number of measurements in order to identify quantitative parameters that would give legitimacy to his studies.

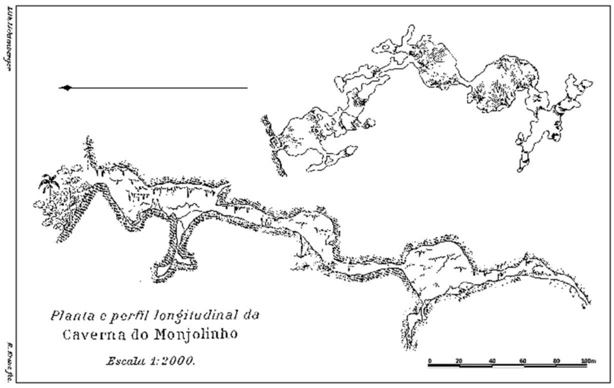

Figure 1. Plant and profile of Monjolinho Cave (Krone 1898. pp. 579)

Starting from the particular observation of the attributes of the caves, observed in the expeditions by the Vale do Ribeira, Krone happened to the description of a general formulation.

> (...) "Between the Palmital and Pilões rivers there are large mountain ridges of microcrystalline limestone rock. Its specific weight is 2.8, the hardness is between 3 and 4 and the stratification is situated from east to west, in addition the dive is between 45° and 85° to the north." (Krone, R. 1898, p. 479)

Although he did not relate these and other parameters, Krone believed that this could be the way to explain the abundance of caves in the limestones of the Alto Ribeira[1].

In the general observations about the relief of the Alto Ribeira appears the notion that the primordial geological processes and the more recent geomorphological ones acted.

> (...) "Some undressed rocks make visible the precipitation of the calcite to the top of the hills already undressed recently by the action of the waters." (Krone 1898, p. 479)

Krone seems to have partially understood the geomorphological situation of the lenticular carbonate formations, which are lower in relation to the set of adjacent impermeable saws. These reliefs result from tertiary folds and subsequent quaternary denudation. (Karmann 1994).

> "The road passes in a depression between the last two elevations and it is easily verified the outcrops of limestone and diabase." (Krone 1898, p. 480)

Comparatively, the limestone is lower relative to the higher adjacent impervious formations. The water basins on the impermeable rocks present a trellis type drainage pattern composed of runoff channels. On the limestone, the drainage flows underground. (Martins 2014).

After the general contextualization, Krone turns to the analysis of the particular singularity of the caves. Among his methodological choices, Krone used a case study that believed to be representative of the Alto Ribeira's identity. The justification for the choice was relatively subjective. According to Krone, the Monjolinho Cave was the "most important" (Krone 1898, p. 480) he explored in the region.

In describing the causal factors to the existence of the Monjolinho Cave, Krone understands that

> "The origin of these caves came from water infiltrations (Tagwaesser). In the absence of a noticeable stratification in the rock, the water randomly followed its course to the lower layers following the more fragile parts of the rock. The more water passed through the cracks, the more the conduits widened into galleries. "(Krone 1898, p.482)

The aforementioned passage refers to the fact that the debates about speleogenesis in the passage from the nineteenth to the twentieth centuries tended to follow the cyclical view of morphogenetic processes in general. Such tendency culminated in the proposition of the davisian model to explain the relief from a temporal point of view, in the light of positivism, according to fragments or significant sampling stages.

Considering the enormous initial acceptance that the "Geographic Cycle" had in the mentioned context, thanks to the strong influence of the Anglo-Saxon school of Physical Geography, Davis and his disciples, like Cvijić (1918), for example, debated, formulated and began to use a cyclical explanatory model also for the genesis of caves.

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[1] Geologically, the area studied by Krone corresponds to what Campanha (1992) and Karmann (1994) described as a tectonic compartmentalization in lenticular, elongated, NE-SW blocks separated by large regional lineaments. In a large part, the Alto Ribeira is located in the compartment called by the same authors as "Bloco Lajeado", constituting a sedimentary sequence (composed of seven lithostratigraphic formations, alternately of terrigenous and carbonate origin, with an intrusive rock body basic at the top of the sequence) of low metamorphic degree at its most central portion.

In the davisian model applied to karstic-speleological phenomena, the importance of erosion in the process of lowering the relief is replaced by the overvaluation of the subterranean dissolution of the limestone. In this same sense, the opening of caves occupies the place of the valleys as a product of the process of carving and dissecting the modeling of the surface.

In another passage, Krone states that

> “Where rainwater is able to penetrate occurs the widening of cracks due to the mechanical action of erosion or the chemical effect of corrosion.” (Krone 1909, p. 144-145)

The previous sentence demonstrates the alignment of the author with another change in the scientific panorama of the late nineteenth century in relation to geomorphic processes. It is the notion that the morphology in the terrains on carbonate rocks was derived primarily from chemical dissolution rather than the general idea of mechanical erosion by "pure water" (Gunn 2004).

