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Future Educational Challenges From Science & Technology Perspectives

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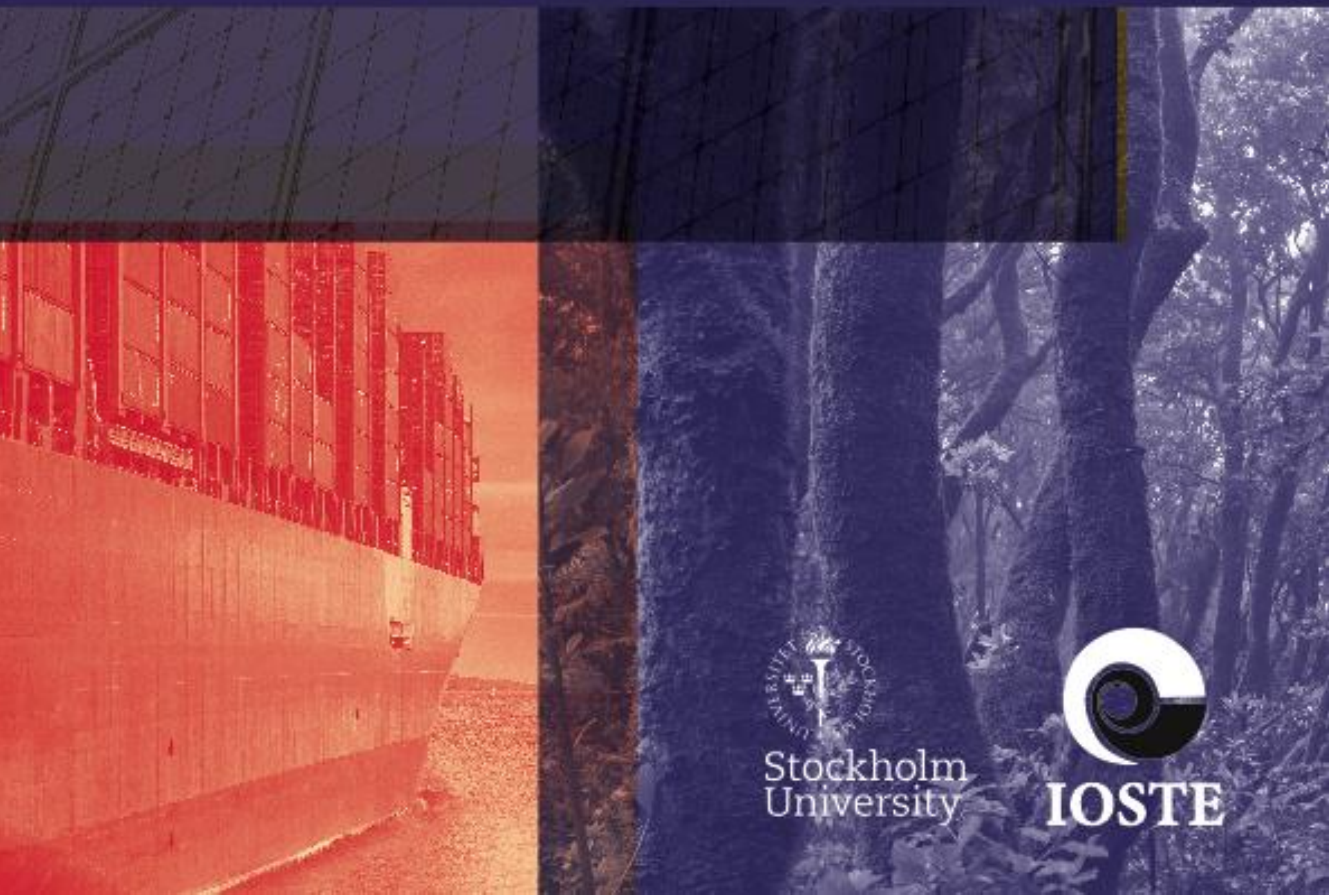

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Introduction

It is with great pleasure we hereby present the Symposium book of proceedings from the XVIII symposium. The theme of the conference was *Future Educational Challenges from Science and Technology Perspectives* and the papers all addresses this theme in different ways.

We would like to thank the authors of the papers, the organizing committee, the scientific committee and not at last the the reviewers in their work with the conference and this book of proceedings.

Yours sincerely,

Assistant professor/senior lecturer Anna Jobér
Chair, IOSTE 2018 Conference

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Teaching nature of science to chemistry teachers: How do their views change?

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Abstract

One of the major aims of science education is scientific literacy. The nature of science (NOS) is one of the main goals of achieving scientific literacy. The aim of the study is to determine chemistry teachers' views' of NOS; to develop their views with explicit-reflective activities based on their initial understandings and to investigate their views about science. The study was designed as a qualitative case study. 6 female and 5 male chemistry teachers who were also master students in chemistry education department participated in the study. The data of the study were collected with Views of Nature of Science Questionnaire-Form C (VNOS-C) and interviews with the participants. The data was analyzed by content analysis. Generic and context-specific NOS activities were used to underline the NOS aspects in the intervention. The findings showed that chemistry teachers held naïve and eclectic understanding of NOS prior to the intervention. Even though a small number of teachers still held their eclectic ideas, most teachers stated more informed views after the intervention. In the light of the findings, some recommendations will be given for future science education and NOS studies.

Keywords: Chemistry teachers; explicit-reflective approach; nature of science; science education

INTRODUCTION

Scientific literacy is one of the major aims of science education and there is a consensus among science education experts that understanding the nature of science (NOS) is very important for achieving scientific literacy (NRC, 1996; Lederman, 2007). According to Driver, Leach, Millar, and Scott (1996), there are five arguments about the benefits of students' learning of the NOS. These arguments suggest that NOS helps students to (a) understand the process of science and relate it to their daily lives (as a utilitarian argument), (b) participate in the decision-making process on socio-scientific issues (as a democratic argument), (c) appreciate science as an important factor of contemporary culture (as a cultural argument), (d) be aware of the norms of the scientific community (as a moral argument), and (e) learn science content successfully (as a science learning argument). In Turkey, educational reform in secondary science education also aimed at raising scientifically literate students. This reform movement launched in 2007 and has affected the philosophical approaches related to learning and teaching in that constructivism has been adopted instead of behaviorist approach. This new philosophical understanding has also affected the meaning of science, which was reflected in a very rigid and traditional way before the reform. According to the new understanding, science is a dynamic and tentative way of understanding the universe. In this manner, a second revision was made to secondary chemistry curriculum in 2013 and the importance of NOS for scientific literacy has been emphasized (MNE, 2013; Irez, 2016).

There are different descriptions of NOS that science educators and philosophers have defined. McComas, Clough, and Almazroa (1998, p.4) gave an extensive description and defined NOS as “a fertile hybrid area which combines certain aspects of different disciplines including philosophy, sociology and history of science as well as psychology and searches for answers to the questions of what science is, how it operates, how scientists work as a social group and how society itself both directs and reacts to scientific studies”. However, a consensus among academics has been established on the aspects of NOS to be included in science curriculum. The aspects are the empirical, the tentative, the theory-laden, the creative-imaginative nature of scientific knowledge, the social-cultural embeddedness of scientific knowledge, scientific theories-laws and observation, inferences and theoretical entities in science (Lederman, Abd-El-Khalick, Bell, and Schwartz, 2002). Students’ and teachers’ views of the NOS have been investigated for nearly 60 years by researchers. In this sense, NOS has become an important concept for science education worldwide (Lederman, 2007). However, students as well prospective teachers and teachers do not have an adequate or informed understanding of NOS (Abd-El-Khalick and Lederman, 2000; Akerson, Abd-El Khalick, and Lederman, 2000; Dickinson, Abd-El-Khalick, and Lederman, 2000; Irez, 2006; Abd-El-Khalick, 2013). Teaching NOS to students requires teachers to have informed understandings of NOS. Also, they need to recognize NOS as an important part of the curriculum and their teaching (Lederman, 1999; Akerson, Cullen, and Hanson, 2009). Teacher development programs and master programs are incapable of improving teachers’ NOS understandings and supporting them to teach NOS effectively (Akerson and Abd-El-Khalick, 2003; Akerson and Hanuscin, 2007; Akerson, Cullen, and Hanson, 2009). Therefore, it is important to determine teachers’ views of NOS and change their misunderstandings as they will shape their students’ views of science.

THE PURPOSE OF THE STUDY

The purpose of the study is to assess chemistry teachers' views of NOS; who are also master students at the chemistry education department; to develop their views with explicit-reflective activities based on their initial understandings and to investigate their views about science. Within this direction, the research questions of this study are:
- What are chemistry teachers’ views of NOS before the intervention?
- What are chemistry teachers’ views of NOS after the intervention?
- How do chemistry teachers’ views of science and NOS change after the intervention?

METHOD

This study was designed as a qualitative study and chemistry teachers’ views of NOS were examined thoroughly. Within this aim, case study was utilized to determine the changes in chemistry teachers’ views of NOS aspects.

Turkish chemistry teachers who were also master students in chemistry education department were investigated in the study. 6 female and 5 male teachers participated the study voluntarily. One of the teachers’ teaching experience was over 10 years whereas the rest were in the beginning of their careers 1-3 years of teaching experience. They were teaching at state high schools except 3 teachers working at private sectors. In their years of university education, they took pedagogical content courses as well as chemistry content courses. Some of them (n=5) stated that they had attended classes on NOS, history of science, or philosophy of science.

Data collection

The data of the study consists of collected Views of Nature of Science Questionnaire-Form C (VNOS-C) and interviews with the participants. Teachers' views of NOS were determined by VNOS-C questionnaire. The questionnaire was designed and validated by Lederman, Abd-El-Khalick, Bell, and Schwartz (2002). It consists of 10 open-ended questions that aim to determine the participants' views of NOS aspects. The questionnaire was used before and after the intervention to determine the changes in teachers' views. Also, semi-structured interviews were conducted with the teachers before and after the intervention. The findings from the interviews helped to establish the validity of the teachers' answers to the VNOS-C questionnaire. The interviews all lasted between 30 min to 60 minutes. In the interviews, participants were handed their VNOS-C responses and asked to explain their thoughts in a detailed way and to elaborate on their answers if possible. The interview process was recorded with participants' permission and then was transcribed for further analysis. In addition to the interview questions, 2 additional questions were posed to the teachers after the intervention. One of the questions was about their point of views of science; whether they had a contemporary view of science or not before this intervention and how their view had changed with the intervention. The other question asked was to explain which of the NOS aspects that were difficult for their students to understand.

The data gathered from VNOS-C questionnaire and interviews were analyzed by content analysis. Teachers' answers to the questionnaire and their responses in interviews in terms of each NOS aspect were categorized as naive, eclectic or informed. The changes in their views were analyzed individually.

Intervention

Generic NOS activities (Tricky Tracks, The Card Exchange) as well as context-specific activities were implemented in the course (Table 1).

Table 1. The NOS activities used in the course

Documentary (Einstein's Big Idea $E=mc^2$)*	Tricky Tracks!
That's Part of Life!	Young? Old?
New Society	Is astrology science?*
The Card Exchange	Tubes
Hypothesis Box*	The History of Thermometers*
From phlogiston theory to oxygene theory*	Periodical Table*
Articles about NOS	Articles about NOS

The NOS aspects were underlined and discussed with the participants in these activities. Also, chemistry teachers read various articles about NOS and were introduced with some historical cases during the intervention.

FINDINGS

The findings related to the views of NOS could be sorted under seven aspects: the empirical NOS, the tentative NOS, the functions of and relationship between scientific theories and laws, the distinction between observation and inference, the theory-laden NOS, the social and cultural embedded NOS and the creative-imaginative NOS can be seen in Table 2.

Table 2. Teachers' views of NOS before and after the intervention

NOS aspects	Before the intervention			After the intervention		
	Naive	Eclectic	Informed	Naive	Eclectic	Informed
The empirical NOS	3 (27%)	5 (45%)	3 (27%)	-	3 (27%)	8 (73%)
The tentative NOS	2 (18%)	6 (54%)	3 (27%)	-	4 (36%)	7 (64%)
The functions of/relationship between scientific theories and laws	2 (18%)	6 (54%)	3 (27%)	-	4 (36%)	7 (64%)
Observation vs inference	1 (9%)	8 (72%)	2 (18%)	-	2 (18%)	9 (82%)
Theory-laden NOS	5 (45%)	4 (36%)	2(18%)	2(18%)	-	9 (82%)
Social and cultural embedded NOS	-	8 (73%)	3 (27%)	-	2 (18%)	9 (82%)
The creative and imaginative NOS	2 (18%)	4 (36%)	5 (45%)	-	2 (18%)	9 (82%)

Teachers' views of empirical NOS were investigated with their definitions of science and experiments and their ideas of whether experiments were required in science. Before the intervention, 3 teachers (27%) held naïve views stating that "Scientific knowledge is objective/absolute/universal/proven/based on just experiments". 5 teachers (45%) defined science in an informed way but did not explain what made science different from other disciplines of inquiry; therefore, these teachers held eclectic views. Lastly, 3 teachers' views (27%) considered as informed as they replied "Science is open to change/Science is a human endeavor to understand the universe and natural world." After the intervention, there were no naïve views but 3 of them (27%) regarded as eclectic and 8 of them (73%) regarded as informed.

Teachers' views of the tentative NOS showed that they had naïve (n=2; 18%) and eclectic (n=6; 54%) understandings prior to the intervention. Teachers who had naïve views stated that "Scientific knowledge is hard to change/ It doesn't change after it is proven/theories can change but laws don't". Teachers who implied that "Scientific knowledge can change" but gave no satisfactory explanation or example were regarded as having eclectic views. Only 3 teachers (27%) had informed views by stating "Scientific knowledge including theories and laws can change in the light of new evidence or reinterpreting the existing evidence". After the intervention, there were 4 teachers (36%) with eclectic views and 7 teachers (64%) with informed views.

The findings were found to be the same for the aspects of the functions of/relationship between scientific theories and laws. Prior to the intervention, 2 teachers (18%) had naïve views stating that "There is a hierarchical relationship between scientific theories and laws/ Laws are more important than theories" and 6 teachers (54%) had eclectic views stating that "There is a difference between scientific theories and laws but I cannot explain what the difference is" whilst 3 teachers (27%) had informed understandings stating that "Scientific theories and laws are different sources of knowledge/Theories don't become laws". After the intervention, there were 4 teachers (36%) with eclectic views and 7 teachers (64%) with informed views.

Teachers' views of the distinction between observations and inferences were determined with a question asking them to explain the structure of atom. In this question, they were asked to explain how scientists determined the structure of an atom and whether they observed it. Before the intervention, only 1 teacher (9%) stated that "Scientist could see atoms with high powered microscopes…etc" and this showed a naïve understanding about the aspect. Most of the teachers (n=8; 72%) explained the history of the atomic models and the experiments the scientists conducted as in the textbook style. However, they did not show informed understandings, regarded as having eclectic views. Only2 of the teachers (18%) answered as "With indirect evidences- inferences-they could not see atoms- (Explaining the nature of models)" showing their informed understanding. 9 of the teachers (82%) had informed views and 2 teachers (18%) had eclectic views after the intervention.

The views of the theory-laden NOS were determined with "the extinction of dinosaurs" question. In the question, there were 2 explanations about the extinction and "How are these different conclusions possible if scientists in both groups have access to and use the same set of data to derive their conclusions?" were asked to the teachers. Before the intervention, 5 teachers (45%) implied that "Data are not adequate and clear for scientists to give a satisfactory explanation/ Scientists have to go back in time to observe the incident." and were coded as naïve. 4 teachers' statements (36%) were about the uncertainty of the situation such as hypothesis were not proven, experiments could not be performed, there was no clear evidence and were assessed as eclectic. Only 2 teachers (18%) explained that "Different interpretations of the same data set are possible in science because scientists are influenced by their academic backgrounds/prior knowledge/ imagination" and these were coded as

informed. After the intervention, there were no eclectic answers but some (n=2; 18%) still had naïve understandings whereas 9 of the teachers (82%) had informed understandings.
There were no naïve views for the social and cultural aspect of the NOS before and after the intervention. Teachers who implied that "Science is embedded with social and cultural values, but eventually it is universal/it must be universal" were coded as eclectic and 8 of the teachers (73%) held eclectic views before the intervention. 3 teachers (27%) implied that "Science is a human endeavour. It reflects social and cultural values" and were coded as informed before the intervention. After the intervention, 2 teachers (18%) still held eclectic views but 9 teachers (82%) had informed understanding for the social and cultural embedded NOS.

Lastly, there were 2 naïve (18%), 4 eclectic (36%) and 5 informed (45%) understandings for the creative and imaginative NOS before the intervention. Views such as "Scientists must be/are objective when collecting data and analyzing" and "Scientists use creativity and imagination at some stages of their investigations" were coded as naïve and eclectic. Replies such as "Scientists use creativity and imagination at every stage of their scientific investigations" were assessed as informed. After the intervention, 2 teachers (18%) held eclectic and 9 teachers (82%) held informed views related to this aspect. In addition to NOS views, teachers were also asked to explain their science understanding; whether they had traditional or contemporary view science and what changed in their views. They stated that they had traditional views before the intervention. One of the teachers stated that he had a traditional view of science before the intervention:

> *"I could say I had a traditional understanding… I believed that the scientific knowledge is absolute and scientists have to be objective…" T11*

The teachers were also asked to explain which NOS aspect was difficult to teach. Below, two teachers stated that the differences between scientific theories and laws were challenging and one teacher found the tentativeness of NOS was difficult to teach.

> *"Before the activities, I knew that for example laws and theories were different kinds of knowledge. A gas law explains something, and kinetic theory is very different from it. However, it is hard to teach students about the differences." T3*
> *"I could say that my students usually have difficulties in understanding of theories and laws. They believe that laws cannot change and laws are absolute, like laws in law school. I have to show them examples from chemistry." T8*
> *"My students sometimes say that if scientific knowledge can change, how can we trust scientific books or articles." T3*

CONCLUSIONS

NOS is a main goal in order to achieve scientific literacy. Teachers play a key role in the process as their views will shape the students' views. However, the review of the literature have shown that teachers have misunderstandings and naïve ideas about the nature of science and even though they have informed views, they cannot teach NOS effectively in their classroom practice (Akerson and Abd-El-Khalick, 2003; Akerson and Hanuscin, 2007; Akerson, Cullen, and Hanson, 2009).

All teachers in this study completed chemistry content courses and did experiments like scientists in their laboratory classes. Also, they taught chemistry content knowledge to their students. This might bring the idea that they should had informed views of NOS. However, research about NOS have shown that doing science and/or teaching process skills does not adequately help people learn NOS. Therefore, even though the teachers were expected to be more informed, they mostly held eclectic views prior to the study. The teachers might pass their eclectic views on to the students. Even though, the teachers in the study had different backgrounds, their views were basically the same. The explicit-reflective approach as well as reading assignment about NOS were effective in improving teachers' views of NOS as their post-intervention views have shown. After the intervention, teachers also thought that the distinction between scientific theories and laws and the tentativeness of NOS were difficult to teach and they needed more activities that emphasize these aspects.

Akerson and Hanuscin (2007) state that teachers can be effective in explicitly teaching NOS when professional development and an inquiry-based curriculum are provided. Therefore, the main focus should be on teaching NOS effectively to teachers in professional development and/or master programs. Also, teachers should be able to integrate the NOS aspects to their topic in an explicit way. Therefore, they need activities and sources specifically designed to teach NOS and chemistry knowledge together.

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The production of digital videos: a learning situation in science class

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Abstract

The present article aims to analyze the digital video production as a learning situation in the teaching of natural science in the classroom. The approach of this research is qualitative, guided by an exploratory bias and the case study design. Thirty students from a public school of a city in São Paulo state – Brazil - participated in it. At the time the study was performed, the Biology teacher attended a mandatory curricular component of the in-service teacher training program Specialization in the Teaching of Natural Science at the University of São Paulo, the Media and Scientific Literacy. The production created in this teaching process articulates media and scientific literacy issues. Therefore, approaching scientific content through the making of digital videos triggers a teaching/learning process that should favor a dialogical interaction between different contexts and various fields of knowledge. This method supports the development of a respectful behavior concerning all persons involved in the process, and it allows the insertion of media in the classroom, what enables the media literacy, and an increasingly democratic social participation and critical view of media. This approach also contributes to the teachers´ elaboration of the didactic materials which meanings emerge from negotiations with the students.

Keywords: context based; digital video; ICT; media literacy; science education

INTRODUCTION

Today it is possible to consider that the new technologies can offer many possibilities to be explored. In fact, people from all over the world used to have high hopes that new technologies could promote a healthier life, as well they also expect a considerable impulse to encourage social freedoms, and at least to increase knowledge and more productive livelihoods (Arroio, 2017). If media and their influence on society and also individuals is an essential skill for everybody, in this sense, media literacy is recognized as an essential area to promote critical view for citizens by the blurring of the education and communication gap. When we consider the students interaction with media the main point that highlight is their increased concurrent media use and also their rate of media multitasking (Roberts & Foehr, 2008). But how they are dealing with this new situation?

> The power of technology is unleashed when students can use it in their own hands as authors of their own work and use it for critical inquiry, self-reflection, and creative expression (Goodman, 1996).