On the other hand, Krone understood that the process that leads to the formation of caves can not be seen from a linear perspective.

> “The growth of speleothems is quite irregular and depends on both the amount of rainwater and the rate of atmospheric carbon dioxide. The first factor varies according to geographic location and the second factor depends on the amount of vegetation on the surface of the mountain.” (Krone 1909, p. 146)

> “As water supply conditions changed due to the great climatic changes or by blocking the supply channels, the development of a great diversity of speleothems.” (Krone 1898, p. 482)

This view of Krone reflects a critical stance that emerged in the Germanic tradition on the unilateral application of the Davisian Geographical Cycle. As an alternative, Walther Penck proposed (1924) to consider the morphogenesis of the Earth's surface as a result of the dialectical action between endogenous (formative) and exogenous (modeling) forces (Lana & Castro 2012).

Concern about the permeability / porosity that causes the water to disappear in the soil or the rock was another aspect that caught the attention of Krone.

> (...) “the infiltration of rainwater into the great depths of the mountain" (...) "is not sufficient to produce erosion at the lower levels.This is only because the water is able to circulate, otherwise the crystallization of the soluble minerals.” (Krone 1909, p. 144-145)

Recent studies have highlighted this theme by addressing the importance of the epikarst or subcutaneous zone in speleogenesis. Williams (2008) shows that, when present, the epikarst consists of an outcropped or subsurface weathered limestone with a secondary porosity between 10 and 30%.

The high porosity and permeability have to do with the fact that there is greater dissolution of limestone associated with the surface due to the proximity to the sources of CO_2 production. As the depth increases the porosity decreases and the concentration and number of faults increases. This occurs to the vadose zone[2] of the untempered rock. At this depth, the porosity density becomes less than 2% and allows the percolation of the acid water producing speleogenesis. (Williams 2008).

Another relevant aspect observed by Krone has to do with one of the most recurring themes in cave studies to date. The one that deals with the speleogenetic processes.

> “The rocks with very evident stratification facilitate the work of the water in opening conduits in the same direction of the stratification planes.” (Krone 1904, p. 91)

> “This widening of conduits precedes the formation of the caves which are effects and the continuity of that same initial enlargement.” (Krone 1909, p. 144-145)

Since the time of Krone, this theme has been widely debated by scholars of caves and karst. Bretz (1942), for example, stated that the genesis of limestone caves depends on pre-existing porosity. This allows the water to percolate through the rock, initiating the process of underground expansion. Recently, Klimchouk (2007) corroborated this notion by stating that speleogenesis is the creation of permeable structures in a rock, developed as a product of the widening of the dissolution of pre-existing porosity.

2.3 The constitution of a theory of the Alto Ribeira

After characterizing the particularities of the Alto Ribeira, Krone began to elaborate his theoretical explanation of why the region contained so many caves.

An important aspect to be considered in advance is that Krone rejected the paradigm of the time represented by the Kantian method to approach the phenomena of nature.

> “The Geographia Physica of the great Immanuel Kant presented many errors of interpretation. Thereafter, there was great progress in knowledge about the origin of the caves and their varieties, which did not allow for a single explanation.” (Krone 1909, p. 143)

According to Vitte (2006), Kant conceived his theory to be a general theoretical (metaphysical) referential for all the natural sciences. Kantian metaphysics is a solid methodology for the formulation of a philosophically and scientifically ordered world-system of knowledge of phenomena. These must be treated according to the teleological grounds of their time, that is, they obey causal laws and exist for predetermined purposes.

Kant believed that the definition of an a priori metaphysics for the laws of nature enabled the possibility of true knowledge about existing things. The objects of experience, that is, those which are appropriated by the senses, are not referenced in a logical system that allows understanding by the intellect. Assuming that phenomena have teleological links, it is possible to represent them from a transcendental perspective. This would allow theoretical understanding by the intellect. (Vitte 2006).

For Krone, the valorization of particularities to the detriment of generalities is justified by the fact that.

> “Each cave has its own particularities in terms of form and content. Such variety is the major attraction for the work of conservationist researchers.” (Krone 1909, p. 143-144)

For Krone, the particularities of each cave might correspond to the multiple emerging interests in the particular sciences in the context of the early twentieth century.

[2] Or Karst Unsaturated (Gunn 2004)

Despite his empathetic-empiricism, Krone understood that apriorism could be employed on a more general scale to explain the whole of the Alto Ribeira caves.

> "The most important factors in the formation of caves are erosion and corrosion" (...) "and all the caves known to date in the Ribeira River Valley belong to this subdivision. Erosion and corrosion act in the horizontal and vertical direction forming, respectively, wells and tunnels. " (Krone 1909, p. 144)

If, on the one hand, the (particular) form of each cave is the product of the genetic conditions and their location. On the other hand, the process must be generalized (universal) and should be represented in a simplified way and show the set of caves as a whole. The Monjolinho Cave served as an example for the genetic simplification of speleogenesis. This principle shows the repercussion that the Newtonian paradigm had on Krone. This indicates that he was concerned to demonstrate his concern with a scientific representation well grounded in natural philosophy, based on the empirical-inductive method.