Today media systems and society are more complex. Even the life is multi-faceted everybody should avoid making quick judgments. It is clear that when we claim for a peaceful world, it ought to build a real democratic society where citizens should be able not only to access the mass media critically but also to express themselves as producers. In this scenario, we shouldnot deny that media literacy is an essential part of education for the promotion of a democratic and peaceful society (Tornero and Varis, 2010).

> Today's advancement in information technologies and the diffusion of new digital media and learning environments can stipulate the growing importance of media literacy, which is now recognized almost universally as one of the key competencies in the educational system (UNESCO, 2010, p. 5).

The use of media resources, especially video, enables the awakening of creativity and stimulates the construction of multiple learning, in line with the students' sensibility and emotions experienced. Burn and Parker (2003) pointed out the collaboration process between teachers from different subjects as art, media, and music was productive in a learning situation supporting 10-year-old students create an animation. For Buckingham (2005) to promote media literacy necessarily entails “writing” as well as “reading” the media, in a way to engage people into the process. It also contributes to the contextualizing of different contents. From this set of possibilities, the teacher can lead the students to meaningful learning that fosters principles of citizenship and ethics. Taking into account that this new young generation used to has a huge number of experiences with mass media due it they need to share it with teachers to making sense of these experiences.

> Media literacy is the ability to access, analyze, and evaluate the power of images, sounds and messages that we encounter every day and play an important role in contemporary culture. It includes the individual's ability to communicate using media in a competent manner (UNESCO, 2010, p.5).

Media literacy could also be able to prepare citizens for many competencies that are needed to promote the individual’s right to communicate and express, and to seek, receive and impart information and ideas concerning this fundamental human right. A major concern in these circumstances would be to take advantage of this situation and to use media to improve access and quality of scientific education for different contexts. It would be relevant to learning to ask good questions to training analytical skills being able to analyse information as interpreting and evaluating several forms of it. As more the students are able to know they would be able to questioning deeper and better their concerns allowing them to move forward in science content and media content too.

The purpose of this communication is to report a pedagogical experience explaining the process of elaboration of a problematizing and contextualized learning situation for the insertion of the production of a digital video as a media in the science classroom of a public school. Due to avoid concerns about digital video production as decontextualized or even without a focused content is to link it with the ongoing natural science curriculum of particular learning contexts in this case cloning on molecular biology topics in biology classes. On this approach it is like digital video production becomes an instructional strategy for teaching scientific content in practice.

METHODOLOGY

The work focused on unveiling both the contributions of this process to the construction of knowledge in Biology classes, in scientific content, and the teacher’s needs to carry out these activities. A qualitative approach was chosen based on the nature of the project carried out and the use of interviews also enhanced a better tool to obtain information in this context since their expectations, perspectives, conceptions and practices could be revealed on this situation (Bogdan and Bliken, 1997).

In the data analysis for the accomplishment of the research the content analysis (Bardin, 2011) of the screenplay elaborated by the students, film analysis of the student's productions and interviews with the students were employed to have a better understanding of this learning situation involving media and scientific literacy. Herein this process is considered inductive in the sense that themes emerged during the process of categorizing, coding, and organizing data.

The Biology teacher selected the subject of molecular biology in what refers to specific cloning to be treated with the research participants (30 High School students) from a public school from a city in São Paulo state in Brazil, both in theoretic classes and in exercises. Later, the teacher discussed the possibility of production of digital videos addressing the scientific content covered in the previous lessons.

RESULTS AND DISCUSSION

The experience showed, according to the screenplays analyzed and interviews with the students, that the production of videos in the classroom demystifies the conception that the process of producing audiovisuals is a complicated and impossible task to be carried out in classes. During the process, several activities were carried out, such as elaboration of screenplays by students supervised by teacher, planning, recording, analysis of the audiovisual language, and video edition towards to digital video production. But also, students were requested to study and research about cloning content developed in their Biology classes. The accomplishment of these tasks means much more than a simple video production; it means, above all, to show to the students, from disadvantaged communities, that they are capable and that learning is not as suffering and discouraging as usually believed. And also, to connect these students with the 21st century skill promoting the real ICT integration into science class by using media as a strategy to engage them into a collaborative process involving scientific and media literacy.

In the beginning, the teacher showed insecurity to develop digital video production activities, as she never had any kind of experience doing it. She recognized that it would be important to include this kind of activities in her classes, but unfortunately, she did not have any practical experience in her pre-service and even in in-service education program. During the teacher participation in a continuing training course, in which there was a discipline of media literacy, she could share her doubts and difficulties with the supervisor of the course. The supervisor's support to the development of the digital video production with the students in the classroom enhanced her confidence in conducting the production activities.

Figure 1 – Frame of video produced by students about cloning; collecting DNA from sheep and manipulation of stem cells.

The students elaborated screenplays in workshops organized by the Biology teacher and then started to capture the images for the video production. To the sound output, a digital camera and a mobile phone, a computer and the Windows Movie Maker application were used for editing the footage.

The teacher showed some stop motion videos about Biology content as examples of an audiovisual products during the production workshops. It was noticed that the teacher was not confident about the process so she decides to present some samples of video to students to be sure that they would understand the task. But she displayed only stop motion genre, and according to figure 1, most of the students produced the same genre as the sample, 80% of them used stop motion. In this sense the repertoire is an essential item to consider, as most of them reproduced the same genre as teacher displayed. To avoid this situation, it seems media literacy has an important role to increase the experiences with different genre, otherwise students could have a misunderstanding about the adequate genre for science classes. Until now this is the kind of problem that school insist in explore just documentary genre in science classes promoting the misunderstanding of its relationship.

It is possible to noticed that students were able to create their own messages based on their access to digital video production about scientific content, in this case the dolly sheep cloning process. In figure 1 it is showed the sheeps made with modelling clay, also the cell and syringe with remarks. They could develop different skills to prepare the scenario to shot this video as it is presented in figure 1. It is important to highlight that the creation and composition of video are a relevant collaborative process, as they needed to develop abilities to work in group together.

According to Larossa (2002), the experience needs to reach you and to touch you, otherwise the experience will not promote changes. As it can be noticed these students are in transition, sometimes they reproduce the system (reproduce the displayed video genre) and sometimes they try to do on their own way (at the end they include the song they used to listen and strike a pose like *rappers*, an element of identification with their young generation as portrayed in figure 3. Due to media literacy statement by UNESCO, also to move from consumers to producers are expected from the youth as 21st century skill.

When this video was displayed for all students the situation revealed in the video about the relationship of belonging to the group, for them an important factor was the concern with what would be "displayed" in the video and how the general audience would react about their video production.

Herein it is a fruitful integration of media and scientific literacy to engage students into classroom activities. The biology teacher had identified the power of integrating digital video production to motivate and engage student to science tasks as an unexpected positive outcome.

Figure 2 – Frame of video produced by students about cloning; genetic therapy and biotechnology application.

According to figure 2 it is possible to note two cases of application of cloning; one in a genetic therapy with stem cells to restore the human cells and on the second situation a biotechnological application in plants. In both cases students were requested to do a research about application in everyday situation and then they included this research results into the screenplay to prepare the scenario and materials necessary to shot it. At this moment it is pointed out that when diversified instruction modes are used to stimulate sensory memory in more than one pathway (auditory and visual), students can better understand the information provided by the student research from their pictorial and verbal productions, for example. This content is not part of the curriculum for biology in high school, but as they found this information relevant, after some discussions they concluded that it would be important to include this content on their video about cloning.

As it is portrayed in figure 2, students should be encouraged to reflection, they realized that it would be important to expand the information and not just to consider the class. It is clear how this experience affected their identity as a group as well their self-esteem, and the teacher had opportunity to foster their social and emotional development based in a collaborative activity. They could work alone and with other students, in a way to share their thoughts, ideas and knowledge about the scientific and media content. For example, to find the best example of a plant to show the biotechnological application as well to choose a good situation to show health therapy application. On figure 2, it is noticed the lung made by modelling clay with a lot of details in different colours, as well the sugar cane plant that come from a research done by them.

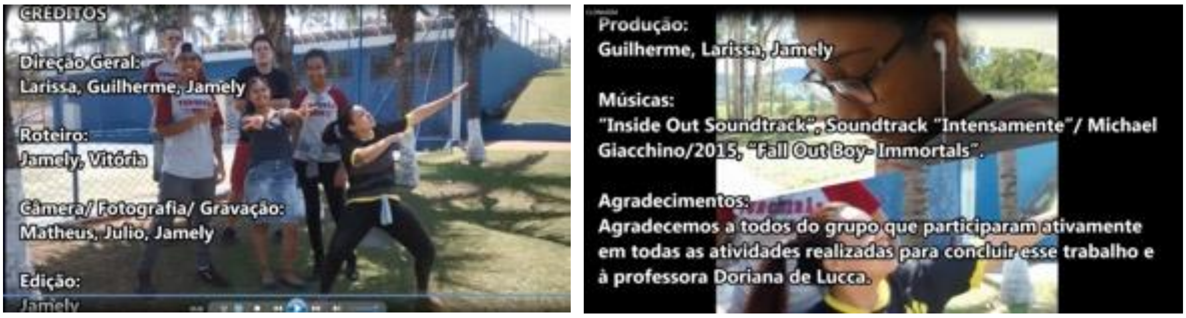

Figure 3 – Frame of video produced by students about cloning; final credits, copryright and acknowledmets to teacher.

As showed on figure 3, students felt so confident on doing this kind of activity, digital video production, "the millennial generation, immersed in popular and online cultures, thinks of messages and meanings *multimodally* - not just in terms of printed words, but also in terms of images and music" (Miller, 2007, p. 62). It is noticed that the more significant part of the groups of students produced stop-motion genre, probably due to the exhibition of video examples at the beginning by the teacher, which might influence the student's choices.

It is emphasized the importance of increasing the audiovisual repertoire of the students that can lead them to think about other possibilities. Also, the soundtrack they employed is the music that they are used to listen every day, an essential index of identity. Another critical point is the Biology content expressed in the videos. In general, they presented more information, suggesting that research was necessary to prepare the screenplays. In this way, the conciliation of pedagogical training as the provision of equipment becomes essential (Buckingham, 2007).

The teacher highlighted that the students´ creativity surprised her as she was not confident, she expected something not interesting. According to Bolam (2000) professional development of teachers is an essential part of improving school performance, to achieve a better education. Otherwise if teachers are not confident probably, they will not develop this kind of learning situation.

The digital video production in the classroom is a fundamental mechanism for the renewal of the school context, a tool of media inclusion, democratization, resignification or transformation of knowledge and of the roles to be performed by the actors in school.

CONCLUSIONS

The use and production of digital video when adequately exploited is a crucial teaching learning strategy since it contemplates the construction and socialization of a lot of knowledge in science and media fields. In this sense, it can be affirmed that the use of this kind of media in the school environment avoids the dichotomy between school and world of culture, and between the teaching and the learning actions, contributing to the social insertion of the students. In this way, it was noticed that the use of the media, in this case digital video production, approached students and teachers, aroused interest in the classes motivating them in the process of science education, as well as the professional development of teachers preserving their contexts.

These competencies should allow different social groups to create and to defend their counterbalance to face dominant cultures as they would be able to share their stories with people in different ways, promoting discussions and creative engagement to protect cultural diversity and pluralism for all. It is highlighted that some challenges faced by biology teachers included issues related to equipment use, media production process, and time.

In short, our results suggest that the actual use of the information and communication technologies in the public school must provide an expansion of learning, and emphasize that the media resources must be seen as a formative pedagogical tool since they can produce education in a significant, motivating and dynamic way.

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Production of Animations for the Investigation of Submicroscopic Representations by High School Students

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Abstract

Nowadays, a discursive resource widely used is images, whose use can facilitate the explanation of concepts, constituting essential support for the communication of scientific ideas. Here, we report the results of a study on the perception of 107 students of two High Schools located in the city of São Paulo (Brazil) concerning representations of the physical state change processes at a sub-microscopic domain. After the development of a teaching-learning sequence (TLS) about the properties of matter, discussions were conducted both in small groups and with the whole class. At this point, students were asked to draw up images that represent their understanding of the phenomena of physical changes at the sub-microscopic level. In the second phase of the TLS, after some discussion about the drawings previously produced, each group of students was asked to create an animation concerning the phenomena. It was possible to perceive both the evolution of their expressed mental representations that present scientific features more consistently, and the students more coherent and secure speech. These results suggest that the creation of diverse opportunities both for the building of models by the students, and their expression is essential to chemistry language learning.

Keywords: image; representation; submicroscopic domain; media literacy; Science education

INTRODUCTION

One of the objectives that underlie science education programs is that students be able to understand theories, laws, formulae and scientific models, establishing correlations between them. Students also need to learn to reason about information contained in graphs and tables. These abilities will be essential to their understanding of the different aspects of the socioeconomic issues posed to be decided by citizens in our current societies. In short, acquiring the language of natural sciences and mathematics provides a better understanding of the world, which contributes to the exercise of critical citizenship. More specifically, as far as chemistry learning is concerned, it may be considered that an adequate understanding of chemical concepts requires the acquisition of a language distinct from that used in daily communication. Shortly, the understanding of chemistry is based on attributing meaning to the invisible and untouchable, much more than required by other natural sciences (Kozma and Russell, 1997). Among various other possible models to describe the aspects of chemical knowledge, the one proposed by Johnstone (2000; 1991; 1982) has been widely accepted by researchers in the field of chemistry teaching.

Johnstone proposes an explanatory model to articulate the three dimensions of chemical knowledge, showing their correlation, as seen in Figure 1, which illustrates that model applied to the phenomenon of the effervescence of an analgesic tablet. These dimensions of chemical knowledge are defined in Table 1.

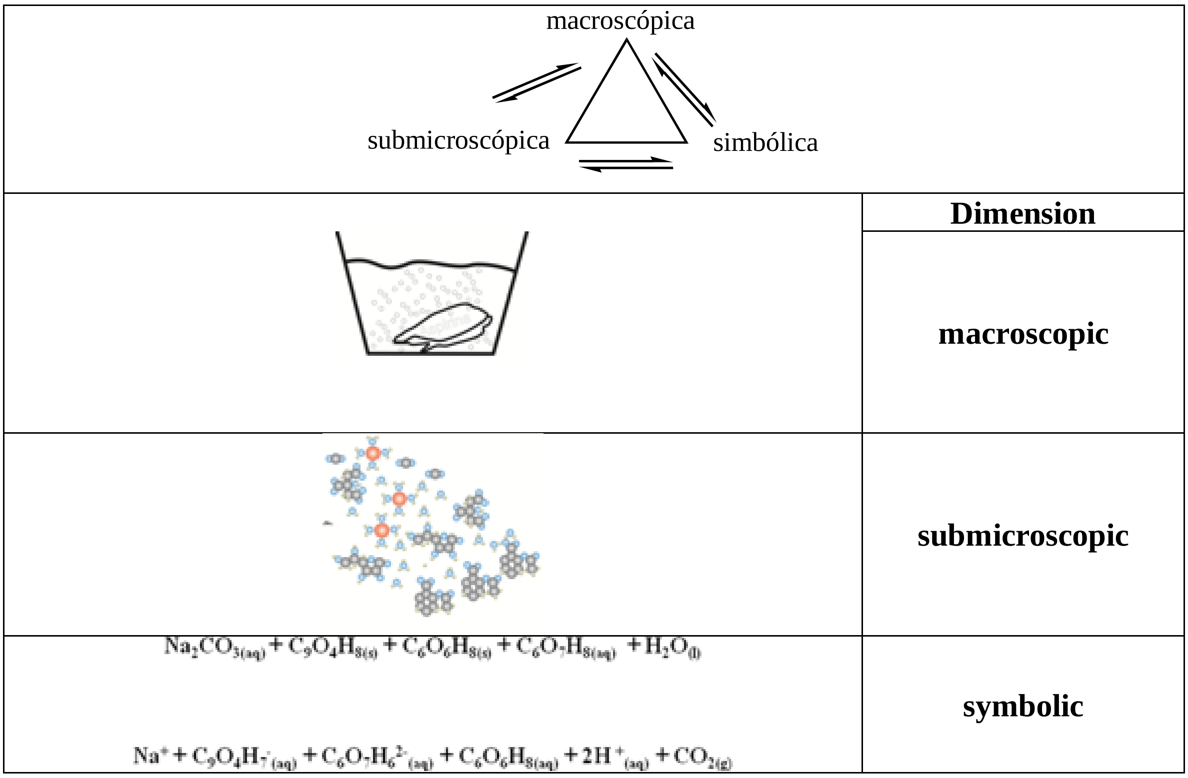


Figure 1. Example of a phenomenon represented in the three dimensions of chemical knowledge.

Table 1 - Dimensions of chemical knowledge

macrochemistry (also known as macroscopic chemistry) refers to tangible, concrete and measurable processes from the perspective of human sensory devices (even if augmented by sophisticated instrumentation);
submicrochemistry (or submicroscopic chemistry) refers to molecular, atomic and kinetic models proposed on the basis of experimental evidence;
representational (also known as symbolic) refers to chemical symbols, equations and formulae.

In addition to understanding the articulation between these three dimensions, chemistry learning also involves being able to transit among them. Numerous studies indicate that students, especially those in elementary school, find it difficult to interpret and represent the submicroscopic level (Chittleborough and Treagust, 2007; Chandrasegaran *et al*, 2007; Cook, 2006; Jansoon, Coll and Somsook, 2009; Gibin and Ferreira, 2010; Jaber and Boujaoude, 2011; Scalco, 2014). To facilitate their learning, greater attention must be given to the submicroscopic level. This requires the development of teaching activities that promote the establishment of interactions between the different levels of chemical knowledge.

In this context, a multimodal approach promoting effective student participation can facilitate chemistry learning, as this kind of approach stimulates the use of various cognitive processes: in addition to digital integration, students can use visual resources to communicate their knowledge and, thus, share their ideas and productions with other students and the teacher.

This favors the teaching-learning process, both because students become protagonists of their own learning and because they can more easily express their mental representations.

The use of different tools in the teaching and learning processes, as proposed in the literature (Mayer, 2003), should favor the construction of knowledge connected to the production of models. Thus, from the expression of mental models and their socialization, students can build a new model through the creation of animations in line with Mayer's proposal: the construction of knowledge by the autonomous student manipulation, either through animation or other multimedia tool.

We believe that the visualization of phenomena – as well as their description or imagination– favors the production of internal representations. The internalization of the characteristics, images or sensations associated with concepts leads to the creation of those representations. They are subjective (idiosyncratic), which does not imply that they are not shareable or unalterable through interaction with the social group.

In this article, internal representations are considered to be mental models, expressed by the external ones, which not necessarily are their exact copies. In this context, this article presents an investigation into the submicroscopic representations of Brazilian High School students concerning experiments about the changing of the physical states of matter. The focus is on the alteration of the submicroscopic model concerning the macroscopic phenomena, in the course of an educational intervention process using the production of animation from consensual models (models accepted by the group).

METHODOLOGY

The research carried out was a qualitative investigation. The participants were 32 students of a private school and 75 of a public one, both of them located in the city of São Paulo (Brazil). Students' ages range from 16 to 19 years old. In brief, the developed teaching-learning sequence (TLS) begins with the reading of a text about the properties of matter, followed by experimental classes on melting and boiling points of pure substances and mixtures.

In the private school, the activities were performed in three meetings, held in the period opposite to that of regular classes, that is, in the afternoon. In the first meeting, a text entitled "Why do we perceive smell?" was read. The text discussed some basic concepts about the relation between physical states and molecular interactions, but the submicroscopic dimension of the described phenomena was not explicitly presented. The students were then asked to answer some questions about the text. Their answers were analyzed to unveil their understanding of the interrelation between the macro and submicro dimensions. In the second meeting, the students carried out two experiments to determine the boiling points of water and of water/glycerine mixtures with different volume percentage concentrations (from 20% to 60% $_{v/v}$). They also obtained the boiling point of paraffin wax and naphthalene. The experiments were designed to lead the students to signify the concepts of mixture and substance based on their individual and collective analyses of the registered observations of the phenomena. Some questions were posed to the students to guide their individual analyses, which were collectively shared in another meeting.

After the experiments, the students were asked to draw up images that represented their understanding of the physical change phenomena they had observed at the submicroscopic level. For a less ambiguous interpretation of the images produced, interviews were held with the groups so that they could explicit their representations. In the third meeting, the groups shared and discussed some of the models externalized in their drawings on paperboard. The objective was for the students' models to be re-evaluated on the basis of their interaction, mediated by the teacher. After discussions of these models conducted both in small groups and with the whole class, each group of students was asked to create an animation concerning the phenomena. The sequence developed in regular classes at the public school is similar to the one described above, only with a greater number of steps, but maintaining the instructional objectives. The students' reports, pictorial representations, animations, and interviews provided data that were submitted to content analysis techniques (Bardin, 1996).

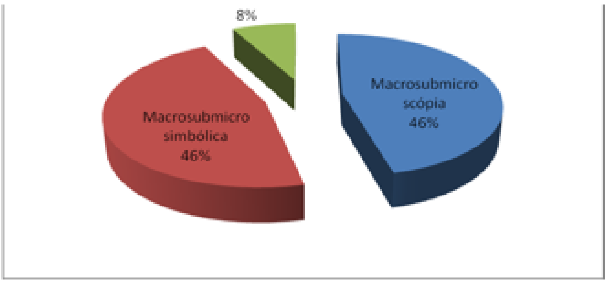
RESULTS

Although a significant part of chemistry language comprehension occurs at a molecular level –not accessible to direct perception– teachers tend to stick only to the sensory understanding of the phenomena. For example, they select experiments in which the judgment of the possible occurrence of a chemical reaction involves criteria such as color change, gas release or precipitate formation, not pointing out the limitations of this approach. This posture privileges student sensory perception in detriment of other levels of phenomenon understanding that would lead to a broadening of the conceptual representation. So, the implementation of these TLS was based on the facilitation of student expression through different discourse genres, including the production of images and audiovisual objects (AO). Images, animated or not, enable the expression and sharing of students' mental models, favoring the identification of conceptual mistakes and their collective resignification.

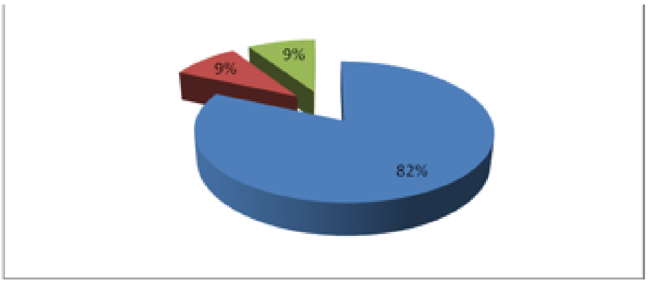
Chemical knowledge levels

A categorization was carried out based on the dimensions in which chemical knowledge can be expressed, according to Johnstone. From the analysis of the images produced by the students and the interviews held with the group, a categorization emerged, as seen in Figure 2.

Chemical knowledge levels



A: paperboard posters
Blue: macrosubmicroscopic
Red: macrosubmicrosymbolic
Green: macrosymbolic



B: audiovisuals
Blue: macrosubmicroscopic
Red: macrosubmicrosymbolic
Green: submicroscopic

In total, 13 paperboard posters were produced, one by each group of students, discussing the melting and boiling points of pure substances or mixtures. As for the audiovisual resources, only 11 were produced, as two groups left the project in this phase. For this project, we consider an audiovisual resource to be any material where images, static or dynamic, with or without sound, are used. This constitutes another way for students to present their models more dynamically and with a broader range of resources, unlike the images produced on paperboard. Audiovisual resources make it possible to produce studies on intergalactic space and, likewise, penetrate realities of microscopic dimensions (Arroio and Giordan, 2006, p. 7).

Figure 2 - Classification of images according to representation levels

At first, the analysis of the drawings on paperboard permits to conclude that the students have difficulty in expressing their models of the submicroscopic domain. The explanations are simple, and the images display misconceptions such as the spatial position of particles or the indistinction between substances and mixtures.

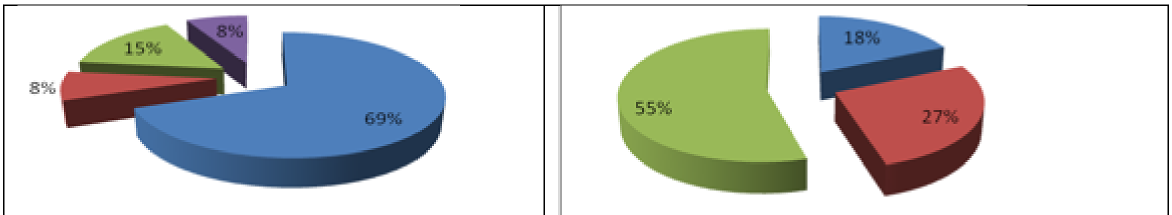
The analysis of Figure 2 shows an increase in the macrosubmicro category in audiovisual productions compared to the paperboard ones: from 46% to 82%; on the other hand, the macrosubmicrosymbolic category goes from 46% in the case of paperboard posters to 9% in audiovisual productions. Although the literature shows that students should transit across the different dimensions of chemical knowledge, our results show that most of them rely on the macroscopic and submicroscopic dimensions, ignoring the symbolic one. However, in this case, it can be assumed that this result is due to students' greater confidence in expressing submicroscopic models of phenomena, not resorting to representations of the symbolic level of chemical language in their audiovisuals.

It is important to emphasize that the participants made use of macro-level images, indicating that students find it difficult to abandon the observable aspect, i.e. what they are used to seeing and interacting with.

According to Mortimer (2011), students have difficulty in moving from phenomenological observations to atomistic explanations, in other words, in establishing relations between particulate models and material behavior in various phenomena. "Students interpret the structure of matter based on its macroscopic properties, with ideas surrounded by a real world. They barely use scientific models for their explanations." (Martorano and Carmo, 2013, p.

238)

Spacing/Interaction/Energy
Another categorization arisen from the analysis of the paperboard posters was relative to particle spacing and interaction, as well as to the energy involved in the process. In this phase of the teaching sequence, all the groups pointed, in their paperboard images and/or interview discourse, to the role of particle spacing in explaining the properties of different physical states of materials. This fact permits to infer that students are aware of the various degrees of freedom in the movement of particles in different physical states. However, they do not attribute the behavior of materials to this factor, ignoring intermolecular interactions, which were only mentioned by two groups. As for the amount of energy involved in changes of physical state, this factor was also brought up by two groups. It cannot be affirmed that students who, for instance, did not mention, in their discourse or images, that the amount of energy interferes in particle spacing have not considered this aspect. However, it is important to note that, when explaining their models, they did not mention this factor. What was perceived, in the paperboard poster phase, is that 69% of students only mentioned spacing. However, 15% mentioned, in addition to spacing, the energy involved in the process, whereas 8%, in addition to spacing, mentioned molecular interaction. Lastly, 8% were able to correlate spacing, energy and interaction in their explanations, as seen in Figure 3.



A: paperboard posters	**B: audiovisuals**
Blue: spacing	Blue: spacing
Red: spacing/interaction	Red: spacing/interaction
Violet: spacing/interaction/energy	Green: spacing/interaction/energy
Green: spacing/energy	

Figure 3 - Classification of the images produced about spacing, interaction, and energy.

A significant improvement in student discourse was seen during the interviews, a fact observed in the group of concepts “spacing/interaction/energy” (Figure 3). 55% of the groups mentioned, in their representations, particle spacing, intermolecular forces involved in the process, and energy increase involved in physical state change. These results permit to infer a better understanding of concepts and phenomena, possibly due to the discussions held when students presented their paperboard images. These discussions encouraged the groups to seek better explanations and representations for their models, since they would be charged with producing new material.

Another category discussed, following the same reasoning of previous analyses, had to do with particle spacing, energy involved in physical state change, and intermolecular interaction of matter. An important observation about this categorization, found previously in the paperboard images, was that a great part of the students mentioned only particle spacing in the different physical states. This is no longer the case in this phase of the learning sequence, since just 18% of the groups mentioned only the factor “spacing”, against 69% in the previous phase. This shows greater engagement and, consequently, better understanding of the context discussed.

Our results corroborate the literature. Mortimer (2011), for instance, points out that, when an explanation of atomic models is given, atoms are represented by spheres, and reactions are represented by equations with the use of symbols and formulae. For the understanding of daily phenomena, however, such as physical state change, and gas and liquid dilation, it is not extensively discussed that matter is made up of particles moving in empty space. Still according to this author, students are commonly assumed to already possess this scientific atomistic conception, which most of the time is not the case.

> The consequence of not discussing the students' alternative models in the classroom is that they "learn" more sophisticated models of matter, but are incapable of establishing relations between the properties of matter (in its solid, liquid, and gaseous states) and the arrangement, spacing, interaction force, and movement of particles by means of an elementary atomistic model (Mortimer, 1995, p. 24).

An example of this is the fact that, in a first moment, the groups representing water molecules in their various physical states did not take into account that, in the solid state, the particles are more spaced out than in the liquid state, thus making the solid less dense than the liquid. They had a hard time relating the characteristics of an atomistic model to the properties of materials.

Another hypothesis to account for the lack of more precise terms in the students' explanations is their scarce familiarity with the language of science. In such context, there may be a certain degree of difficulty in interpreting ideas and using the right terms. Sometimes students understand a process, but are not capable of using adequate words when advancing explanations. Learning is linked to scientific discourse (Villani and Nascimento, 2003). So, we could perceive that the students who participated in our study would not yet have an adequate apprehension of the content discussed when they produced images on paperboard. For Oliveira *et al.* (2009), the language of science has its peculiarities. It furthers scientific thinking, and the more complex scientific thinking becomes or the more problematizing situations surround it, the greater.

CONCLUSIONS

We could perceive that students present difficulties to express (external representations; expressed models) their models (internal representations; mental models) concerning the observed phenomena at submicroscopic level. We conclude that this difficult can arise from their lack of familiarity with the articulation of the three dimensions of the chemical knowledge due to the little emphasis to the proposition and the employment of submicroscopic models during the most part of the instruction on Chemistry at Brazilian High Schools.

The results show that it is essential to employ diverse communicative genres to favor the students´ expression of their ideas facilitating the development of scientific language by the students that will be performing an enriching form of knowledge creation. This goal can be contemplated in the multimodal approach to the teaching-learning process to consider not only the particular preferences of the people involved in the development of the activities but also the features that are possible to be perceived due to use of various communicative approaches in the classroom.

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Teachers' use of ready-made curriculum materials: The case of ENGAGE

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Abstract

Use of curriculum materials has been studied as a means of supporting both pre-service and in-service teachers' learning. However, the teachers' own aims for using such materials, and how they use them, has not been much in focus, and is investigated in the current paper. We collected data from 13 teachers that used ENGAGE curriculum materials. Most of the teachers' aims were related to scientific content, inquiry skills or the interests of their students. Most teachers only did minor adaptions, such as adding or removing scientific content, activities or supporting structures, but some of these changes greatly changed the impact of the lesson on the students. Also when the teacher tried to follow the teacher guide, the teachers own aims, knowledge, interest and teaching style affected the enacting of the lesson. The teachers seemed to use their PCK much more actively in their reflections regarding adaptions and class management after the lessons, than before the lessons, suggesting that the experience contributes to developing teachers' PCK, practical knowledge and reflection. Thus, our results support the notion that teachers can use curriculum materials not only for variation in their teaching, but also as a means of boosting their own professional development.

Keywords: Adaption; curriculum materials; pedagogical content knowledge (PCK); practical knowledge

INTRODUCTION

The use of curriculum materials as a means of supporting both pre-service and in-service teachers' learning, including developing their pedagogical content knowledge (PCK) (Magnusson, Krajcik, & Borko, 1999), has been studied by many researchers (e.g., Beyer and Davis, 2012). However, teachers' actions in practice are guided by his or her practical knowledge, including their experimental and formal knowledge, beliefs, personal goals and the teaching context (van Driel, Beijaard and Verloop, 2001).

In 2007, Roberts described two competing visions of scientific literacy (Roberts, 2007), that in a broader perspective can also describe science education. The two visions represent the extremes on a continuum: *Vision I* focuses on the orthodox natural science, i.e. the products and processes of science itself and thereby literacy or knowledgeability *within science*. In contrast, *Vision II* focuses on science-related situations in which considerations other than science have are important, and thereby literacy or knowledgeability *about science-related situations*, including situations that students are likely to encounter as citizens (Roberts, 2007). The rapid developments in science and technology, and the need for a society that can adapt to and thrive in such fast changes, have led to a gradual change in the focus of science education over the last decades. In short, where Roberts' Vision I was predominant some decades ago, Vision II is now getting more and more attention.

Many countries have incorporated socioscientific issues (SSI) in science curricula in order to educate future citizens who are familiar with the scientific way of thinking, and can use this insight in everyday life. Moreover, scientific competency goals have been included in the curriculum of most European countries. This implies that science teachers should help students to acquire certain skills, such as argumentation, decision making, interrogating media, assessing the validity of sources of information, etc. in order to become responsible citizens. There is evidence that teaching SSI fosters students' learning of the aforementioned skills and their motivation for science learning (Simonneaux & Simonneaux, 2008). However, teachers experience difficulties while teaching SSI in science classrooms (Ekborg, Ottander, Silfver & Simon, 2013), for example because of the aspects of controversy and uncertainty in SSI, or because of unfamiliar methods of teaching. One way to help teachers to deal with this problem is giving access to SSI curriculum materials. Literature shows that curriculum materials improve the quality of instruction (Beyer & Davis, 2012).

This study is undertaken on material developed in the EU-project ENGAGE, that was part of the Science in Society call, and ran 2014-2017. ENGAGE aimed at equipping students to participate in authentic socio-scientific issues, and claimed that to engage the young generation in SSI, the traditional ways of teaching science should be changed. For this purpose, the project team designed online ENGAGE curriculum materials, that are ready-to-use, open educational resources that include a teacher guide, student worksheets and presentation materials. The lessons contain short stretches of different activities and supporting structures for the students' training of inquiry skills such as argumentation and decision-making. The lessons start by posing an in-the-news socio-scientific dilemma and a short recap of the science involved. Then, students have to use scientific evidence to make a decision or argument. The ENGAGE materials are intended for students age 11-16.

The international ENGAGE website (www.engagingscience.eu) contains in total 30 curriculum materials, of three different kinds;

- 22 single-lesson (30-60 minutes) materials
- 6 double-lesson materials with more emphasis on inquiry skills ("sequence")
- 2 long projects

The materials were produced in English, translated into ten different languages by the partner countries and presented on separate websites. The translated materials were also partially localized to the different partner countries, using for example national examples or links to national news when relevant.

The author was a Norwegian partner in ENGAGE 2014-2017. She also took part in research on the impact of using one, single-lesson ENGAGE curriculum material on the teachers' PCK in four countries, where they saw indications of developments in PCK (Bayram-Jacobs et al, 2017).

The aim of this study is to investigate how teachers make use of ready-made curriculum materials, and how they adapt them to their own needs. The research questions are:

- How do teachers use the curriculum materials developed in ENGAGE?
- What makes teachers adjust the ENGAGE lessons?

METHODS

The dataset in the overall study consists of different kinds of data from teachers that have used the Norwegian ENGAGE material (www.engagingscience.eu/no, specified in figure 1):

- Sets of lesson preparation form, lesson reflection form and observation data from 11 in-service and pre-service teachers
- Questionnaires and feedback on the Norwegian ENGAGE website
- Interviews with two in-service teachers that have used one or several short ENGAGE materials
- Interviews with two in-service teachers that have used long ENGAGE projects
- Practical pedagogical assignments from three pre-service teachers

The data material analysed and presented in this paper consists of sets of lesson preparation form, lesson reflection form and observation data from nine in-service and pre-service teachers, interview with two teachers using short materials and practical pedagogical assignments from two pre-service teachers.

The data were first analyzed by a holistic approach, giving an overview of the teachers' thoughts and experiences, followed by thematic coding of the data regarding teachers' aims, adaptions, challenges and advantages.

Figure 1: ENGAGE materials used in this study; the first ten were short, one-lesson materials, while the last thee were either double-lesson (marked "sequence") or long projects (marked "project").

RESULTS

An overview of the factors affecting the teachers' use of ready-made curriculum materials in this study, is presented in figure 2.

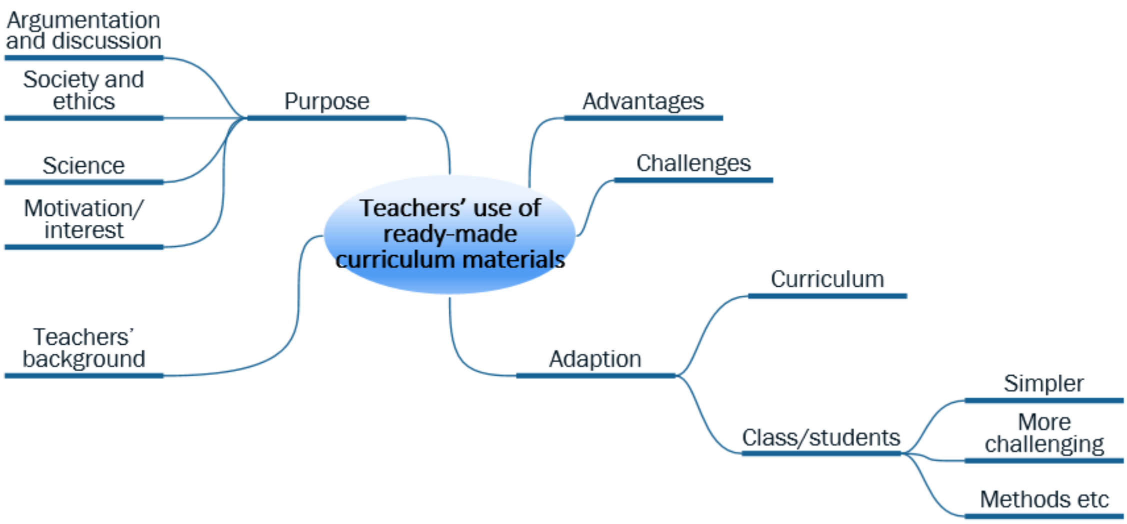

Figure 2: An overview of factors affecting the teachers' use of ready-made curriculum materials in this study.

Most of the teachers' aims were related to the scientific content and/or inquiry skills that were trained in the lesson. In addition, several teachers chose material they thought would interest their students.

Teachers' adaptions of the ENGAGE material

Most teachers did minor or moderate adjustments of the ENGAGE lessons in advance, for example:

- Adding or removing scientific content in the introductory part of the lesson in order to adjust to the level of the class and the curriculum, or increasing actuality/interest. For example, when using the material "Death to diesel" with 14-year-old students, one teacher referred to the class' previous group work on the efficiency and CO_2-emissions from different types of engines – thereby showing the complexity of the problem. At the same time, to ensure enough time for follow-up of the students, she ran the material in half of the class at a time. In contrast, another teacher, teaching the same material to 15-year-old students decided to leave out the most complex scientific part of the material, in order to adjust to the class level and keep the time.
- Adding an extra activity, for example, film for increasing engagement and actuality in Sinking Island or a blood sugar test for adjusting to the curriculum for older students in Ban Coke.
- Adding their own learning goals for the lesson, for example,
    - More personalized learning goals – focusing on the students' own personal life, their own future etc in order to increase relevance and engagement: One teacher added a goal for the students on "how global warming would affect *their* life in the future – in the north of Norway" - not only the lives of the people living in the pacific, as was the topic of the material.
    - Goals that reflect the teachers' own special interests: A teacher with a strong interest and experience in science and medicine added a learning goal to "Stimulate the *genera*l education of the students as responsible citizens, focusing on the society aspects of vaccines, antibiotics, medical industry and the public debate" to the material "Ebola".

    - Goals that fit better with the curriculum or the level of the class.
- Simplifying the enactment by skipping parts, for example, parts they did not completely understand, especially games, or taking «short cuts» if they had not had time to prepare properly or if they did not have enough time to use the whole lesson.

The aim of the teacher, and the adaptions the teachers make to meet them, could greately affect the impact of the lesson on the students. For example, two teachers used a material called “Eat insects”, where the task is to persuade your fellow students to eat insects rather than meat. The students get a set of arguments that they can use in this persuasion. One of the teachers performed the lesson in an elective science class with focus on research methods, and focused very strongly on training their abilities to find their own arguments and evidences online, adding an extra lesson beforehand for doing this. The other teacher focused on sustainable use of food recourses, and added a part where the students calculated how much meat they eat per week, and used this to calculate how much this represents on a larger scale.

Another example is the most used material, “Ban Coke”, where the dilemma was whether sugary drinks should be banned for all under 18 years, the teachers of the youngest students (12 years old, 2 teachers) had a strong focus on the argumentation skills, while the teachers of the oldest students (16 years old, 2 teachers) focused on the scientific theory of the material, adding activities and scientific content.

All the before mentioned adjustments were more or less planned by the teachers beforehand. However, also when the teacher tried to follow the teacher guide, the teachers’ own aims, knowledge, interest and teaching style affected the enacting of the lesson.

Challenges mentioned by the teachers
Among challenges that the teachers meet is that they feel that they don’t get time to do the different activities thoroughly enough to ensure maximum learning. On the other hand, a teacher that added extra time for preparing student presentations for 12-year-old students, realized that the students got bored and worked less efficiently.

In addition, in retrospect, several teachers realized that using the materials demanded more preparation, stronger class management and better instructions and follow-up from the teacher in order to work to it’s full potential. Furthermore, even though the teachers often foresee several potential challenges before the lesson, they do not always realize the problems or do anything about it during the lesson. In retrospect, however, they reflect upon the challenges and suggest solutions. Some of the challenges may partially be related to fact that the materials include unfamiliar metods and skills for both students and teachers, resulting in unfamiliar ways of working at several levels.

Advantages mentioned by the teachers
Among advantages in using ENGAGE materials, teachers find the ready-made arguments and evidences, as well as the checklists that are included for the students to help structure their work especially helpful with younger students or low achieving students. Also, the variation of activities fits the diversity of the students in the classes, and many of the teachers comment that the students were more active and engaged in the ENGAGE lesson, than in the “ordinary”

lessons. In addition, the variety of ENGAGE materials on different up-to-date and in-the-news topics are seen as a valuable alternative to the out-dated examples in the school books.