On the other hand, Krone also sought to value the need for a theoretical conceptualization of ordering the phenomena of sensory experience. This is the case of the taxonomic differentiation between "grotto" and "caves".

> “Among the caves in general, and especially those of the Ribeira River Valley, are the 'grottos' that are currently dry, but present the evidence of the passage of water that formed them in earlier times when they were appropriately called caves.” (Krone 1909, P. 145)

> “The Monjolinho Cave belongs to the so-called dry caves or ‘grotto’. However, there are innumerable forms that evidence the excavation by the water that ran by it in the past.” (Krone 1898, p. 481)

The analysis of the abovementioned passages allows to affirm that Krone tried to relate its observations to the evolutionary principles, being the dry caves, called by him of grotto, environments already abandoned by the speleogenetic processes. This class would be formed by caves that are no longer worn by the circulating water, unlike the caves with circulating water that are fully active. The way in which Krone defines his understanding of speculative evolution corresponds in part to a rather ordinary view of cave scholars and karst, which is the contemporary concept of paleokarst.

The paleokarst includes the features left by the speleogenetic processes. This occurs in underground sites that are no longer the locus of dissolution / erosion by the subterranean river of allogeneic origin[3]. Nevertheless, the same features are permanently under the influence of the dissolution arising from the waters of autogenic infiltration in the epikarst. Krone pondered this using the example of the sedimentation technique of calcite[4].

An interesting aspect to be noted about Krone, is that it specifies each case. If, on the one hand, it is no longer possible to see the processes taking place in the caves, on the other hand, they allow human access and observation and keep past processes in the ornaments that adorn their interior. By dealing with the attributes of caves and caves together, it is possible to make a comprehensive synthesis of the evolution of the whole.

Krone suggested delineating the specificity of each particular cave as a parameter. This means that, when compared, each cave is situated at a certain stage of development. With this, he denied the a priori model and valued the evolutionary process in the caves. For this, Krone used a calcite deposit called "The Giant" (Fig. 1) found in the Monjolinho Cave.

Figure 2. "The Giant" (Krone 1898. pp. 486)

> "It is not possible to calculate the growth of speleothems by rules considered valid, since the conditions necessary for the formation vary a lot from one place to the other. However, explorers such as Dawkins, Krauss, Kriz and Martel have developed techniques that if applied to the 'Giant', allow to deduce an age superior to 25 thousand years. Relatively few compared to the millions of years required to form calcareous caves." (Krone 1898, p. 487)

The evolutionary question also appears in Krone's writings in relation to his conjectures about the geological-geomorphological dynamics attributed to the calcite deposit currently known as the "Pata de Elefante."

> “A proof that the galleries that have been abandoned for millennia by the water can be reactivated, is in a lateral conduit whose floor formed by a calcite crust of 10 cm of thickness suffered a interruption of continuity by about 3 m. During a period of inactivity a layer of 2 m of alluvial sediments was deposited on the crust which was then covered with a thin layer of calcite by the stagnant water. Subsequently, the reactivation of the water stream mechanically eroded the surface layer of calcite and easily carrying the alluvial soil left suspended the calcite crust that covered the whole set.” (Krone 1898, p. 484-485)

Krone's statements indicate that he had a relative capacity for recognition of the forms that represent great global climatic oscillations.

This theme has become quite common in paleoclimatic studies that use speleothems as indicators for radiometric dating and geochemical analysis.

The "Pata de Elefante" speleothems (Fig. 3) were used by Karmann (1994) as indicators of geomorphological processes guided by alternations of erosion and sedimentation. This technique was used to obtain the estimated rates of underground fluvial carving of the Pescaria Cave, located near the Monjolinho Cave.

[3] Recharge water running from adjacent waterproof surfaces towards the limestone (Karmann 1994).

[4] $CaCO_3$

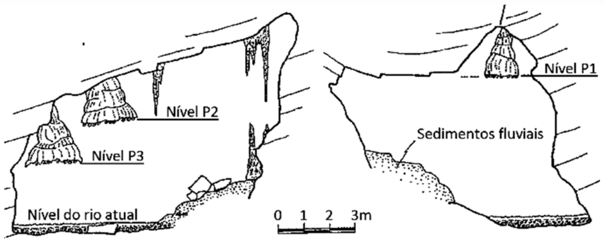

Figure 3. "Pata de Elefante" speleothems of the Pescaria Cave (Karmann 1994. pp. 140)

Karmann (1994) used calcite deposits at different heights considered as testimonies of old riverbed beds at different levels of carving. The comparison demonstrates the evolutionary dynamics of the carving and alluvial and calcitic sedimentation phases. These have in common the progressive lowering of the channel bed associated with the base level.