DISCUSSION

Our results indicate that the teachers use the curriculum materials more or less as intended by ENGAGE, but with minor adaptions, such as adding or removing scientific content, activities or supporting structures. These adaptions are motivated by the main aim of the teacher, for example learning science, training skills or becoming more responsible citizens, and can greatly change the impact of the lesson on the students. In addition, the teachers adapt the lesson to the class or to special groups of students.

Some of our results may indicate that teachers in the lower grades tend to focus more on inquiry skills and the socioscientific issues in the materials, thereby voicing Roberts' Vision II, while teachers of older students tend to focus more on scientific facts, voicing Roberts' Vision I (Roberts 2007). On the other hand, it is apparent that the individual teacher's practical knowledge strongly affects the teacher's use of the ENGAGE material (van Driel et al., 2001).

After the lesson, many teachers suggest additional changes and several teachers realized that their role as teacher was more important than they thought; they should have had stronger class management, better instructions and follow-up. Interestingly, although most of the teachers reflect well upon the use of the material in their class beforehand, they seem to use their PCK much more actively in their reflections, especially regarding adaptions and class management after the lessons. Similar results were seen in a larger study on the impact of using one, single-lesson ENGAGE curriculum material on the teachers' PCK in four countries (Bayram-Jacobs et al, 2017), that included data from 6 of the teachers in the current study. This could indicate that the teacher's personal experience of how the material works in the classroom, and then sharing these reflections, contributes to developing the teachers' PCK, practical knowledge and reflection (van Driel et al., 2001; Beyer & Davis, 2012).

So…What can we learn from this?

Our results suggest that the following factors can make curriculum materials more useful for the teachers:

- Curriculum-relevant, up-to-date topics, aimed at students. Can be an alternative to old fashioned or outdated school books
- Simple but thorough teacher guide
- Short time span for preparation and lesson
- Multiple short and varied activities – easy to add, remove or change
- Easy to adapt to level or diversity of the class
    - Supporting structures that can be removed for advanced students
    - Group tasks that include several different types of skills, so that the students can use their different kinds of strengths in the work (theoretical, practical, technical, artistic, creative, logical, systematic etc)
    - Alternative student outputs/products

Active, retrospective reflection upon the use curriulum materials seems to boosts the teachers' professional development. Using curriculum materials can be a practical and low effort way to enhance teachers' PCK and practical knowledge – probably especially when working in groups, or otherwise sharing their experiences and reflections with each other.

CONCLUSIONS

The teachers use the curriculum materials more or less as intended by ENGAGE, but with minor adaptions. The adaptions, however, can greatly change the impact of the lesson on the students. Adaptions are often motivated by the teachers aim for the lesson, but also the needs of the class. Both the age of the students and the teachers' practical knowledge seems to affect the teachers' aims and adaptions.

The teachers seem to use their PCK much more actively in their reflections regarding adaptions and class management after the lessons, than before the lessons, suggesting an improvement in their PCK, practical knowledge and reflection. This further suggests that teachers can use curriculum materials not only for variation in their teaching, but also as a means of boosting their own professional development.

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Crossing borders in using drama to teach science. What is required for teachers to use physical role-plays most effectively?

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Abstract

Drama can be successful in building knowledge and understanding in science as part of a socio-linguistic, constructivist approach. Role-plays, where learners act as analogues for components and processes, help access abstract ideas. However, a problem restricting many science teachers using these approaches has been that they may lack sufficient pedagogical knowledge of drama or might assume that these methods are best suited to teaching in the arts. The Drama in Science Research Group in Cape Town South Africa has addressed these issues by studying how two groups of student teachers adopted and handled role-plays to teach a number of science topics in grades 6 and 7. The first group of students were drama specialists and the second science specialists. Thus, for the drama specialists the pedagogical border-crossing was from drama into science and for the science specialists it was for drama to be incorporated to serve the learning of science. Data collection involved interviews with student teachers before and after their lessons, video recording of lessons, field notes and post-lesson interviews with selected groups of pupils. Findings show that role-plays can act as sufficient border crossing objects and have positive outcomes for pupil learning even when lessons are not particularly well executed. Drama specialists used more variety of effective drama methods but both groups of students required development to link learners' actions to concepts and to provide more suitable analogues and sufficient learner autonomy in using role-plays. We see drama as an important tool in science teaching and use the findings to suggest conditions necessary for science teachers that could make them better users of drama to teach science.

Keywords: Drama, curriculum, pedagogy, role-play

INTRODUCTION

Drama is advocated as a way of helping access concepts in science through learners' active involvement in analogous learning, for example using physical role-plays (Aubusson and Fogwill, 2006). However, teachers may be reluctant to use drama methods because they fear pupils' disruptive behaviour or lack sufficient training and expertise in drama pedagogy (Fels and Meyer, 1997). Thus, for the science specialist, there may be border crossings to be negotiated from adopting drama into their pedagogy for science. A border might also exist in the reverse direction for the drama specialist teaching science. Consequently, a group of researchers at a university in South Africa studied ways in which drama specialist student teachers training to teach in the General Education and Training (GET) band (Grade R-Grade 9) prepared and taught science topics using physical role-plays. Outcomes from this first phase were used to train a second group of students who were science specialists, studied in the same way.

Questions addressed by the study were: what are critical episodes of teaching using physical role-play that lead to successes or hindrances for learners and how do these critical episodes compare for the two groups of student teachers; drama and science? A question was also addressed to compare the impact of role-plays for equivalent classes taught the same content using drama compared with non-drama lessons. This was done using a post-test of questions linked to the target concepts to collect quantitative data and calculate an effect size for role-play use.

THEORETICAL BACKGROUND

Borders exist between school subject disciplines through ways knowledge is perceived and as a product of entrenched disciplinary structures. Dillon (2008) sees such borders favouring a utilitarian view of knowledge and creativity, often under-valuing the creative and performing arts, not directly associated (like STEM) with primary means of economic production. The borders between self-reinforcing disciplinary structures hinder potential of working across and beyond disciplines (Dillon, 2008).

An important process in attempting to cross borders through interdisciplinary work is by deploying 'border objects'. These can have different meanings in different disciplinary worlds, but at the same time have a structure that is common enough to make them recognisable across these worlds (Star & Griesemer, 1989). From this perspective, the role-plays used by student teachers in this study are border objects with structure in the 'drama world' applicable and useable in the 'other world' of the science classroom. Fels and Meyer (1997) employed several border objects from drama (dance, role-play, improvised plays) to help cross borders reinforced by their students' previous negative experiences of learning science. Border crossing requires, as Fels and Meyer put it, 're-interpretation of science learning/teaching that recognises performance as a critical and creative means of engaging mindful participation with phenomena' (p. 76).

The particular type of drama used in this study was physical role-play where learners provide analogues for phenomena, structures, concepts and processes. On the spectrum of drama activity to teach science recognised by Odegaard (2003) shown as Table 1, these tasks, used to teach science content rather than to address socio-scientific issues, are relatively high on the scale of pupil autonomy though in reality this will depend on the amount of support and structure (e.g. by using role-play cards) provided by the teacher.

Table 1. Framework for types and uses of drama in science education (based on Odegaard, 2003).

	Uses for drama to teach s*cience*		
Degrees of freedom in the drama activity	**Science concepts**	**Nature of science**	**Science and society**
Explorative	Free role-plays where pupils enact a concept or process according to their own designs		Improvised role-play of an SSI context with pupils creating their own roles

Semi-structured		Role-plays stimulated by role cards involving a scientific process or sequences of discovery	
Structured drama (theatre)	The teacher uses a scripted dramatization of a concept and the pupils play it out		Reading a play about a scientific discovery or taking part in a topical play about current ethical or moral dilemmas

McSharry and Jones (2000, p. 74) offer four reasons why role-plays in science are effective. In their view, they provide: a sufficiently different narrative method from written media, a sense of ownership for learners through creation and performance, ways into debates and discussions of otherwise sensitive issues and a physical experience through which abstract material is made more comprehensible.

METHODS

Research participants were eight volunteer student teachers, four in each cohort; the first cohort being drama specialists and the second science specialists (two each from Physical Sciences and Life Sciences). Student teachers were interviewed before and after they taught to establish viewpoints on using role-plays. Lesson plans were reviewed by three researchers (university education lecturers) and suggestions made for improvements. All lessons were videotaped and audio recorded by two independent camera operators. Three researchers recorded independent field notes for each lesson. A focus group of learners (as school pupils are known in South Africa) was interviewed following each lesson to establish what they thought of these methods to learn science. In all cases the student teachers also taught a lesson on the same content to a different class of similar ability but without using any drama methods. Both classes were tested after the lesson using non-standardised tests designed by the student teachers. A modified version of Tripp's Critical Analysis Model of Reflective Practice (Tripp, 1993) was used to analyse video transcripts and documentary data. Critical episodes can be positive, enabling meaning-making by establishing links between drama actions and science concepts, or negative, in cases where they hinder effective learning. Each researcher independently analysed lessons and a consensus view on what critical episodes were most important was then reached. Test results were subjected to statistical analysis to establish an effect size measure (F value) for the drama lesson compared with the non-drama one.

FINDINGS

Data for the eight student teachers are shown in Table 2. The numbers of positive and negative critical episodes are shown in separate columns but without stating what each of these episodes involved. The F value for the effect of the difference between the mean test scores for the drama versus non-drama lessons is shown in the last column. In all cases this was a positive value showing that role-play lessons had advantages for pupils' learning except for Stacey (*F* = -0.25) where her drama lesson did not result in any learning gain, indeed pupils in the non-drama group seeming to benefit more. Numerical data were not available for Sally and Ricci as they did not submit any test results.

Table 2. Critical teaching episodes and impacts of role-play lessons used by drama and science specialist student teachers.

Student teacher	Specialism	Teaching topic/concepts	No. of +ve critical episodes	No. of –ve critical episodes	*F* value for effect of role-play
Annie	Drama	Planets (orbits)	4	4	0.3
Taneal	Drama	Solubility (Particles)	4	4	0.97
Sally	Drama	Solar system (Sun, moon, gravity/tides)	5	3	No data
Ricci	Drama	Cells (form and function)	3	3	No data
Anthea	Life Sciences	Sound and hearing (generation, transmission and reception)	3	6	0.55
Stacey	Physical Sciences	Energy (Forms and transformation)	6	5	*-0.25*
Elroy	Physical sciences	Energy (Forms)	3	3	0.35
Kim	Life Sciences	Cells (nucleus, chromosome functions)	6	2	0.43

In most cases there was a balance between the number of critical teaching episodes when compared with negative ones, except in the cases of Anthea (3+ and 6 -) and Kim (6 + and 2 -). For the drama, student teachers most commonly recorded positive teaching episodes involved: thoroughly preparing space for the role-plays, allowing learner autonomy in designing and performing role-plays, using warm-up activities, intervening by using encouraging discourse and ensuring that as many learners as possible could be engaged or at least be involved peripherally in an activity (class sizes can be very large in South Africa and was 60+ learners for Taneal, Ricci and Kim). Negative critical episodes for the drama students most commonly involved a failure to link concepts sufficiently to the actions being played out. For example, in Annie's lesson learners modelled the rotations and orbits of the

Sun, Earth, Moon and planets. At one stage in the enactment she stopped the action and asked learners, "Right, can you all see the sun, yes or no?" In all cases learners' responses were simply, "yes" or "no", depending on their orientations to the light from 'the sun' (a bight bedside lamp). There was no attempt to link these observations to the idea of night and day, or that different rotation speeds of planets produce different lengths of day and night. There was only one case, Sally, where opportunities were provided for learners to critique role-plays in terms of their accuracy for portraying the science concepts involved.

The science specialist student teachers also prepared spaces well for their learners to use role-plays but did not use warm-ups as some Drama students did and they tended to manage activities in less inclusive ways and to provide much more structure and support. In two cases the suitability of the role-play as a designed activity to map against the science concepts to be taught could be questioned. This did not happen for the drama students. For example, Anthea (a Life Sciences student) provided supporting 'role cards' which resulted in her learners playing out scenarios that had little to do with the target concepts; generation, transmission and reception of sound waves by the human ear. One group played out a scenario of trying to gain attention for rescue from being stranded in the jungle by banging a drum. While the scenario had potential to address the science, the played out actions seemed to avoid them. It was as if her attempts were more to do with contextualising the role-play scenario than providing structure to include the science. At the post lesson interview Anthea said:

> *I included this scenario, about the drumming to call for help, because in some cultures it's a form of communication… some of my learners come from the Congo … so maybe they know about it.*

Possibly due to their lack of Pedagogical Content Knowledge (PCK) for drama, science student teachers tended to over-direct their learners' role-play attempts, though this did not mean that outcomes were always negative. In the two lessons on energy, for example (by Stacey and Elroy), a creative space for learners seemed to emerge differently. In Stacey's case the suggestions for actions to model energy types appeared trite and limited: miming a scream (for sound), falling off a chair (for gravitational potential energy) and so on. In Elroy's case the suggestions for actions modelling energy were open and more subtle, representing more challenge in the representations. For example: powering a toy to 'life', water power for a mill, a car running out of petrol and cooking food in a forest using timber from trees. Thus, for Elroy, role-plays as 'border objects' were already 'switched on' for the learners and worked to a greater extent through his and his learners' more imaginative designs. Whether this is just a characteristic of a creative student teacher, more open to interactive learner-centred methods is of course open to question. Putting it metaphorically, Elroy, by his pre-dispositions to learning, may already have had 'one foot over the border'.

DISCUSSION

Our work with student teachers in Cape Town has allowed us insights into a number of aspects of how physical role-plays can best be used as a type of drama to teach science, mainly from a conceptual standpoint. As a border crossing from the pedagogy of drama into the pedagogy for science, physical role-plays successfully fulfil the role of the border crossing object to reduce pedagogical barriers for the science specialist anxious of using an arts-derived teaching strategy. In this section, four aspects that seem the most important ones to discuss at this time and that emerge from our work are featured, for they are ones that allow us to reflect on how physical role-plays can be most effective.

Drama as analogous learning
Just like simulations, conceptual and physical models and some practical work, drama presents analogues of reality that are steps to understanding (Aubusson and Fogwill, 2006). Thus, the movements of learners as actors playing a sperm cell, modelling the behaviour of atoms in a solution, being the cell wall of a plant cell and so on are not really like the movements, structures and forms in the real world but they can work as effective analogues and metaphors. Our observations (more so for the drama specialists), that there was a lack of linking from the drama to science reality, reminds us of a point made by Lemke (2000), that science has always used different modalities to communicate ideas, such as mathematics, diagrams, graphs and visualisations. His point is that whatever science teaching design is chosen we have hopes that sufficient concept linking is made (by the teacher for the pupils and by pupils themselves). The challenge, these student teachers did not always respond to, was to capitalise on the richness of pedagogy afforded by the drama simulations as a communication mode. It strikes us that if high levels of interaction are used, such as in these drama simulations, the teacher must make extra effort to create conditions under which the purposes and expectations of activities are made clear for learners. For drama, simulating and portraying a scientific reality means making explicit links between body actions and movements and phenomena, concepts and processes and crucially some dialogic space and conditions under which discussion as critique can take place.

Where to place drama in a learning sequence
I am often asked if drama activities are best carried out as topic summaries or revision exercises or used within the body of a teaching sequence to first teach the concepts to learners. We have found that teachers who intervene a lot ‘in the action’ can obtain good learning outcomes when using drama to teach new content. For example, we watched a student teacher (not reported in this paper) cover the ideas of plant and animal cells by creating a huge model of a cell with 50 pupils. This teacher explained what was happening as she directed the action. For example, she stopped the action and said, “That’s right you are the membrane but there are some holes between you that can let the little particles like water in and out – but, hey you big ones (sugar) you can’t get through, can you?” This example could be used at any time in the learning sequence, but maybe the more complex, self-directed role-plays like those attempted by Stacey and Elroy need some background science knowledge before the pupils devise and rehearse their actions and this could come from the teacher, books, the internet, and so on.

Managing the learning space
It is not always necessary to use a hall or studio for a science drama lesson, though if a teacher wants a few groups to work simultaneously or to have a large amount of free movement this might help. South African classrooms are overcrowded and cramped compared with many elsewhere but we have seen highly successful lessons with classes of over 80 pupils with just a few chairs and desks pushed back to the sides of the room. Having groups rehearse, and then each one portraying a concept or sequence and the rest of the class asking questions after their ‘performance’, works very well and helps make the drama inclusive.

Avoiding the 'fish bowl' effect

One of the problems our drama student teachers had was expecting drama activities to have power to stand alone as learning experiences (they did this much more than the science specialist students) – they often chose to stand back and did not often help pupils connect actions with concepts. It was as if they had implicit faith in performance as learning. But drama for theatre is not the same as drama to learn science. Pupils should not have to act as if being observed by others from outside a "fish bowl". Drama for science is not like acting a play for an audience – it is an example of 'rough' or 'good enough' drama (see Braund, 2015 for an explanation of this) where the experience must produce sufficient connections to help make content meaningful.

CONCLUSION

To some, drawing on arts-derived pedagogy to teach science might seem strange. We have found, however, that arts methods provide a way into science that many pupils find more accessible and fun than those that make up the rather impoverished diet provided in many lessons. Because of the reduced language load of these approaches, we have found particular strengths for pupils who have learning difficulties or those whose first languages are not ones used by the teacher. Like many other methods, we cannot use drama in all lessons; it has to be used sparingly and with thorough preparation. Ultimately the power of drama is that pupils' physical involvement in portraying scientific phenomena, ideas and stories embeds content in the mind in ways that are meaningful and enjoyable (and might even help in examinations). As one of the pupils we interviewed in a Cape Town school, following his science lesson using drama, said:

> *I liked doing the moon and tides drama because you can learn and you can do it yourself, so you will know what it would feel like and that kind of thing. Like … maybe we could remember about the rulers and the waves* (methods pupils had used in a drama simulation used by Sally) *in the grade exams.*

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Light talking: Students' reflections on the wave-particle duality for light in small-group discussions

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Abstract

Quantum physics breaks fundamentally with our experiences and view of the world. This paper investigates how upper secondary school students conceptualise the wave-particle duality in small-group discussions, during a teaching sequence with use of digital learning resources developed in the ReleQuant project. The resources are developed with Design-based research as a methodological frame. Earlier results indicate that students may hold an uncritical conception of the duality for light. Therefore, the resources were modified to include a discussion task that encourages students to reflect on the dilemma of having two models for light that are contradictory in a classical sense. 55 small-group discussions on this task were recorded and analysed qualitatively. Results show that students were able to reflect thoughtfully on the two contradicting models for light and on what the duality entails. However, students encountered challenges concerning how the duality should be interpreted. It is concluded that upper secondary physics should let students go deeper into conceptual and ontological aspects of quantum physics, and this way contribute to students' understanding of philosophical aspects of modern physics and the nature of scientific knowledge.

Keywords: Light; small-group discussions; upper secondary school; quantum physics.

INTRODUCTION

Quantum physics breaks fundamentally with our classical view of the world and everyday experiences. Research has shown that even if university physics students may master the mathematical technicalities of quantum mechanics, their conceptual understanding is often fragmented (e.g. Hadzidaki, 2008), and students often interpret quantum phenomena in classical terms (see e.g. Kalkanis, Hadzidaki, & Stavrou, 2003). A recent review undertaken by Krijtenburg-Lewerissa, Pol, Brinkman, and van Joolingen (2017) shows that there is a lack of empirical evidence of which teaching strategies promote understanding in quantum physics.

The present paper contributes to the field by investigating how philosophical aspects of quantum physics can form part of pre-university physics teaching. The results stem from the project ReleQuant (see Bungum, Henriksen, Angell, Tellefsen, & Bøe, 2015), where Design-Based Research (DBR, also referred to as Educational Design Research) is used as a methodological frame for combining research and development in several cycles (see e.g. Anderson & Shattuck, 2012). The developed resources in ReleQuant are digital modules for the teacher to use with students during physics lessons in upper secondary schools. With a sociocultural view of learning, the resources emphasize students' use of language and reflections on philosophical aspects of modern physics. The resources are adapted to the Norwegian curriculum for Physics in the curriculum for upper secondary school, where it is stated that students are required to gain insights into how the wave nature of particles represents a break with classical physics and reflect on philosophical consequences of modern physics. These issues are quite unusual in a curriculum for pre-university physics (see Bungum et al., 2015; Krijtenburg-Lewerissa et al., 2017), and gives an opportunity to explore new approaches to the teaching of modern physics for young students and to research students learning challenges.

Quantum physics and interpretations

In the early twentieth century, quantum mechanics was developed and was soon successful in describing and predicting experimental results for quantum-scale phenomena by means of mathematics. Today, it forms part of the theoretical foundation for development of new technologies such as quantum computers. This theoretical foundation includes a description of light as having both particle properties and wave properties, referred to as the wave-particle duality. However, there is no consensus about how to interpret quantum physics, including the contemporary scientific description of light, on an ontological level (Bunge, 2003). Physics students are presented with the wave-particle duality for light, but discussions on what it means on an ontological level rarely form part of physics teaching . The mathematical formalism of quantum mechanics constitutes a body of knowledge that most physicists agree on, but the link between this formalism and a physical reality remains far from consensual (Cheong & Song, 2014).