Parallel to the field studies, Krone worked with Hermann Von Ihering[5] to formulate a representation of the Alto Ribeira as a pole of paleontological studies.

As a member of the Scientific Society of São Paulo, Krone organized numerous conferences. In them he highlighted the aesthetic aspects and defended the acquisition of the lands of the Alto Ribeira that contained caves potentially considered paleontological sites, by the state government. Always with the favorable support of the Scientific Society.

The most commonly used argument by Krone at the conferences was the similarity he believed existed between the caves of Minas Gerais and the rich patrimony they contained, which Peter William Lund studied, with the potential paleontological sites that the caves of the Alto Ribeira represented.

2.4 *Political pragmatism directed to research*

In his articles and lectures, Krone was very emphatic about his claim that the Alto Ribeira was known for its paleontological wealth (Brandi 2007). His political position is evidenced by the fact that Krone argued that the fossils of the Alto Ribeira should contribute to the formation of the brazilian national patrimony.

> “There are at least 55 genera that represent the Brazilian cave fauna. They are all at the Lundii Museum in Copenhagen, Denmark. [...] We now have in the caves of Iporanga the probability of forming a new collection. This time we will try to keep this for your homeland!” (Krone 1898, p. 500)

Krone's ideas are also in line with the modernist trend of formation of public museums that broke with the typical collecting practices of the sixteenth century. This trend reflected the principles that guided the advent of the concept of national patrimony, which included in a restricted way the geological heritage, in the brazilian post-colonial national project.

The statements made in the last citation represent the interaction between the geological spheres and the noosphere, or the human sphere (Potapova 2008) present in Krone's work. Especially as regards his contribution to the understanding of the processes that have occurred in geological time in the composition of the culture of the present moment.

At the international level, there have been studies of Earth Sciences in which geological heritage has appeared as part of the natural heritage and must be managed and preserved (Carcavilla et al 2016).

Krone's conservation of caves was aimed at the scientific bias and concern to promote sustainable tourism use of caves. This purpose used as a pretext by Krone is currently a subject of wide representativeness. This is because the paleontological heritage is considered one of the attributes that most attract the curiosity of the public that visits the caves (Ardila & Valsero 2016).

By the time of Krone the caves had already aroused the public interest and the private owners charged entrance of the visitors. In defense of cave preservation, Krone also warned about this and emphasizing the need for a sustainable tourism practice. This principle has become one of the main references in the tourist activities in Alto Ribeira, especially in the PETAR.

This is a recurring theme in the texts on the degradation of the environmental quality caused by speleological tourism (Ardila & Valsero 2016) and has generated discussions about ways to minimize the negative effects of public visitation. Nowadays, in addition to the environmental education practices, there are several methods of assessing the levels of human influence caused to the cave by speleological tourism. In most cases, they are experiments such as the monitoring of changes in temperature, atmospheric chemistry and humidity due to human presence, which aim to establish standards and limits that ensure both the maintenance of the tourist practice and the conservation of the attributes of the caves. (Sánchez-Moral 2016).

As a consequence of the publicity made by Krone on the possible relevance of paleontological potential in caves, on December 30, 1906, the São Paulo government approved Law no. 1,083 (Krone 1909). In practice, the law determined the expropriation of the areas on Arataca, Arataca Mirim, Chapéu Grande, Chapéu Mirim, Monjolinho, Pescaria, Pescaria Mirim and Tapagem caves in 1910. This decision was taken by the Procuradoria do Patrimônio Imobiliário – PPI' of the Procuradoria Geral do Estado de São Paulo (Guimarães 1966). As a result of all of Krone's work, finally, in 1956, the Parque Estadual do Alto Ribeira (PEAR) was created, now called PETAR (São Paulo 2010).

3 Conclusion

In the Krone texts chosen for this work, it was perceived that he had a clear option by the empiricist-inductive method. He proposed a theory based on the empirical observation of the particular object to form a general definition for the Alto Ribeira.

[5] Hermann Friedrich Albrecht von Ihering (1850-1930). Emigrou para o Brasil em 1880. Além de ter atuado no Museu Nacional, foi fundados e diretor do Museu Paulista por 25 anos.

Krone's observations, experiments, measurements and written and photographic records of the caves of the Alto Ribeira were substantial so that, over time, the recognition of the patrimonial values of this region understood the need for its conservation.

One quite remarkable aspect of Krone's writings on genesis and the form of the caves of the Alto Ribeira is the absolute absence of theological principles and attachment to purely natural causes.

Krone worked tirelessly for the dissemination of the natural and cultural heritage of the Vale do Ribeira as a whole, but he paid special attention to the speleological heritage of the Alto Ribeira.

Directly or indirectly, Krone's descriptions of the cave environment served as a starting point for a series of studies that have consolidated the region's caves as one of the most representative segments of Brazil's natural heritage and can be considered as a key element, although not to determine it more broadly, the regional identity of the Vale do Ribeira.

Krone's performance was of great relevance for the expropriation of the cave - containing areas in 1906 and for the creation of the Parque Estadual e Turístico do Alto Ribeira, em 1956.

As to the title of this work that suggests a "Krone at the frontier of knowledge", what was wanted to demonstrate throughout the text was the effort of Krone in articulating the diverse philosophical and scientific principles that appeared diffuse between the end of century XIX and beginning of the XX in the descriptions that made of the caves of the Alto Ribeira in order to justify the protection of this environment that he believed to be of great importance for the society of Vale do Ribeira and Brazil.

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Thematic Line

Technology and Educational Innovation

"A SCHOOL SEISMOGRAPH SYSTEM AT KVIS, THAILAND": A NEW CONSTRUCTION AND ITS SEISMOGRAMS

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Abstract— A new hand-made seismograph system for school use is installed at a science high school in the eastern part of Thailand. The system consists of one vertical seismometer and two horizontal ones. The seismometers have aluminum + brass pendulums and electro-magnetic sensors. The signals are amplified by integrating amplifiers and AD converting by Arduino. A laptop-PC is employed for recording, while a 40-inch LED TV is used for real time signal display. The students and visitors can watch the real-time ground signals and recognize the mechanism of seismometers. The detecting limits of this system are less than M4.0 for local earthquakes and M6.5 for foreign ones.

Keywords—seismograph, school use, hand-made, Arduino.

Thematic line— "Educational tool".

1 Introduction

Seismographs are a fundamental tool for geoscience, and yet there are only a few attempts to use a seismograph as a teaching tool at high-school level. It is hard to motivate students in Thailand to study earthquake or related disasters because Thailand rarely has earthquakes. We have been developing handmade seismographs for school use over the past two decades (eg. Okamoto, 1999).

A few years ago, we completely refreshed our system by using new strong magnets, a modern micro-controller and a sophisticated programing code (Okamoto, 2016, Okamoto and Ito, 2014). This new system is now successfully installed at the Kamnoetvidya Science Academy (KVIS). The system has been in operation to continuously monitor daily seismic activities on this campus. Many seismograms have been generated by the seismograph for teaching geoscience. The system has detected several foreign earthquakes already. These are, for examples, the recent North Korean nuclear test and the Mexico M8.1 earthquake. This poster shows details of our system and some interesting results generated.

2 Instruments

2.1 Outlines

The seismograph consists of 1) sensor 2) pendulum 3) damper, and 4) logging system. Our all hand-made system is comprised of the parts shown in Figure 1.

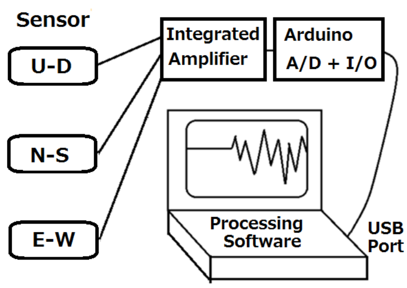

Figure 1. Block diagram

2.2 Hardware

1) Electro-magnetic sensor: copper coil and strong neodymium magnets

2) Pendulums: modified Ewing type (vertical) and Swing-gate type (horizontal)

3) Pivots: thin phosphor bronze plates (0.1 mm), crossed in vertical system

4) Aluminum plate (0.5 mm and electro-magnetic friction damping

5) Integrated amplifier + A/D converter with "Arduino Uno"

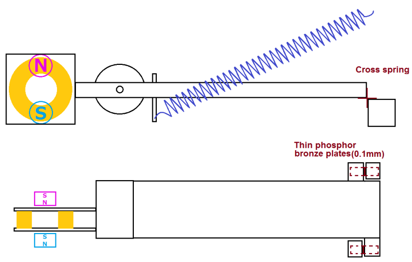

Figure 2. Pendulum (vertical / horizontal)

Figure 3. Winding coil Figure 4. Vertical sensor

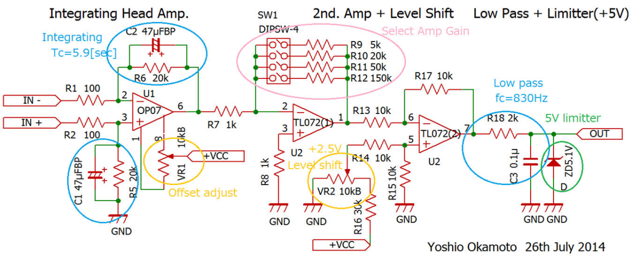

Figure 5. Integrating Amplifier

2.3 Software: Arduino IDE+Processsing

1) 24 hours real-time signal display (3ch) with time marks

2) Save data both digit data + image data

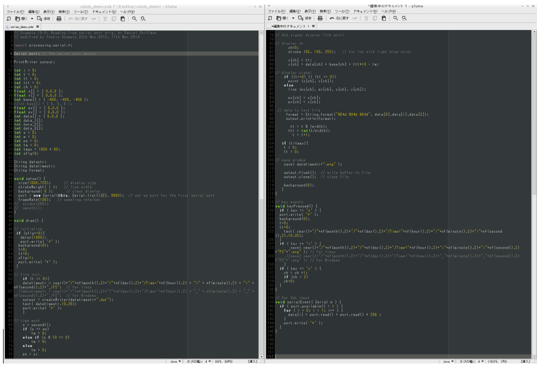

Figure 6. Controlling software
(Arduino IDE + Processing)