One philosophical position is the *Copenhagen interpretation* of quantum physics, stating that a quantum physical system does not have a definite physical state prior to being measured and that quantum mechanics can only predict the probabilities that measurements will produce certain results. A different philosophical stance is *realism*, where it is assumed that the universe exists independently of the knowing subject or observer (Bunge, 2012) and that "the objects of science (…) reflect objective structural aspects of the physical world" (Karakostas & Hadzidaki, 2005p. 607). Many physicists do, however, not consider the discussion about different interpretations, but rather take an instrumental approach where one is satisfied when the calculational rules give results that are successful in predicting a physical reality. This stance will inevitably also influence how one approaches the teaching of quantum mechanics to students. Greca and Freire (2014) have argued that this may be because the very existence of several interpretations of quantum theory seems to be an inconvenient truth for the teaching of physics.

The ReleQuant project and prior results

The ReleQuant project meets the challenges described above by developing learning resources with the aim of engaging pre-university students in discussions about interpretations of quantum physics. The resources are developed in cycles based on analysis of data from classroom trials of the resources. The final version of the resources are available in English from www.viten.no/eng/. The wave-particle duality for light is presented in the introductory part of the resources, with title *"Need for a new physics"* and includes descriptions of the history of quantum physics.

Earlier results from the project have shown that many students express an 'uncritical duality' (see Henriksen, Angell, Vistnes, & Bungum, 2018), which means that they describe light as having properties of both waves and particles, without reflecting on the fact that these models are contradictory in a classical sense. A typical student response of this kind is *"Light is particles where the wavelength determines the colour of the light"*.

The resources were therefore adjusted to include a discussion task where students are challenged to reflect on whether it is possible to imagine that light is both waves and particles in a classical sense. The task is shown i Figure 1. Before the discussion task, the students watched short videos describing the history of quantum physics and two physicists expressing different views on the nature of light.

RESEARCH QUESTION

This paper reports results from the trial of the *ReleQuant* resources in revised version as described above, and addresses the following research question: *What conceptions of the wave-particle duality do students express during a teaching sequence using the ReleQuant resources?*

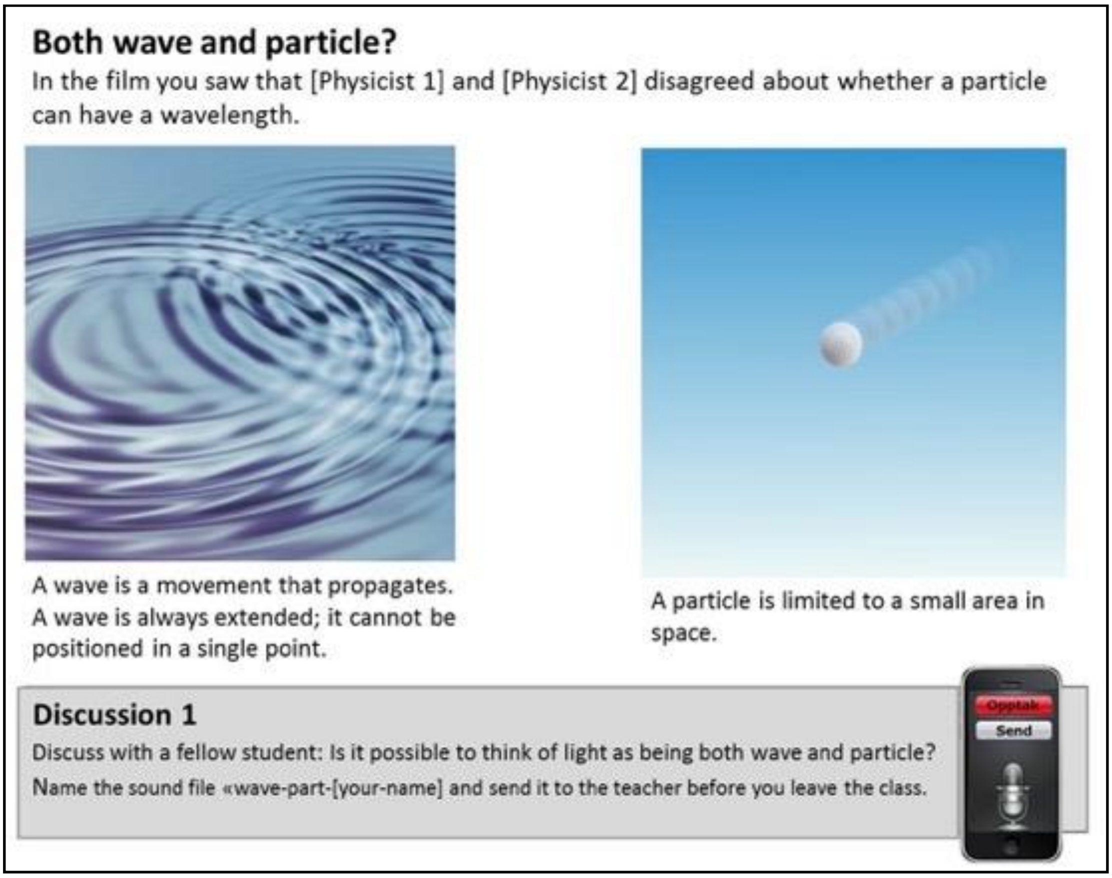

Figure 1: Screenshot from the ReleQuant learning resources: Small-group discussion task about the wave and particle nature of light.

RESEARCH METHODS

The ReleQuant project has a design-based approach, where research on students' learning informs development of learning resources which in turn generate new research data. The data in the study reported here are from the third cycle of development, where the resources include the discussion task shown in Figure 1. Data are drawn from classroom trials of the resources in 9 physics classes from 7 upper secondary schools in Norway. These schools are regarded as having middle to high-achieving students in national comparison. Students recorded small-group discussions on their own smart-phones and sent them to their teacher, who forwarded them to the research team. The analysed material consisted of 55 discussions involving 2-3 students each; thus, a total of ca 120 students contributed to the analysed recordings. The discussions lasted from a few seconds up to around five minutes.

Analysis was first undertaken by means of broad pre-defined categories of students' conceptions of light: (i) Wave, (ii) particle, (iii) wave and particle, and (iv) wave or particle. Further coding was undertaken inductively, involving emerging codes such as 'uncritical duality'. Within these categories, more detailed analysis was made of the reflections and challenges students express and how they relate to issues in the philosophy of physics and interpretations of the wave-particle duality for light. Examples of these are presented as results in this paper. Even if the study is qualitative, we also give semi-quantitative measures (such as "many", "a few"), in order to give indications of how prevailing the conceptions appear to be among students.

RESULTS

Results indicate that most students are able to see the dilemma of having two contradicting models for light in the small-group discussion. This is evident for example in this dialogue:

> *S1 – I think it is strange what he said about particles having wavelength, how can a particle have wavelength?*
>
> *S2 – No, I, find that weird, too (...) because we have learned that light is particles, or wavelength.*
>
> *S1 – M-hm*
>
> *S2 – But that becomes, sort of, a particle with wavelength (…) that is weird*
>
> *S1 – But what I really think, then, is that there are just certain things that are impossible to explain, and that, that is such a thing that just doesn't fit into any of those explanations, so there must be an entirely new... [model]*

The student S1 here shows understanding of how scientific models are not true reflections of reality, but rather human descriptions that correspond to some aspects of reality. Some students also described properties of light in ways corresponding to context dependence, meaning that properties we observe depend on the experiment undertaken:

> *S3 – Is it possible to think light as being both wave and particle?*
>
> *S4 – Yes, I would say so. To explain two, or more, different phenomena related to light, one has to use several models. For instance, one can support the particle model with photoelectric effect and the wave model with interference patterns. Since we haven't come up with any other explanation, we just have to accept that light behaves as both particles in some cases and as waves in others. So yes, it is possible and necessary.*

The student S4 expresses that until we have a better model, we will "have to accept" that light can change behaviour depending on the experimental context, in the sense that different experiments expose different properties of light.

Other students addressed the question of whether the dual nature of light means that light really has both wave and particle properties *simultaneously*, or whether the properties change according to the context. This is found in the final part of this quotation:

> *S5 – I do not know, but I thought that for me it is hard to envision that something can be in waves without being sort of a physical thing. So, it is easier to see a particle or a point that moves in a wave pattern. But the question is really if it can be two things at the same time. Or if it really is two different things.*

Student S5 here expresses the issue of simultaneousness as problematic: Can light be two very different things *at the same time*? The student also finds it hard to envision light as waves without being "sort of a physical thing", and touches on the misconception of the wave-particle duality meaning a particle moving in a wave-like trajectory. This idea came up in several discussions, but mostly described by students as a possible answer to how the contradicting ideas of light as wave and particle can be combined. This may be seen as a product of the discussion question that students are given (see Figure 1), that to some degree gives room for this interpretation. It does not, however, seem from our data that students build their understanding on this mistaken interpretation.

In some groups, students explicitly tried to conceptually reconcile the classical descriptions of wave and particle in other ways. This included ideas of how a wave would appear as a particle if the wavelength is very small, for example:

> *S6 – Light most often has particle properties when the wavelength is very small.*
>
> *S7 – Mhm, because then, then it could be gathered more in one.*
>
> *S6 – Yes, it is kind of, I don't know, the wave gathered more in one point in a way.*
>
> *S7 – Yes, yes, something like that.*
>
> *S6 – What would be interesting to test is if you had a sound wave and a really, really small wavelength, and see if it behaved a bit like a particle, if you understand.*

The students wonder on whether also sound could have particle properties and appear as «sound particles» when the wavelength is small. This is an example of how the small-group discussions generated new and interesting questions among students.

A considerable proportion of groups expressed that the conception of light as a wave is challenging to grasp, as exemplified by student S5 above. In this sequence, students compare light to sound in expressing why light as waves is difficult to envision:

> *S8 – Because, kind of, photons are small packets of energy in a way, but waves … that … what is that, sort of, what kind of wave is it, is it just like propagation in, like, the particles in the room, kind of?*
>
> *S9 – Sound waves make sense, but light waves don't quite make sense.*
>
> *S10 – Yes, because sound waves they vibrate and stuff, and the eardrum vibrates and...*

These students state that sound waves are easier to understand, because they have a conception of vibrations that propagate in a medium and this way produce sound that the ear can detect. The discussion proceeds by the students stating that there is not anything that vibrates in the eye to detect light. It seems that students have problems in conceptualizing light as waves, because they have learnt that waves are vibrations that propagate and it is not clear to them what the material substance that vibrates is when it comes to light. Other student groups bring up further problematic issues concerning light as a wave, such as what is in the end of a wave, and where the wave starts and ends.

DISCUSSION AND CONCLUSION

Our results indicate that the small-group discussions have evoked questions and ideas among students about how the wave-particle duality should be interpreted. The small-group discussions were important in facilitating this process of students articulating their present understanding and formulating questions (Bungum, Bøe, & Henriksen, 2018). It seems from our results that the teaching material in ReleQuant has been successful in building students' understanding beyond the uncritical duality conception that was found in previous trials in the project (Henriksen et al., 2018): Students actively discussed the meaning of duality, sometimes relating it to the role and status of models in science, and in some cases trying to reconcile the two models based on notions from classical physics.

However, the student discussions reveal a range of challenges students encounter in interpreting what the wave-particle duality means, such as how light as a wave should be understood. When going deeper into the wave-particle duality for light than what is normally done in secondary school physics, they ask questions about "what is waving?" when light behaves like a wave. They have learnt that light is *electromagnetic* waves, but this does not help them in envisioning what the wave is like. They also discuss how the duality should be interpreted, in terms of simultaneousness versus context-dependence, that is: Does the duality mean that light is wave and particle at the same time, or does it mean that light shows different properties dependent on the context? Some students also ask whether also sound waves can have particle properties under certain conditions. It is important for the students' learning outcome that these ideas and questions are followed up and shared on the social plane of the classroom monitored by the teacher, in order to support students' learning in the student groups where these issues came up, but also in other groups: Teachers need to make the authoritative scientific understanding available to the students: (Mortimer & Scott, 2003) for them to be able to use the discussion tasks to develop their scientific understanding of light.

The discussions also touched upon philosophical questions about the nature of science and scientific knowledge, and we report elsewhere (Henriksen et al., 2018) that some students were able, through discussion, to touch upon ontological and interpretational problems of modern physics. Some of the students' discussions can be related to fundamental questions that are still discussed in the professional physics community, for example what the Copenhagen interpretation means and whether the duality can be interpreted from a realist point of view (see e.g. Bunge, 2012). Results from our study suggest that students would benefit from going deeper into interpretations of quantum physics than what is usually done in physics teaching at pre-university level. This could counteract the problem that research has revealed, that university physics students can do calculations in quantum physics but lack conceptual understanding (see Hadzidaki, 2008). In particular, the wave model for light should be treated more thoroughly, since students show substantial problems with envisioning light as waves and since the wave model is important for the development of a more advanced understanding of quantum physics. Furthermore, we suggest that physics teaching should explicitly present and discuss various interpretations of quantum physics at an early stage. This could improve students' understanding of quantum physics and the nature of science as well as stimulate their interest in modern physics and its philosophical aspects.

ACKNOWLEDGEMENT

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Preliminary Results on Bhutanese Teachers Conception of Evolution

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Abstract

The Biohead-Citizen project (Biology, Health and Environmental Education) for better citizenship was initiated in 2004 aimed to understand how Biology, Health and Environmental Education can promote a better citizenship in which the teachers' conception related to six topics on Human Brain; Human Genetics; Human Origin; Human Reproduction and Sex Education; Health Education and Ecology and Environmental Education. This research project was extended to Bhutan, a deeply religious country with religion permeating all facets of life under the guiding development philosophy of Gross National Happiness. This paper shared the findings of the teachers' conceptions of evolution varying with their religions on Biology, Health and Environmental Education in promoting a better citizenship, including their affective and social dimensions. A total of 36 student teachers from Samtse College of Education and 5 Lower School Teachers in Samtse, who filled out the questionnaire were life sciences teachers. More than half of the teachers who declared their religion were Buddhist, the official Bhutanese religion, while 31.7% of teachers were Hindus. The older teachers (above 25 years) were more conservative as compared to the younger teachers. Based on 15 questions related to evolution, all the teachers were found more oriented toward the evolutionist pole due to the influence of their religious background. However, the perception towards origin of life oriented towards evolutionists was contrasted by perception of human origin with orientation towards creationist particularly among the Hindus. In asking whether the theory of evolution contradicted their belief, there were similar pattern of response for both religions in which 50% indicated 'yes'. But 65% and 15% of the Buddhist and Hindu teachers respectively indicated that creationism contradicted their belief.

Keywords: Bhutan, Buddhism, Conception of Evolution; Gross National Happiness, Hinduism, Religion;

INTRODUCTION

Bhutan is a small Himalayan country with projected population of 813,328 by world population review. The country is deeply religious with religion permeating all facets of life. Since the time of the fourth King's declaration in 1972, Gross National Happiness (GNH) has been the guiding development philosophy. At its most subtle level, GNH expresses a shift in consciousness regarding how Bhutanese strike a balance between material and non-material values, prioritizing the happiness and well-being of humans and all life. The objective of GNH is to achieve a balanced form of development encompassing nine domains of progress: health, time use, education, cultural resilience, living standards, ecological diversity, good governance, community vitality and psychological well-being, each of which makes a vital contribution to happiness. This approach aims to balance modernity with tradition, material with spiritual, and economic with social, all within the broader context of ecological conservation. Bhutan has organized its education system around the principles of GNH which the Ministry of Education's explicit mission is to "Educate for Gross National Happiness." 75% of the population is Buddhist, mostly of Vajrayana Buddhism, the state religion; 22% are Hindu, followed by 2% folk religion and 1% other religions. Hinduism is practiced mainly by the southern Bhutanese which are ethnic Nepalese.

The historical education system of Bhutan was in monastic form of education where literacy was confined to the monasteries. In 1961, a modern education system in secular form was introduced (Sherab, 2013). Bhutanese schools then followed curricula and textbooks directly from India, which were Anglo-Indian in nature (Namgyel, 2011). Biology learning content is about the rich biodiversity of the country and about the endangered species found in the country and students' role within biosphere and how sustainability can be affected through their actions and the actions of others (Dema and Macleod, 2015).

The Biohead-Citizen project (Biology, Health and Environmental Education) for better citizenship was initiated in 2004 aimed to understand how Biology, Health and Environmental Education can promote a better citizenship (Carvalho et al., 2008). The teachers' conception related to six topics on Human Brain; Human Genetics; Human Origin; Human Reproduction and Sex Education; Health Education and Ecology and Environmental Education were analysed. Conceptions were based on emergences from interactions between the three poles: the scientific knowledge (K), the systems of values (V) and the social practices (P), as proposed by the model KVP (Clément, 2006) in which defined K being referred to the publications coming from the scientific community, while P, the practice of teaching practices associated to personal and professional activities as well as the social and historical context and V associated in a large sense to opinions, beliefs and ideologies. In the analysis of the teachers' conceptions on Evolution, Clément and Quessada (2008, 2009) concluded that the differences among religions are only dealing with values, whereas the differences among countries were dealing with values and knowledge with a very strong correlation between the values which differentiated the countries and the religions. They also indicated there was an interaction between values and knowledge related to teachers' conceptions on some topics such as the role of chance, natural selection, and intelligent design in the evolution of species. In addition, the independence of some knowledge from the values, differentiating teachers among themselves as well as groups of teachers by countries showed a possible acquisition of knowledge related to evolution independently from religions suggesting that when the knowledge increased, the values also could change to be more evolutionists. The Biohead-Citizen research project was extended to Bhutan aimed at analysing the teachers' conceptions of evolution varying with their religions on Biology, Health and Environmental Education in promoting a better citizenship, including their affective and social dimensions.

METHODOLOGY

The questionnaire built and validated inside the Biohead-Citizen research project (2004-2008: Carvalho et al, 2008) containing 153 questions with 15 questions being dedicated to evolution, and 22 questions related to personal information (gender, age, level of instruction, religion, political or religious opinions was used. The collection of the filled questionnaire was totally anonymous. The sampling was the same as in other countries of the Biohead-Citizen project. Nevertheless, in Bhutan, the collection of data was not yet well balanced for the six sub-sampling interviewed in each other country as it is only conducted in Samtse, one of the 26 districts, but it is already possible to analyse the present total of 36 student teachers from Samtse College of Education who filled out the questionnaire categorized:

- 18 Bachelor of Education Student Teachers
- 9 Post Graduate Diploma in Education (PgDE) Student Teachers
- 8 Master of Education Student Teachers (School Teachers from different Schools in Bhutan).

Five (5) Lower School Teachers in Samtse also took part in filling the questionnaires. All the 41 respondents were life sciences teachers. The data were analyzed using the IBM SPSS Version 24.

RESULTS AND DISCUSSION

The declared religion by the 41 teachers is indicated in the Table 1. More than half of the teachers who declared a religion are Buddhist, the official Bhutanese religion, while 31.7% of teachers are Hindus. Only one who declared to be Christian and one who did not want to answer were not taken in consideration in the subsequent analyses. Samtse, being close to India at the southern region of Bhutan explained the lower percentage of Buddhist and the higher percentage of the region as compared to the national percentages.

Table 1. The declared religion by 42 teachers as compared to the national population with 1% of folk religions and 2% of others

Religion	Buddhist	Hindu	Pentecostal Christian	Don't want to answer	Total
(%)	63.4%	31.7%	2.4%	2.4%	41
Number	26	13	1	1	(100%)
Population (%)	75.0%	22.0%	-	-	77%

Based on question related to evolution pertaining to origin of life, perception of all the teachers of Buddhist faith are more towards evolutionists while the teachers of Hindu faith were towards creationist as shown in Figure 1. The result related to the Buddhism was similar to the findings among the Malaysian and Korean practising Buddhist teachers (Chan et al., 2015; Seo and Clément, 2015).

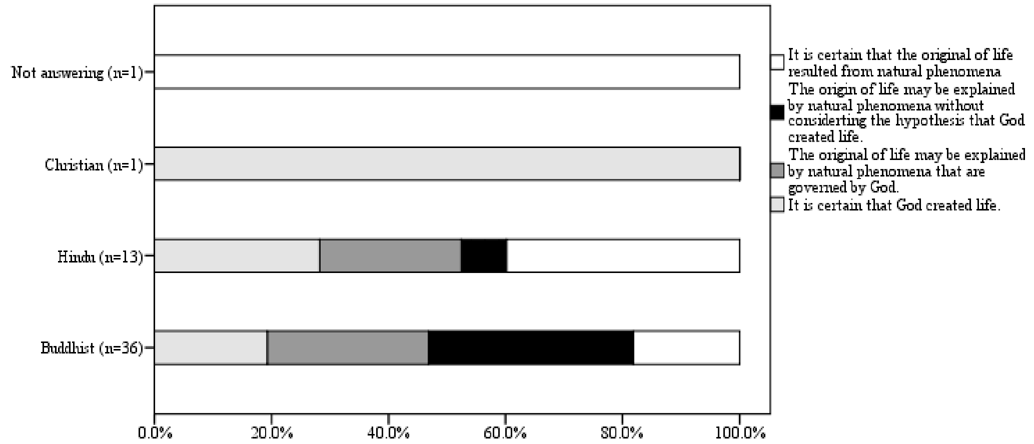

Figure 1: The percentages of respondence grouped by religion to origin of life without significant differences in their perception based on statistical analysis done to compare pairs of religions for each question (Pairwise t-tests, with p value > 0.05)

Similarly, based on the question related to origin of humankind as shown in Figure 2, there was also no significant differences in their perception based on statistical analysis done to compare pairs of religions for each question (Pairwise t-tests, with p value > 0.05).