2.4 The key concepts of our seismographs;

1) To show the mechanism of seismographs, a transparent body cover and an aluminium pendulum with brass as a mass have been used.

2) Continuous real-time display with time-marks; 64 Hz sampling rate, 30 sec signal x 60 lines = 30 min display; one recorded file

3) A 40-inch big monitor is used for real-time signal display. Many visitors enjoy this first Thailand School Seismograph System.

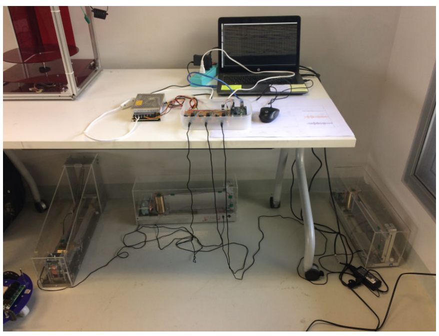

Figure 7. Whole system in the Physics ICT room Three seismometers under the table. (Left:Vertical, Center and Right: Horizontal)

3 Seismograms

3.1 Foreign Seismograms

The KVIS school system was installed in early September and some trial observations were made. In the trial recording period several interesting signals were recorded.

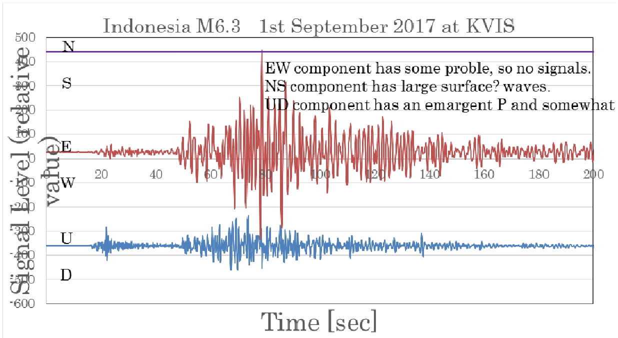

Figure 8. Indonesia M6.3 (Blue: UD, Orange: EW Black: NS, No signal)

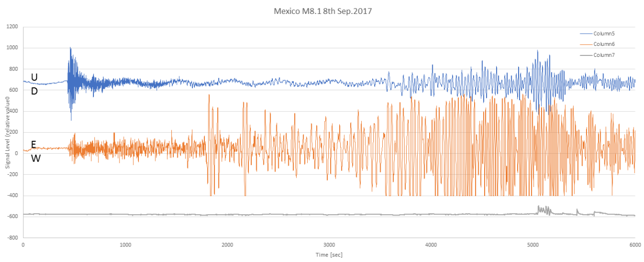

Figure 9. Mexico M8.1 (Blue: UD, Orange: EW Black: NS, No signal)

3.2 North Korean Nuclear test signal

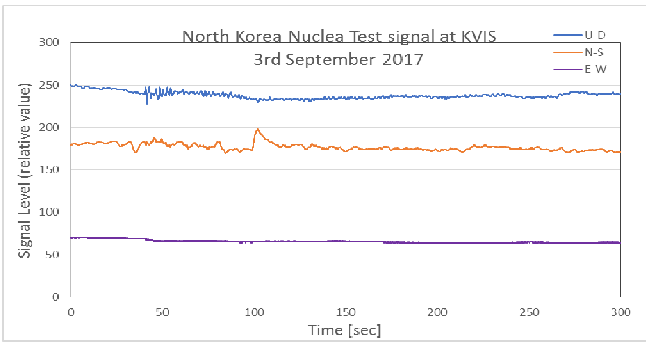

Figure 10. North Korean nuclear test signal M6.3 (Blue: UD, Orange: EW Black: NS, No signal)

4 Discussion

4.1 Evaluation of results

1) An integrated amplifier is used to show the displacement ground motion instead of the velocity output of a common electro-magnet system.

2) The seismic noise level of our campus is quite low due to a stable hard granite base, and also for being far away from coast. Therefore, only weather based long period tremors and artificial tilts are recorded as background noise.

3) The detecting limit of earthquake is less than M4.0 for local earthquakes and M6.5 for foreign earthquakes.

4) The M6.3 North Korean nuclear test signal was clearly recorded as a vertical component. The signal is unique and is characteristic of the nuclear test signal.

4.2 Further study

1) To estimate the magnitude (Richter scale) from our seismograms.

2) More seismograms are needed to perform such quantitative analysis.

3) To study how to co-operate the other school seismology program; eg. https://www.iris.edu/hq/sis

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MINERALS IN THIN SECTION: AN OPEN-ACCESS, INTERACTIVE WEBSITE FOR TRANSMITTED-LIGHT PETROGRAPHIC MICROSCOPY

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Abstract— We present a new open-access website that provides support for the study of rocks and minerals in standard thin sections. The website provides listings of optical and morphological mineral properties, graphical presentations of crystallographic-morphological properties combined with optical indicatrix geometry, and a graphical overview of refractive index range in combination with crystal-plate thickness versus birefringence plots. Above all, thin section images are provided for each mineral that is included in the data set. The advantages of an online data bank are easy access and user navigation, the option of direct access and projection in the teaching venue, plus the availability of a large range of high-resolution images. From the website operators' side, data can be added or corrected anytime, and contents can be expanded as desired. The website can be used by students as a learning resource, by geoscience teachers as a teaching tool, and by geology professionals as a support tool for their projects. Beyond that, anyone interested in rocks and minerals has the opportunity to see details that are normally hidden to the naked eye and enjoy the beauty of the smaller-scale features of the solid Earth.

Keywords— Polarized-light microscopy, mineral identification, thin sections, interactive website.

Thematic line— Technology and Educational Innovation.

1 Introduction

Polarized-light microscopy remains an indispensable tool for the mineralogical analysis of geological samples, and in many instances presents the critical step before taking mineral and rock analysis to the next level (such as electron microbe, XRF, ICP-MS analyses). Petrographic microscopy not only reveals the precise mineralogical composition of rocks, but also critical information on textural relationships between its minerals (crystallization features, reaction textures, deformation structures, etc.). The importance of microscopic mineral and rock analysis is reflected in the variety of textbooks available on the subject that range from pure data compilations to printed atlases of photomicrographs. A drawback of the former is the lack of photographic reference material, and a drawback of the latter is the high cost of colour printing, which limits the scope of any image collection in book form.

The obvious way ahead is a web-based approach, with the advantages of easy access from anywhere, availability of large storage space, and, just as importantly, the option to modify the database at any time, to upgrade, add and delete as desired. While a recently published open-access e-book by Raith et al. (2012) focuses on the methodical-practical approach to thin section microscopy, the new website is essentially an optical-mineralogical database, sorted by minerals and mineral groups, with emphasis on thin section images.

2 Website layout

The website involves the following elements:

- A mineral index (A-Z) with links to data pages and image sets
- A graphical presentation of crystallographic-morphological properties combined with optical indicatrix geometry (Figure 1)
- A graphical overview of refractive index range in combination with a crystal-plate thickness versus birefringence plot using a modified interference colour chart (Raith-Sørensen chart; Sørensen 2013) (Figure 2)
- A condensed listing of optical and morphological mineral properties (Figure 3)
- An extensive archive of photomicrographs involving multiple image sets for each mineral species (Figure 4). These image sets include plane-polarized-light and crossed-polarizers modes showing critical grain sections and orientations as well as lambda-plate overlays.

Furthermore, a search facility will be included that allows input of own observations and/or self-defined constraints on properties.

Mineral (Example Tourmaline)