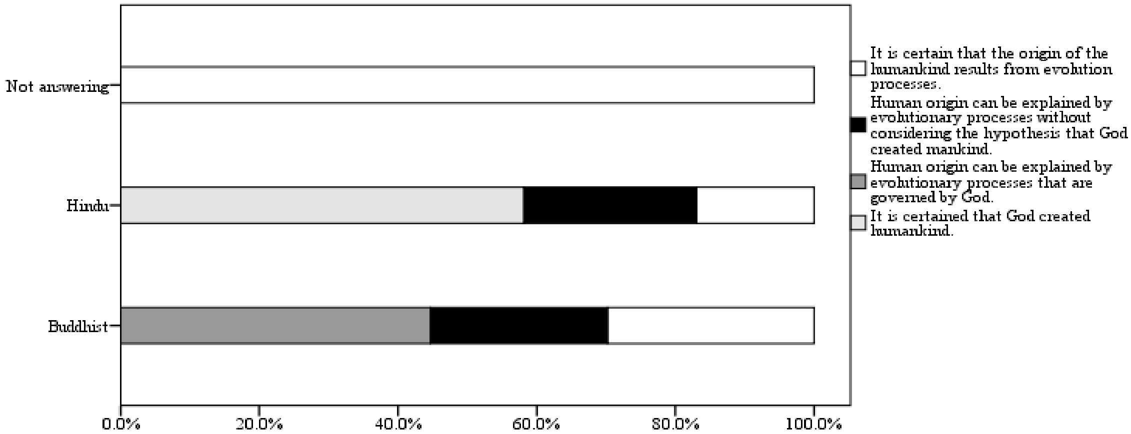

Figure 2: The percentages of respondence grouped by religion to origin of human without significant differences in their perception based on statistical analysis done to compare pairs of religions for each question (Pairwise t-tests, with p value > 0.05)

However, the perception towards origin of life oriented towards evolutionists was contrasted by perception of human origin with orientation towards creationist particularly among the Hindus (Table 2). Hindus believe that the universe is a manifestation of Brahman, Hinduism's highest God and the force behind all creation. In the comparisons between the two religious faithful, the three expressions associated with the origins of humankind to the theory of evolution: Australopithecus, evolution and natural selections, the Buddhists responded with higher percentage towards evolution than the Hindus.

Table 2: Theory of evolution – three expressions most strongly associated with the origins of humankind: Australopithecus, evolution and natural selections

% of Respondents	Adam and Eve	Australopithecus	Creation	Evolution	God	Natural Selection
Buddhist	**15**	**15**	**38**	**88**	**23**	**56**
Hindu	**23**	**31**	**46**	**85**	**31**	**79**

In asking whether the theory of evolution contradicted their belief, there were similar pattern of response for both religions in which 50% indicated the theory of evolution contradicted their belief. While 65% and 15% of the Buddhist and Hindu respondents respectively indicated that creationism contradicted their belief. Rao (2017) enlightened that many Buddhists see no inherent conflict between their religious teachings and evolutionary theory as according to some Buddhist thinkers, certain aspects of Darwin's theory are consistent with some of the religion's core teachings, such as the notion that all life is impermanent. While there is no single Hindu teaching on the origins of life, Rao (2017) also stated although many Hindus today do not find their beliefs to be incompatible with the theory of evolution.

Table 3 shows the evaluation of the importance of factors in species evolution. Seven factors associated in species evolution were studied as shown in Table 3. The pattern of expressing level of some importance in the highest percentages was similar between the Buddhist and Hindu in two factors: chance and intelligent design (a program inside the organism). Majority of both also agreed in great importance in natural selection and surrounding environment. However, they differed in three other factors related to transposons (jumping genes), virus and God. In transposons and viruses, majority of Buddhist expressed great importance while the Hindus expressed only some importance. As associated to the belief in Karma, majority of the Buddhist expressed no importance while majority of the Hindu expressed some importance in relation to God.

Table 3: Evaluation of the importance of the factors in species evolution

		Great Importance	Some Importance	Little Importance	No Importance
Chance	**Buddhist**	**6 (23%)**	**12 (46%)**	**4 (15%)**	**2 (8%)**
	Hindu	**2 (15%)**	**8 (61%)**	**1 (8%)**	**1 (8%)**
Natural Selection	**Buddhist**	**18 (69%)**	**8 (31%)**	**0**	**0**
	Hindu	**8 (61%)**	**4 (31%)**	**0**	**0**
Intelligent Design (A program inside the organism)	**Buddhist**	**9 (35%)**	**16 (62%)**	**1 (31%)**	**0**
	Hindu	**3 (23%)**	**7 (54%)**	**1 (8%)**	**0**
Surrounding Environment	**Buddhist**	**23 (88%)**	**3 (11%)**	**0**	**0**
	Hindu	**10 (77%)**	**2 (15%)**	**0**	**0**
Transposons (jumping genes)	**Buddhist**	**11 (42%)**	**7 (27%)**	**6 (23%)**	**2 (8%)**
	Hindu	**2 (15%)**	**7 (54%)**	**3 (23%)**	**0**
Viruses	**Buddhist**	**8 (31%)**	**7 (27%)**	**5 (19%)**	**5 (19%)**
	Hindu	**4 (31%)**	**6 (46%)**	**1 (8%)**	**1 (8%)**

God	**Buddhist**	**11 (4%)**	**4 (15%)**	**4 (15%)**	**7 (27%)**
	Hindu	**2 (15%)**	**5 (38%)**	**4 (31%)**	**1 (8%)**

The compatibility between religious faith and acceptation of evolution is claimed by several scientists as reviewed by Clément (2015). He cited Dobzhansky (1973) who claimed to be both creationist and an evolutionist attributing that evolution is God's, or Nature's, method of Creation.". Similarly, the palaeontologist Teilhard de Chardin (1956) was simultaneously Catholic priest and evolutionist. Yassin and Bastide (2011) and Clément (2013) reported even in Arabic Muslim countries, several scientists accepted the Darwinian evolution, even when thinking that it is governed by God.

CONCLUSIONS

The teachers' conceptions of evolution in Bhutan are deeply rooted in the socio-cultural context of the country including religion directed by the principles of Gross National Happiness policy. The conceptions of Buddhist teacher's orientation toward the evolutionist pole and while Hindu teachers, intermediate between the two poles of evolutionist and creationist are due to the influence of their religious background of Buddhism and Hinduism respectively. Although majority of teachers have indicted conflict with their religious belief in teaching the biological evolution, there was no cause of any major concern as creationism is not scientific and cannot be taught in biology. The older teachers (above 25 years) were more conservative as compared to the younger teachers. Teachers can accept and teach evolution, just believing that the processes of evolution are controlled by God.

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XVIII IOSTE SYMPOSIUM
Future educational challenges from a science and technology perspectives.
Malmö, Sweden, 13-17 August, 2018

Teachers' Conceptions of Homosexuality in 34 Countries

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Abstract

UNESCO promotes Education for all, and equality for all as a human right regardless of their sexual preference. Teachers have a key role in education. What are their own conceptions related to homosexuality and to the introduction of this topic at school? We used in 34 countries the questionnaire built and validated inside the BIOHEAD-Citizen research project. The sampling was the same in each country. Total sampling: 12130 teachers. The country effect is the most spectacular, from 89% of teachers strongly agreeing that "Homosexual couples should have the same rights as heterosexual couples" in Sweden to 3% in Senegal. And the more a teacher agrees with that, the more he / she wishes to introduce as early as possible the topic of homosexuality at school. These answers are not correlated with those related to the genetic determinism of homosexuality. Globally, more than half of the interviewed teachers are against the same rights for homo and heterosexual couples, and also against the introduction of this topic at school, or just for students aged more than 15. Our results also show other significant effects: gender, religion, level of instruction. This last effect is a hope to counteract a persistent homophobia rooted in sociocultural and religious contexts.

Keywords: Homophobia; Homosexuality; International comparison; Religion; Teachers' conceptions;

INTRODUCTION

UNESCO promotes Education for all, and equality for all, as a human right regardless of their sexual preference (UNESCO 2016a, 2016b, Clément & Caravita, 2011).

> Preventing and addressing homophobic and transphobic violence in educational settings are part of: a) UNESCO's mandate to ensure learning environments are safe, inclusive and supportive for all, and: b) UNESCO's contribution to the achievement of the 2030 Agenda for Sustainable Development (UNESCO, 2016b).

Nevertheless, homosexuality is outlawed in several African countries (Bozonnet, 2014; Grisot, 2014). Two-thirds of European homosexuals are scared to appear in public (Le Monde.fr / AFP, 17.05.2013) while, in Europe, there are often laws for same sex marriage, or at least civil union, and, for less countries, the possibility of adoption and, sometimes, of medically assisted reproduction (Stroobants & Monfils, 2012). Homosexuality is recognized in 47 States (possibility of marriage or partnership, joint adoption), protected in 85 other States, but until now criminalized in 72 States, including death in 8 States (https://ilga.org/downloads/2017/ILGA_WorldMap_ENGLISH_Overview_2017.pdf). The educational system has a great responsibility to promote the value of equality in any country, particularly when teaching biology or philosophy and social sciences, because groups struggling against same sex marriage like to refer to a natural order, while the biologists know that homosexuality is present among several animals (de Pracontal, 2012). For Borrillo (2013, 2016), the rejection of homosexuality (homophobia) grew inside each of the three main monotheist religions (Jewish, Christian and Muslim). Nevertheless, inside each religion, the rejection of homosexuality characterizes today the most fundamentalist trends.

QUESTIONS OF RESEARCH

Teachers have a key role in education. What are their own conceptions related to the equality between homosexuals and heterosexuals? At what stage, according to them, is it necessary to introduce the topic of homosexuality at school?
Do they reduce homosexuality to a genetic predisposition?
Do their conceptions vary with their nationality, or also with other controlled parameters (as their training, their age, gender, religion or other opinions)?

METHODOLOGY

The same questionnaire was used in each country, after translation into the national language, using two parallel independent translations from the initial French or English questionnaire; once completed, it was retranslated into French or English. The questionnaire has been built and validated inside the BIOHEAD-Citizen research project (2004-2008: Carvalho, Clément, Bogner & Caravita, 2008). It contains 3 questions dedicated to homosexuality (Table 1), and 17 questions related to personal information (gender, age, education, level of instruction, religion, religious opinions, political opinions, and so on).

Table 1 – The three questions related to the topic homosexuality

A41	**Homosexual couples should have the same rights as heterosexual couples.**	I agree					I don't agree
B11	**There are genetic factors in parents that predispose their children to become homosexual.**	I agree					I don't agree

At what age do you think the following topics should be first introduced at school by teachers and/or external specialists? (Tick only one box in EACH line):

Topic		**Less than 6 years old**	**Between 6 and 11 years old**	**Between 12 and 15 years old**	**More than 15 years old**	**Never in school**
A89.	**Homosexuality**					

The sampling was the same in all the countries: 1/6 In service Primary School teachers; 1/6 Pre-service Primary School teachers; 1/6 In-service Biology teachers; 1/6 Pre-service Biology teachers, 1/6 In-service Language teachers; 1/6 Pre-service Language teachers. Total sampling: 12,130 teachers, in 34 countries. In 18 countries, the data were collected in 2006-2008 by the teams in the context of the BIOHEAD-Citizen research project (Carvalho et al, 2008). In the other 16 countries, they were collected between 2009 and 2016, under the responsibility of P. Clément. The 34 countries are: Algeria (223), Australia (201), Benin (229), Brazil (402), Burkina Faso (296), Cameroon (523), Cyprus (322), Denmark (259), Estonia (182), Finland (306), France (732), Gabon (269), Georgia (296), Germany (365), Great Britain (154), Hungary (334), Italy (559), Lebanon (848), Lithuania (316), Malta (198), Malaysia (263), Morocco (518), Poland (311), Portugal (350), Romania (273), Russia (403), Senegal (324), Serbia (314), South Africa (336), South Korea (306), Spain (318), Sweden (377), Togo (270), Tunisia (753).

In each country, the collection of the filled questionnaires was totally anonymous. The data were then analyzed in France, using the software "R" for multivariate analyses.

RESULTS AND DISCUSSION

Same rights for homo- and heterosexual couples?

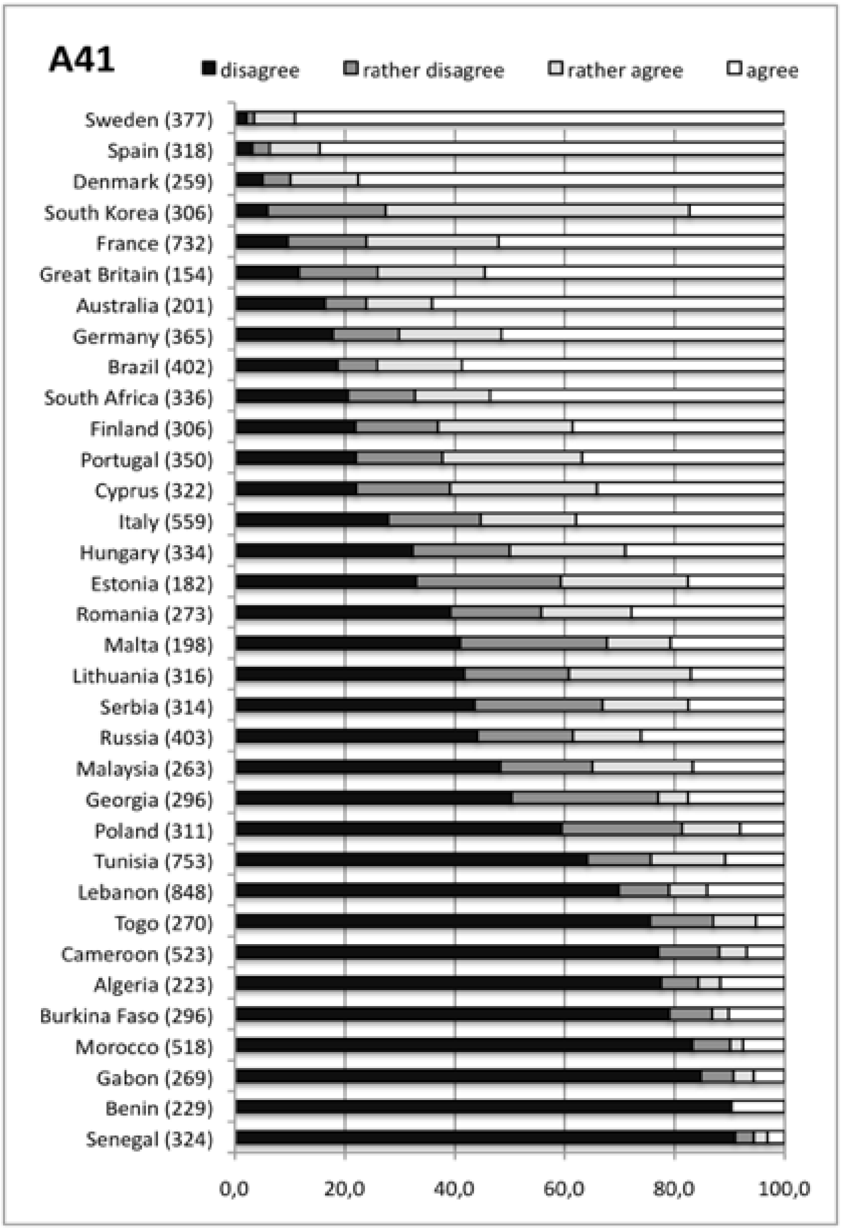

Figure 1 - Teachers' answers (grouped by country) to question A41.

The teachers' answers to question A41 significantly differ depending on several parameters, but some of these effects are consequences of other ones, and disappear when we suppress the other significant effects. Finally, the observed independent effects come from the teachers' nationality (Figure 1), their religion (Figure 2), gender (Figure 3) and level of education (number of years at University: Figure 4).

The country effect is the most spectacular. While in Sweden or in Spain less than 5% of teachers disagree or rather disagree with the same rights for homo- and hetero-sexual couples, they are more than 80% in Senegal, Benin, Gabon and Morocco. Globally, they are more than 60% in 18 countries, mainly countries with a lower level of development, including African countries (except South Africa) and Eastern Europe (Figure 1).

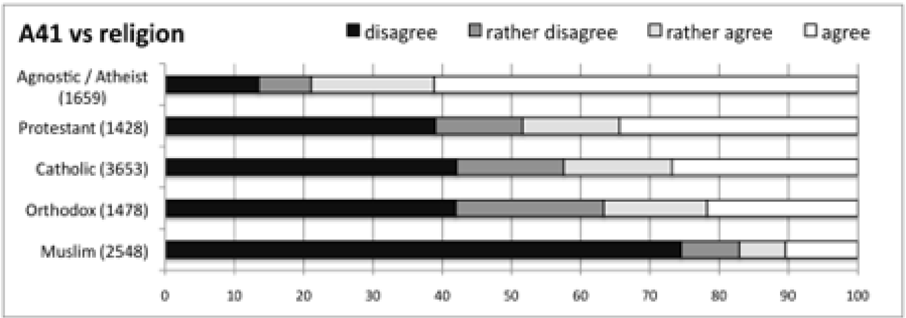

Figure 2 - Teachers' answers (grouped by religion) to question A41.

Are the differences among the countries explained by their specific religions? Only partly because inside each country there are significant differences related to the teachers' religions. Figure 2 shows the main trends: only 22% of Agnostic or Atheist teachers disagree or rather disagree with the same rights for homo- and hetero-sexual couples, while they are between 50% and 60% for the Christian teachers, and 83% for the Muslim teachers.

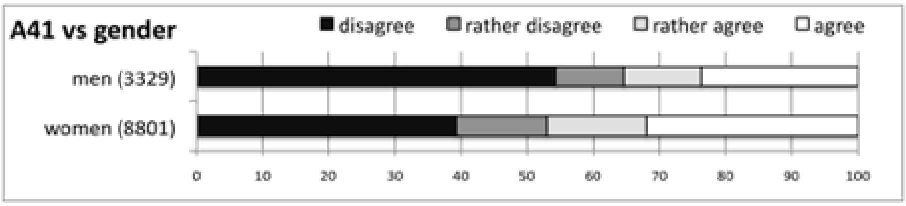

Figure 3 - Teachers' answers (grouped by sex) to question A41.

There is a significant gender effect, even if less spectacular than the two precedent effects: more male teachers (65%) than their female colleagues (53%) disagree or rather disagree with the same rights for homo- and hetero-sexual couples (Figure 3).

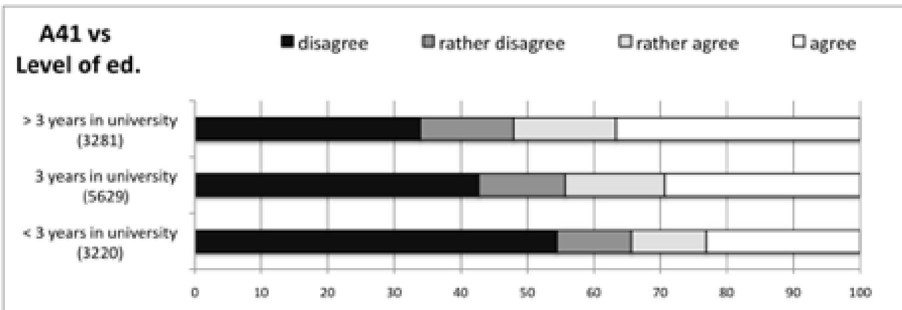

Figure 4 - Teachers' answers (grouped by level of instruction) to question A41.

The teachers' level of education also influences their conceptions: the higher it is, the smaller is the proportion of teachers who disagree or rather disagree with the same rights for homo- and hetero-sexual couples: 54% after more than 3 years at University, 56% after 3 years but 66% after less than 3 years (Figure 4).

At what students' age to introduce the topic homosexuality at school?

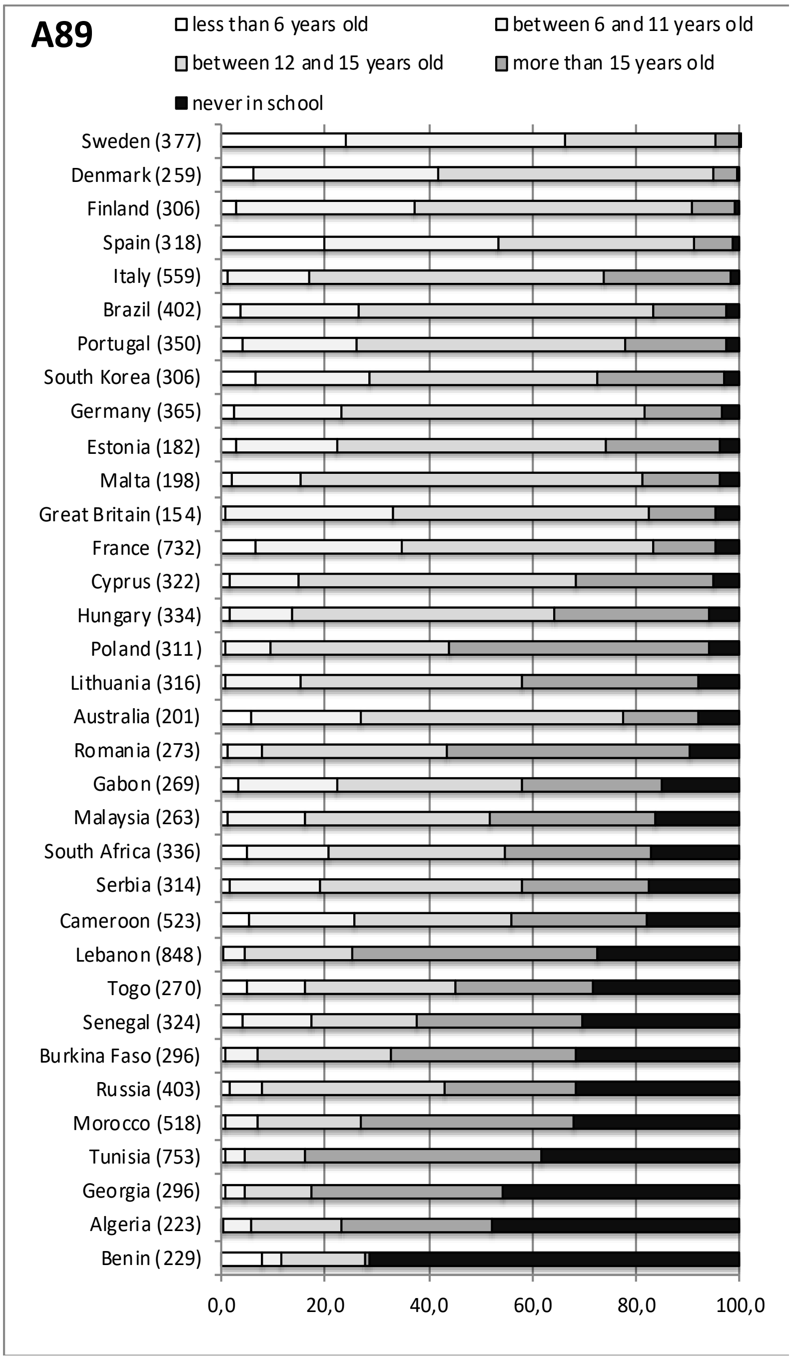

Figure 5 - Teachers' answers (grouped by country) to question A89

The teachers' answers to question A89 show the same trends and differences as those illustrated by Figures 1 to 4: the more a teacher is for the same rights for homosexuals and heterosexuals, the earlier he / she thinks it is necessary to introduce homosexuality at school. There are the same differences among countries: e.g. not a single teacher ticked "never at school" in Sweden or Denmark, but 71% did so in Benin, 48% in Algeria, 46% in Georgia (Figure 5). The teachers' answers also differ according to their sex, religion and level of education.

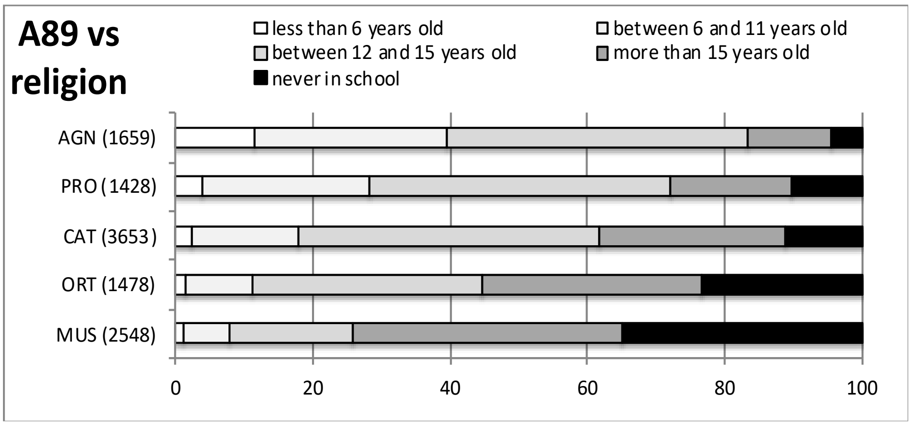

Figure 6 - Teachers' answers (grouped by religion) to question A89.

Figure 6 illustrates the great differences related to the religions: when 83% of Agnostic or Atheist teachers think it is necessary to teach homosexuality to students before they are 15 years old, they are 72% when Protestant, 62% when Catholic, 45% when Orthodox and 26% when Muslim.

Are there genetic factors in parents that predispose their children to become homosexual?

The teachers' answers to question B11 also differ in relation to some of the controlled parameters, but in different ways. For instance, the country effect is here also spectacular (Figure 7): while 82% teachers disagree with a genetic predisposition of homosexuality in France, or 74% in Burkina Faso or in Spain, they are only 9% in South Korea, 34% in Estonia, 36% in Cyprus … Nevertheless, as shown in Figure 7, the ranking of countries is not the same as for the two precedent questions: several African countries disagree with a genetic predisposition, as well as most of the South European countries (France, Spain, Italy, …), while teachers agree more in several other developed countries. This ranking is similar to the results already published for other genetic predeterminisms (Castéra & Clément, 2014; Clément & Castéra, 2014), this innatism is also linked with other topics, such as creationism (Clément et al., 2013).

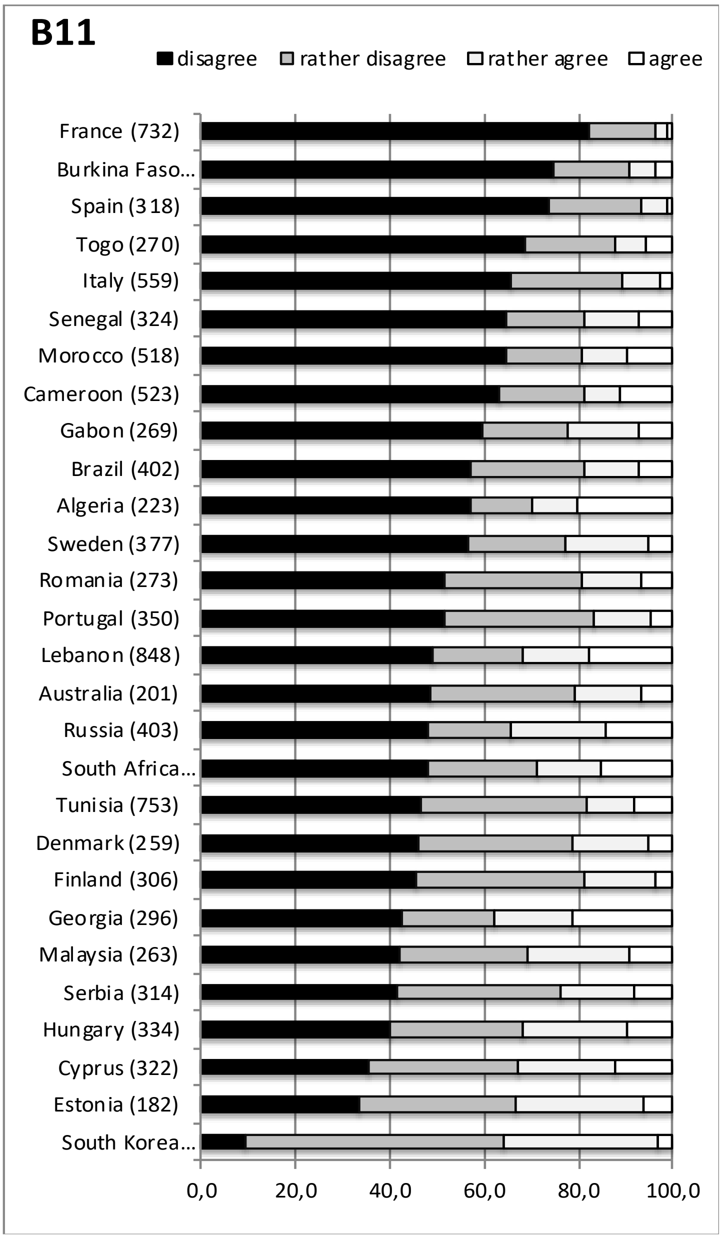

Figure 7 - Teachers' answers (grouped by country) to question B11

Correlation between teachers' homophobia and their religious or political opinions

A Co-Inertia Analysis shows a very significant correlation between a PCA done from the three questions related to homosexuality (A41, A89, B11) and a PCA done from 17 questions related to political, social or religious opinions of the interviewed teachers. The answers to question B11 (genetic predeterminism of homosexuality) have no weight in this correlation.

This Co-Inertia Analysis shows that:

- The more a teacher believes in God, and practises his / her religion, the more he / she is against the same rights for hetero- and homosexual couples, and the more he / she thinks that the topic of homosexuality must be taught only to students aged more than 15 years or even never taught at school.

- Most of these teachers also think that science and religion should not be separated, nor politics and religion. Most of them also think that "The government must make laws favouring the creation of firms to stimulate our economy".

CONCLUSIONS

While, in any country, teachers are part of the most educated population, and have the heavy responsibility to promote, as UNESCO proposes, the fundamental value of equality of all human beings, independently of their sexual preferences, our results show that more than half of the 12,130 teachers interviewed in 34 countries personally think that homosexual couples should not have the same rights as heterosexual couples, and also think that the topic of homosexuality should not be taught at school or only to students aged more than 15 years.
This homophobia is strongly rooted in the sociocultural context of each country, as shown by the spectacular differences we observed from one country to another one, whatever the national dominant religion may be. We have not enough room here to discuss all our results.

If historically homophobia grew inside each of the three main monotheist religions (Borrillo, 2013, 2016), our results show some significant differences among the religions of the teachers. Nevertheless, the main trend is that the teachers' homophobia is more developed when they more believe in God and practise their religion, whatever it is. In each country, the Agnostic or Atheist teachers are those who most accept the same rights for homo and heterosexual couples and also agree to teach homosexuality as soon as possible at school. The proportion of those who most practise their religion varies inside each religion, but is more important in some of them, explaining for instance that the level of homophobia is higher for the Muslim teachers.

We also observed differences inside the same religion, from one country to another, but also inside the same country: these results are not presented in detail here, but are very important to identify the degree of liberty of each believer inside his / her religion. We also showed a gender effect, female teachers being less homophobic than their male colleagues; as well as an effect of the teachers' level of education: the longer they studied at University, the less homophobic they are. This last result suggests that there is hope to promote the value of equality through a longer and better training of teachers, even if it will clearly be difficult as homophobia is a social representation deeply rooted in each sociocultural and religious context.

In collaboration, for the data collection, with the following teams:
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XVIII IOSTE SYMPOSIUM
Future educational challenges from a science and technology perspectives.
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Inquiry based teaching through innovative ICT technology; augmented reality and place-based technology

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Abstract

In our current information-rich society, it is important to adapt approaches to teaching and learning to characteristics of this society. We believe that digital tools adapted to learning goals combined with socio-cultural thinking, are promising approaches with which to meet future challenges. In this article, we bring together three different approaches to these cross-subject challenges. We present literature reviews and empirical data from three different research groups working with augmented reality in lower secondary schools, geographical information technology (GIT) in field courses, and from classroom studies on science teacher students using GIT. The analyses from the three presentations are based on several methods, such as questionnaires, interviews with students and lecturers, students' written reflections, and recorded dialogues between students. Our results suggest that students value technology adapted for learning; that the facilitator role of the teacher is important; and that subject matter knowledge is very important in order to be able to produce relevant content for learning with GIT.

Keywords: Augmented reality (AR); Education; Geographical information technology (GIT/GIS); Inquiry-based activities; Navigationism and connectivism

INTRODUCTION

In our current information-rich society, it is important to adjust approaches to teaching and learning to the characteristics of this society. We believe that digital tools adapted to learning goals, combined with socio-cultural thinking, offer promising approaches for meeting future challenges. However, as highlighted by Higgins et al. (2012) the research evidence so far does not offer a convincing case for the *general* impact of digital technology on learning outcomes. This is not to say that it is not worth investing in the use of technology to improve learning. This meta-study is about learning effects from the use of information and communication technology (ICT). Following Higgins et al. (2012), we highlight that it is not whether technology is used (or not) which makes the difference, but how well the technology is used to support teaching and learning: *"The challenge is to ensure that technology is used to enable, or make more efficient, effective teaching and learning practices*" (Higgins et al, 2012).

Hence, in order to optimize the use of technology in the future, we must take advantage of experiences concerning what works and what does not work, technically and pedagogically. Several authors have discussed the non-appearing success of ICT as a tool for increased learning outcomes e.g., Cuban (1986), Higgins, Xiao and Katsipataki (2012) and Tondeur, van Keer, van Braak and Valcke (2008). Higgins (2016) summarizes the important factors that need to be present in order to succeed in an ICT rich classroom. These factors are connected strongly to pedagogy, teacher skills and the selection of ICT tools, or the “ecology of technology”, as Higgings (2016) describes it.

In this paper, we discuss some challenges and opportunities related to the use of augmented reality (AR), place-based technology (geographical information systems/technology – GIS / GIT), and illustrate these challenges through three case studies.

The first case is examining teaching science in lower secondary school with AR. Here we illustrate some of the challenges in the use of new technology in teaching and learning processes. The title of this section, “Learning before technology” brings us to the research questions for this case, which is to investigate principles for supporting student learning via high-level use of ICT in science based on research literature. Thereafter, we discuss findings from research on the development of AR-resources for lower secondary science. Based on the literature, various aspects of ICT-use for situated learning in science will be presented: the predominantly low-level use of ICT including information seeking and testing; the less-frequent, high-level inquiry-based use, including the use of animations, and the collection and analyses of data; and finally, the use of ICT as a mediating tool and a tool for model-based inquiry. The empirical part of this case, presents results from classroom research, in which lower secondary students developed AR animations themselves (Nielsen, Brandt and Swensen, 2016).

In the second case, we broaden the perspective by investigating the use of various GIT tools in preparation for, and during excursions in several academic disciplines, namely, geography, geology, biology, engineering, human movement science, and teacher education; as well as in upper secondary school. Through a framework based on navigationism (the knowledge and ability to navigate in the digital era), cf. Brown (2006) and virtual field trips, we will present experiences and results from using GIT tools on excursions. The research questions of this case seek to enrich the knowledge of how these GIT tools can support active and playful learning, navigational skills, and question if there are pedagogical and practical benefits of using such tools in learning processes. The ICT tools include storytelling with maps (through the application "StoryMap"), crowdsourcing (using "Survey123") and geo-games (using "Wherigo") (cf. Panek et al., 2017). The results from this case will concentrate on student and lecture feedback.

For the last case, we focus on science teacher education. We look at the challenges of an ICT-rich society, in which students are confronted with huge amounts of formal and informal information, and demands for networking (Siemens, 2005). The research question for this case focuses on the reflections science teacher students have on ICT (as part if *pedagogical content knowledge* - PCK) and geological *subject matter knowledge* (SMK) after constructing a geology website (see Abell, 2007, p. 1107, about the model of SMK and PCK). How do future teachers solve that “how to know” is on the way to being as important as “knowing”? As teacher educators it is important to both provide students with SMK and to have a thorough philosophy concerning adapted learning, preferably, while using teaching methods (as part of PCK) that are exemplary for the practice as science teachers. The same or similar ICT tools as those used in the second case were used in two science teacher classes. After introducing the tools, the use of these applications was taken a step further by giving the students the task of designing their own applications with built-in maps.

In the final discussion, we will to shed light on some specific learning affordances and, for two of the cases also the importance of SMK in geography, and in science teacher education.

THEORETICAL BACKGROUND

International comparative research has shown that students are still predominately using ICT for low-level tasks, such as seeking information on the internet, net-based tests and so forth (ITL Research 2011; ICILS, 2014). Based on this there is a call for more innovative approaches supporting students' high-level use of ICT. Such uses could include inquiry-based work in meaningful contexts that involve the use of ICT for data collection and analysis and producing various kinds of representations (Hennessy et al., 2007; Krajcik and Mun, 2014).

AR is defined by the combination of real and virtual objects in a real environment. In educational settings, AR can be used to represent content in multiple ways facilitating students' abilities to experience phenomena that are otherwise invisible (Radu, 2014). Referring to the affordances mentioned above, in science education, it is of particular interest to examine how students can be active producers with AR tools.

To take advantage of available information, new technology and to become familiar with high-level use of ICT, students need to acquire knowledge and skills to navigate in this advanced digital landscape. In addition, they need approaches to the combination of student-active and social-constructivistic teaching and learning. Theoretical frames which can be used for the acquisition of this skill set include navigationism and connectivism.

Navigationism is a term used to describe the knowledge and ability to navigate in the digital era, in which the amount of information is enormous (Brown, 2006). The background is what Brown (2006) describe as a possible paradigm-shift in academia, shifting focus from content to manipulation, integration and configuration of knowledge. To be competent knowledge navigators, students need navigational training and skills. GIT offer possibilities for this, for instance, through virtual field trips and location-based gaming. Virtual field trips are advantageous due to issues of costs, disabilities, ability to visit dangerous or remote areas, and the possibility of multiple visits (Stainfield et al., 2000). Since adequate preparations prior to field trips are vital for learning outcomes, our use of virtual field trips are as preparation for actual field trips (Remmen and Frøyland, 2014). Panek and co-workers (2017), who used Wherigo as a tool for interdisciplinary, location-based gaming on field trips, inspire our use of Whereigo. Wherigo can help with physical and content-based navigation in the field. Panek and co-workers (2017) showed that playful learning with the Wherigo-application can be a "common ground" for meeting across personal boundaries.

The other frame, connectivism, is, according to Siemens (2005), a learning theory where social-constructivistic approaches meet today's information- and communication-technology-rich society. Connectivism may aid in the development of teaching and learning. Connectivism is described by Dunaway (2011, p 682) as "a learning theory that provides a useful framework for understanding how students learn *information literacy*". Individuals taking part in such a learning process can be described as nodes in a learning network. Today, this landscape of nodes is accessible for all through the internet, and knowledge is a result of extracting information and self-organized participation. The view that: "We are moving from formal, rigid learning into an environment of informal, connection-based, network-creating learning", (Siemens, 2005) and that future learning processes will be «coming to know, rather than of knowing» (Siemens, 2005) has become fundamental. Students participating in such an approach are active and seen as resources rather than passive listeners, and knowledge on extracting information, critical judgment and ability to make connections in the network of information is more important than remembering facts (Siemens, 2005). Inquiry-based teaching and teachers scaffolding students in their meaning-making related to science SMK is also important.

As a critique of connectivism, Clara and Barberat (2014) point to three major challenges. The theory does not explain how knowledge is created, only the possibility of its distribution (in networks), which they denote as "the learning paradox". They claim that the theory is insufficient as a learning theory because it does not point to the source of the learned content or the knowledge creation in the learner. Last, but not least Clara and Barberat (2014) find the theory to have little potential for further development. With this in mind we use the theory as a frame for constructive alignment (cf. Biggs, 1996), rather than a learning theory.

CASE 1: "LEARNING BEFORE TECHNOLOGY": WHAT IS NEEDED, PEDAGOGICALLY, FOR STUDENTS TO BENEFIT FROM NEW TECHNOLOGY? AUGMENTED REALITY AS AN EXAMPLE

Possibilities for stimulating high quality, innovative ways of teaching and learning with ICT are discussed widely in contemporary educational research. In science education ICT can, for example, be applied to mediate student learning in terms of problem-solving and inquiry-based approaches and support them in modelling, animating and communicating about science phenomena (Krajcik and Mun, 2014). This section starts by condensing pedagogical principles for supporting student learning in science with ICT based on the research literature about ICT in science education. This is followed by a discussion of the data from the ARsci project (2014-17) involving lower secondary science teachers and students from Denmark, Norway and Spain (Nielsen et al., 2016). Multiple types of data were collected: student questionnaires, interviews with students and teachers, classroom observations and video, both full-class and video/audio following the dialogues in groups of students.

Use of augmented reality in upper secondary school science lessons

Contemporary science education research refers frequently to a socio-cultural understanding of learning as *situated, mediated* and *distributed*. So, these overarching learning principles can be highlighted based on the research literature and used to frame the empirical research in the present paper.

The principle of situated learning of science with ICT can, for example be applied in an educational setting by supporting students in using digital tools and artefacts in inquiry-based projects done in real-life contexts. Such inquiries can obviously be mediated by using ICT-tools, such as data-logging equipment, but the understanding of mediating tools must be informed by the research literature and expanded to also include student-teacher and student-student exploratory dialogues and co-construction of meaning mediated by the digital artefacts (Mercer, Hennessy and Warwick, 2017). Referring to the principle of distributed learning there is, based on the research literature, furthermore, also reasons to think about

ICT-supported inquiry-based activities as *model-based inquiry* in which students are engaged with the content by collaboratively generating, testing and revising explanatory models (Windschitl et al., 2008).