Mineral Data

Datapage

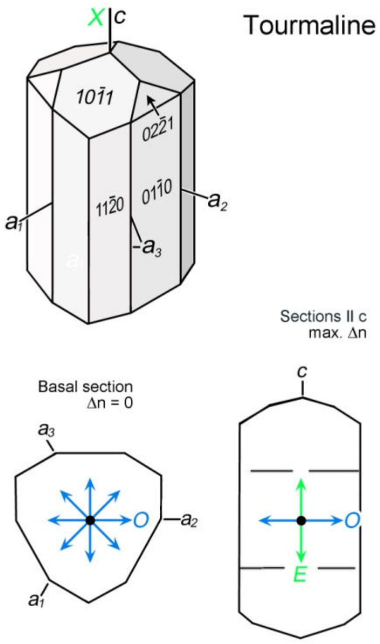

Figure 1. Crystallographic-morphological properties

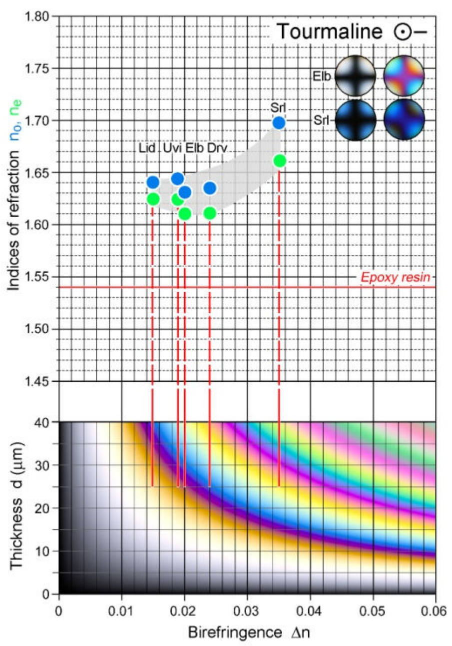

Figure 2. Overview of refractive index range

Formula		$Na(Mg,Fe,Li,Al)_3Al_6(Si_6O_{18})(BO_3)_3(OH,F)_4$
Optic class & sign		Uniaxial negative
Relief		Moderate to high
Refractive indices		n_o = 1.631 -1.698
		n_e = 1.610 -1.675
		Increase of n with increasing Fe, Mn, Ti; Fe^{3+}-rich varieties may have an n_o as high as 1.8
Birefringence (max.)		0.015 - 0.035
		Increase of Δn with increasing Fe, Mn, Ti; Fe^{3+}-rich varieties may have Δn values up to 0.110; interference colours may be masked by mineral colour
Sign of elongation		Length-fast, I (-)
Interference figure		Weakly coloured varieties provide well-defined isogyres and first- to second-order isochromes; masking of isochrome colours in strongly coloured varieties. Minor isogyre separation up to 10° may occur.
Colour / pleochroism		Colourless to strongly coloured, with highly variable colours; colour zoning is common. Coloured varieties display strong pleochroism with O>E (hence, basal sections show darker colour); Schorl may be green, blue, gray, or pink; elbaite: colourless to light-coloured; dravite-rich varieties: light brown, yellow, or colourless; colour intensity increases with Fe content. Absorption in O direction may be extreme such that crystals appear black.
Form	**Habit**	Stubby to acicular, elongate in c direction; also radiating aggregates; basal sections of simple crystals may be six-sided-trigonal; otherwise, multiple prism faces give the basal sections a characteristic triangular shape with "outward bulging" sides
	Surface	Typically euhedral to subhedral
Cleavage		$\{11\bar{2}0\}$, $\{10\bar{1}1\}$ very poor, fractures roughly orthogonal to c
Twinning		Rare
Extinction		Straight to prism faces in sections ll c
Reaction textures		
Alteration / decomposition		Sericite, chlorite, lepidolite; relatively resistant to weathering
Occurence	**Ign**	Granite, granodiorite, pegmatite
	Met	Rocks affected by boron metasomatism; common accessory mineral in metapelites; meta-evaporites derived from borate-rich deposits
	Sed	Detrital in sands (heavy mineral fraction)
	Hyd	Veins, tourmaline-quartz rocks (products of "tourmalinization")
	Other	
Distinctive properties		Strong pleochroism if coloured, upper-first to second-order interference colours, characteristic basal sections, lack of cleavage, maximum absorption orthogonal to c axis. Small grains of colourless anhedral tourmaline may be most easily overlooked.
Additional comments		

Figure 3. List of optical and morphological mineral properties.
Images

Range of Images

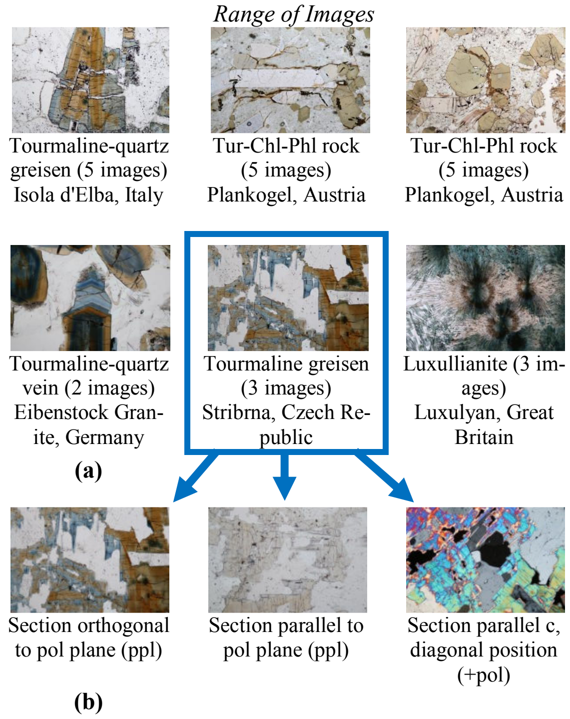

Figure 4 (a). Archive of photomicrographs (examples tourmaline), (b) Sub-image set include plane-polarized-light (ppl) and crossed-polarizers mode (+pol)

3 Website layout

The website is presently in the data-capturing stage. Once this is completed an initial version containing the most common minerals and mineral groups will be released. From this initial set of minerals we will move towards a more extensive coverage including less common minerals. Input from "outside" will also be encouraged. The website will be hosted by the Deutsche Mineralogische Gesellschaft (DMG), and a link will also be available through the International Mineralogical Association (IMA) website.

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