These learning principles have inspired the focus of the research in the ARsci project on teacher scaffolding and students' representational/modelling competences (Waldrip and Prain, 2012). Based on for example analysing classroom dialogues during the piloting of AR resources, the possibilities for supporting students' meaning-making related to the science content appear to be dependent on the teachers' thorough use of micro-scaffolding with questions and prompts. In particular, the examples from the piloting events in which students themselves produced AR animations and representations in particular revealed affordances for their creative and collaborative use of the digital resources, stimulating, for example, dialogue about ICT from their everyday life as produced by someone (Nielsen et al., 2016).

CASE 2: HOW TO FACILITATE INQUIRY-BASED LEARNING BY PLACE-BASED TECHNOLOGY

In this section, we examine the educational advantages/disadvantages, and practical possibilities of using storytelling with maps (StoryMaps) as field-course pre-work, and crowdsourcing (using Survey 123) and geo-games (Wherigo) (see Table 1) during field-courses in eight different disciplines. The examination is based on interviews with students and lecturers, observations, reflection notes as well as questionnaires for students after having used GIT.

Table 1. Description of tools and their technical platform

Tool	Description of tools	Technical platform
Storymap	Storytelling with maps (optionally interactive), maps/figures/animation/videos/pictures/integrated tasks/text.	Web-based
Survey 123	Surveys/Crowdsourcing. Optionally: Geoposition/picture, text/multiple choice/date/text e.g.	Surveys are built in the web-browser. Geo-tagged pictures are conducted on phone/tablet.
Wherigo	Gives sound with text/info/picture when entering/leaving pre-programed polygons.	Mobile or tablet-based. Content/tasks added in web-browser

We first examined how to use storytelling with maps, crowdsourcing and geo-games to support active and playful learning and navigational skills in university field course disciplines; and, secondly, if there are educational and practical benefits of such tools in learning processes.

During 2016-17, approximately 400 students from eight different disciplines (physical and social geography, biology, introductory engineering, human movement science, science teacher education and upper secondary school) used GIT in relation to field courses. Initially, we facilitated the students and their lecturers through the practical part of the GIT-programs before and during field courses; afterwards, we conducted semi-structured interviews with some students (n=9) and all the lecturers (n=10), studied reflection notes (n=100), and conducted surveys (n=133). Here we report some of our findings from the material. Quantitative data were analysed in SPSS and Excel, qualitative data by analogous grounded text-analysis in Microsoft Word.

Virtual field trips as preparation for real field trips: feedback

Lecturers found it difficult to know where to start when implementing new digital tools. Some may be reluctant to replace lecturing with new approaches to teaching such as, for instance, GIT-based learning activities. However, in some cases, the replacement of lectures can be a way to gain resources that may be used to develop content within GIT tools. One of the lecturers said *"[...] I think this actually will save me time".*

After our examination of students and teachers across disciplines, we found consistently positive feedbacks on the possibility for adapted learning and self-explorative learning through the use of the GIT-programs. Use of these programs provided navigational training in different media containing professional content. *"[...] in a way a book can´t give"* (student in interview, on the use of Storymap). The lecturers found GIT programs beneficial as tools for concretizing content, and making students more active during learning, providing new educational opportunities. For example, "[…] *may not control what they learn, but at least where they walk"* (lecturer in interview on the use of Wherigo).

In movement science, more than 80% of students (n=75) answered "Agree" or "Very much agree" on questions concerning whether they learned more and were more engaged in the learning situation when using (Wherigo) compared to a possible paper-based instruction.

CASE 3: PLACE-BASED TECHNOLOGY IN AN ADAPTED LEARNING ENVIRONMENT. EXPERIENCES FROM INQUIRY BASED TEACHING OF SCIENCE TEACHER STUDENTS

The undertaking of science teacher educators in Norwegian teacher education for primary and lower secondary school is dichotomous; to teach science SMK and PCK; cf. Abell's (2007, p. 1107) model of science teachers' various knowledge.

In today's society, with its ever-increasing information, the use of information and communication-based technology (ICT) to handle the situation, it is important to find teaching methods that match this reality, and enables the teacher students to someday teach their students adequately for this reality.

In this section, we examine science teacher students' reflections on ICT (PCK) and geological SMK, after constructing a geology website. The website was constructed as a post-lesson task based on knowledge acquired through geology lessons, a short excursion and a teacher-constructed website with geological information prepared with "StoryMap".

We singled out statements connected to the user interface, the potential for using similar tools as teachers in primary/lower secondary and related to obtaining SMK. In addition, we were interested in comments on the potential of using such tools as a means to work within the networks described in connectivism.

Reflections were collected from 24 science teacher students after approximately 10 hours of instruction in geology. Group A consisted of 7 pairs of 4th year preservice science teacher students which produced paired reflection notes, while Group B consisted of 10 in-service teacher students who produced individual reflection notes. The tool used in group A was "ESRI StoryMap" (a website tool developed for place-based information). In group B, one group used StoryMap and four groups used the somewhat older tool "Wikispaces" combined with Google Maps. The reflection notes were analysed and categorized into: geological (SMK), didactical (PCK) and ICT tool-based reflections.

Teacher students' reflections after geology lessons with ICT
Here, we present examples of statements connected to SMK and ICT only, leaving statements on PCK for later analyses. However, where statements on PCK integrate ICT, we have included them in our analysis for the present presentation. The reflections from the in-service teachers go deeper than the preservice students' notes, partly due to the different requirements in their tasks.

The majority of SMK-statements also included thoughts on PCK (time consumption, guided vs. "free" tours, lectures vs. group work and so on). In addition, statements on ICT often included reflections upon other aspects, such as classroom organization or which age group of students the tasks would best suit.

Table 2. Statements (examples) from the two groups sorted into the categories ICT-reflections and reflections upon geological SMK. (Translated from Norwegian).

Group	ICT reflections	SMK reflections
A	…pretty advanced programs…... could have done the same with pen and paper, and Powerpoint.	Smart if the students get more introduction to how you classify different rocks/stones
	Some technical problems during the work	Requires more time and prior knowledge on stones
	This way of working contributes to effective digital learning	There are a lot of abstract concepts
B	You should find simpler tools….. especially for the work with the youngest students	….Would have preferred a guided tour
	User friendliness and simple navigation is important	….we were going to test on our own…. very inefficient because we had too little knowledge
	Motivating for students to work with digital tools……suits students in lower secondary school well	acquired a lot more knowledge…., ..…the learning outcome was good.
	Most important argument for the use of StoryMap as a digital tool is the possibility for cooperation	Want more traditional lectures

FINAL DISCUSSION AND CONCLUSIONS

The overarching challenge in relation to using ICT to enable and support students' teaching and learning highlighted by Higgins et al. (2012) is, in various ways, illustrated in the three cases. Higgins' meta-study recommends having a clear rationale and defined goals for using

ICT and to identify the role of the ICT (learning affordances). Furthermore, technology should support collaboration and effective interaction for learning, and teachers and/or learners should be supported in developing their use of ICT to ensure learning (Higgins et al., 2012). Some of the specific learning affordances across the three cases are: cognitive processes (e.g. through representational mediation, repetitive options and so forth); access to experiences, phenomena and data; peer interaction and networking; and students' autonomy. In addition, cases 2 and 3 draw attention to the importance of SMK.

The main conclusion in case 1, "Learning before technology", is captured in the case title and is very much in line with Higgins. The results from the ARsci project highlight the importance of meditation in the teacher's thorough scaffolding of the students' meaning-making from inquiry with ICT, including model-based inquiry.

In case 2, we found that planning and the pedagogical framework for choosing GIT tools and content, together with time resources and skills among lecturers, were the most important factors for a successful adaptation of GIT for educational purposes. The lecturers participating in this case were divided in their view on the overall benefits of such GIT tools in the learning processes. However, most student interviews and reflection notes provided positive feedback, even though the quantitative data were not entirely consistent. More research is needed to conclude on this point, but the content type, pedagogical framework and research methodology may influence the answer. Overall, the students were generally positive, but they expected high technical quality and adequate SMK.

Only a few of the reflections from the teacher students in case 3 regarding the task of making a website, mentioned a culture of sharing as beneficial for their learning process. In contrast, several students called out for traditional lectures and guided tours. Whether it was due to limitations in the ICT-tools or the lack of students' willingness to engage in these newer learning methods, it seems that the learning situations in this case did not facilitate the kind of setting described in connectivism theory (Siemens, 2005). In our data there was a tendency towards in-service teachers being less satisfied with inquiry-based teaching methods used as well as the sociocultural teaching approach involving activities, group work, sharing experiences and so forth. Some students also reported that technical challenges with the ICT tools were limiting the efficiency of their learning processes. Overall, they were challenged on their own shortcomings regarding geological SMK, consequently accentuating the need for attaining more geological SMK in order to use the GIT tools more effectively. In relation to student autonomy, this might best be seen as a subtle balance.

Navigationism (case 2) highlights the personal empowerment in an ICT-embedded world and, based on case 1, the importance of students being producers with AR tools is a key message. So, open learning spaces and task degrees of freedom are issues that can be highlighted, but the studies also illustrate the importance of streamlining the ICT infrastructure to be able to focus on PCK. In some situations, features of the ICT systems, e.g., applications' quirks, licensing schemes and hardware confinements, were found to be limiting and made the use of new approaches to teaching challenging. In case 2, involving teacher education, some students referred to the software as pretty advanced and questioned whether the same results could have been achieved with paper and pencil. This accentuates the importance of user-friendliness and ease-of-use of the ICT applications.

To sum up, lecturers' and teacher students' ICT-related self-efficacy and attitudinal barriers to using ICT, seem to be an issue across cases 2 and 3. Case 1 also highlights the teacher role and teacher scaffolding as an influential factor; here, however, as something that added positively to student outcomes.

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XVIII IOSTE SYMPOSIUM

Future educational challenges from a science and technology perspectives.

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Fulfilling diverse learner needs: Preparing learners for high school science success through differentiated instructions

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Abstract

This paper examines the impacts of differentiated instruction on learner perception, engagement, learning retention and outcomes and perceived challenges in its implementation. Using a pragmatic mixed-methods design, an experimental study was conducted in one public high school in Mthatha, South Africa, with one grade 11 physical science class. A total of one physical science teacher and 42 physical sciences learners in their intact classroom constituted the sample for the study. The intervention involved learners in physical science classroom instructed under Type 1 teaching styles: where the differentiated instructions were implemented for three weeks for the teaching of sub-topics under electricity and magnetism. The intervention was followed by a control in the same class where physical science learners were instructed under Type 2 teaching styles: where the traditional teacher-centred strategies were implemented for another three weeks for the teaching of sub-topics under electricity and magnetism. A pre-test and post-test questionnaire, followed by semi-structured focus group interviews and bi-weekly class observation schedules were used to gather data for the study. A series of statistical analyses were conducted to reveal the impact of differentiated instruction on learner engagement, perception, and retention and learning outcome. Qualitative data was analysed using inductive data analysis. The findings indicated that learners developed positive learning experiences, engaged in their school work and retained the information they learned. The study has implications for curriculum development, teacher professional development and research directions. Conclusions drawn from this study may be used to help improve teacher instructional practices and ultimately learner achievement in physical sciences.

***Keywords**:* differentiated instructions; learner achievement; learning styles; physical sciences

INTRODUCTION

The current state of public education in South Africa has created a system in which high school learners' achievements and teachers' performances are scrutinized intensely. Both private and public schools are accountable for the performance of learners in yearly *matric* end of year examination. Schools are then evaluated based on their performance in the NCS matric examination. As a result of the increased accountability placed on schools and the continuous pressure to meet national and provincial standards, teachers are constantly challenged with the difficult task of meeting the needs of all learners and preparing them to succeed at the end of year examinations. However, learners come to the science classroom with their diverse individual cultural backgrounds, learning styles preferences, interest, and with different intellects. This diversity among learners in the science classroom could result in a considerable challenge for teachers in reaching out to all learners.

Nonetheless, during classroom interactions, some learners may find the topic to be too easy and the lesson interesting, while other learners may find the topic to be too difficult to comprehend. However, knowing learners allow teachers to respond to learners' readiness, interest, and learning profile (Martin, 2013). Responding to learners' readiness involves the learner's current understanding of a topic. When learners' readiness levels differ, the teachers' instructional strategies must be differentiated to meet the needs of each learner. What the learner loves to do and what motivates the learner refers to learner interest. Interest differentiation, involves taking the curriculum or content and delivering instruction based on what interest the learner (Heacox, 2012). Therefore, it is utmost important that learners are provided with different instructional strategies to cater for their individual differences. As Burke and Garger (1985) argued, effective educational decisions and practices must derive from an understanding of the ways that individuals learn, and therefore, as suggested by Landrum and McDuffie (2010) the use of differentiated instructional strategies are necessary to reach individual learners.

For that reason, differentiated instruction is considered an effective method for providing instructions for all learners and hence as argued by Tomlinson (2000a) "promotes equity and excellence by focusing on best-practice instruction in mixed ability classrooms," (p. 25). Drawing on the work of Broderick, Mehta-Parekh, and Reid (2005) who specified that, by using differentiated instruction, teachers expect learners "to bring a variety of experiences, abilities, interests, and styles to their learning; they acknowledge that these affect learners' performance in the classroom; and they address this natural diversity when planning and delivering rigorous and relevant, yet flexible and responsive instruction," (p. 196). Thus, for learners to be engaged and motivated in the classroom simultaneously, teachers must understand and acknowledge their differences when teaching.

Although much research has been conducted on differentiated instructions, much less research seems to have been conducted on the use of differentiated instructions in high school science classrooms. Smit and Humpert (2012) agreed on this view by stating that, differentiated instruction "has not been deeply researched" (p. 1152), especially in high school science classrooms (Maeng, 2011, Callahan, Moon, & Oh, 2017). In addition, previous qualitative studies determining the effectiveness of differentiated instruction have reviewed conflicting results. Some studies have revealed the effectiveness of differentiated instruction over traditional teacher-centred instruction (Aliakbari & Haghigi, 2014; Dosch & Zidon, 2014). However, some studies showed no significant difference with the traditional teacher-centred instruction (Maxey, 2013; Vincent, 2012). Indeed, after a review of the literature, this perception seems to hold some validity, yet a few studies suggest positive learning outcomes resulting from differentiated instructional practices. The gap in the literature has therefore motivated the researcher to conduct this study.

Against this background, this study aimed at implementing differentiated instruction in a science classroom to determine its impacts on learners' academic outcomes. This study further investigated learners' experiences with differentiated instruction. Hence, this study was set to specifically address the following research questions:

(1) What impacts does the differentiated instruction have on learners' academic outcomes, interest and retention?
(2) What are the learners' experiences with differentiated instructions?

THEORETICAL BACKGROUND AND THE REVIEW OF THE LITERATURE

Differentiated instruction is rooted in a number of learning theories including; the Theory of Multiple Intelligence (Gardner, 1999), Vygotsky's sociocultural theory (1978) and the learning style theories (Felder-Silverman, 1988). Gardner's theory of Multiple Intelligence (1999) asserts that people have one or more of nine core intelligence preferences, including: spatial, linguistic, logical-mathematical, bodily-kinesthetic, musical, interpersonal, intrapersonal, naturalistic, and existential. Gardner's work shows that individuals differ in the specific profile of intelligences they display, which may result from what is valued in their culture. This paper highlights the importance of considering a broad range of intelligences so that the talents and abilities of all learners are emphasized and valued. Thus, differentiated instruction provides learners with flexible options for receiving and processing information and ideas depending on those learners' "intelligences".

Vygotsky's sociocultural theory of human learning describes learning as a social process and the origination of human cognition in society or culture. The major theme of Vygotsky's theoretical framework is that social interaction plays a fundamental role in the development of cognition. Vygotsky believed everything is learned on two levels. First, through interaction with others, and then integrated into the individual's mental structure. Vygotsky, (1978) argued:

> Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher functions originate as actual relationships between individuals. (p.57)

A second aspect of Vygotsky's theory is the idea that the potential for cognitive development is limited to a "zone of proximal development" (ZPD). This "zone" is the area of exploration for which the student is cognitively prepared, but requires help and social interaction to fully develop (Vygotsky, 1978). A teacher or more experienced peer is able to provide the learner with "scaffolding" to support the learner's evolving understanding of knowledge domains or development of complex skills. If a learner is not in that zone yet, the instruction needs to be adjusted to a level that the learner is cognitively ready to take. Tomlinson (2001) was of the view that strategies that can help facilitate the intentional learning of a learner include collaborative learning, discourse, modeling, and scaffolding.

Nevertheless, learning style theory is another theoretical basis of differentiated learning. Felder-Silverman (1988) defines learning style as the characteristic's strengths and preferences in the way people receive and process information. Several well-designed recent studies (e.g. Akinbobola, 2015a) have shown that, learners have different learning styles, and the responsibility of the teacher is to identify these learning style differences and find appropriate instructional strategies that will match the preferred styles to enhance effective teaching and learning. However, Willingham (2009) argued that in order to maximize learning for everyone, the lessons should be adjusted to accommodate these differences because learners with different styles might benefit from different ways of presenting the material.

Research studies (e.g. Pablico, Diack, & Lawson, 2017) shows that when learners are taught through their individual learning styles their attitudes towards subjects change for the better, they concentrate more readily, and they process information with greater ease, with the result that their overall performance improves significantly. The challenge is therefore for teachers to match their teaching styles with the learners' styles in their diverse classroom. Teachers should therefore be reflective and flexible and incorporate a variety of teaching styles in their lesson programmes in order to respond to the diversity of learning styles among the learners in their classrooms.

According to Hume (2008) differentiated instruction is a cyclic process of finding out about the learner and responding by differentiating instruction. As teachers learn more about their learners, they respond to them by differentiating instruction with augmented precision and efficiency. Emphasized in Danielson's (2011) domain one, teachers need to devise a plan that highlights what students need to know, understand, and do. As part of this plan, teachers must include the instructional strategies that will be employed to meet learners learning goals.

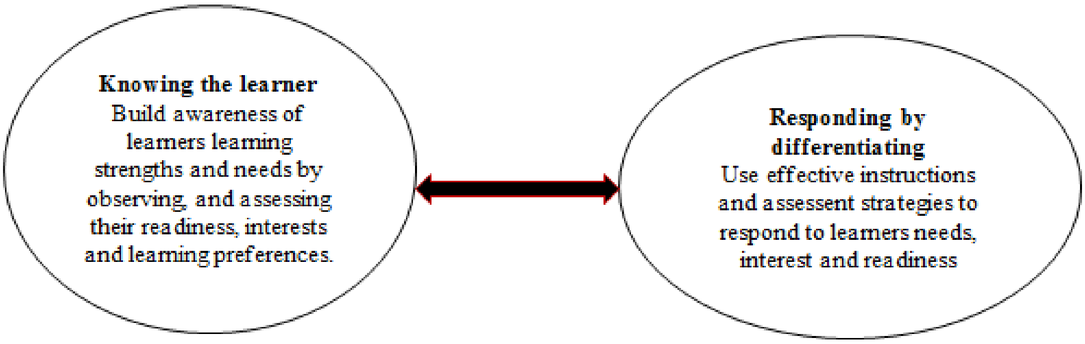

Figure 1: Adapted and modified from: (www.edugains.ca/Educator sPackages 2016, educator guide)

METHODOLOGY

Research methods

The study employed mixed methods sequential explanatory design in which both qualitative and quantitative data were collected, separately analysed, and results are compared to see if they confirm or disconfirm each other (Creswell, 2014). As the purpose of a qualitative research method is to investigate a specific phenomenon and then provide comprehensive descriptions (Mentens, 2015), this study intended to discover participants teacher's and learners' views on their experiences with differentiated instruction in their own words referring to their own classrooms. The quantitative part focused on the effect of differentiated instruction on learner learning. The purpose of the quantitative study was to determine if the implementation of differentiated instruction had an effect on learner achievement as measured by physics achievement test scores.

Sample

This study purposefully employed one science teacher and 42 science learners in their intact classroom. Consent was obtained from the school's principal. This school was selected on the basis of their convenient location and accessibility to the researcher. This school also represented a typical South African public high school which has basic infrastructure, but overcrowded with large class sizes. Precautions were taken to protect the anonymity of the research participants.

For three weeks, learners were taught unit 1 under electricity and magnetism using differentiated instructions. A pretest was given before the treatment and just after the treatment, a post test was given. For the following three weeks, learners in the same classroom were again taught unit 2 of electricity and magnetism using traditional teaching method. A pretest was given before the treatment and a post test was again given after the treatment. The PSAT questions, interviews and bi-weekly classroom observation schedules were the main instruments used to collect data. I selected these instruments to "add rigor, breadth, complexity, richness, and depth" to this study as argued by Denzin and Lincoln (2000, p. 5).

The short intervention
The intervention introduced the sampled teacher to a range of concepts and approaches orientating him towards the use of different instructional strategies and the feasibility of differentiating instructions to cater for different learning style profiles and different needs of learners in the science classroom. At the onset of the workshop, the participant was handed a resource pack made up of instructional programmes and lesson plan templates to serve as resources and reference materials for the participant in his subsequent practices. The participant in this study was put through a two-day workshop, which was co-facilitated by the author and a colleague high school teacher.

Data analysis
Various statistical methods were employed to analyse the quantitative data. Responses to interview transcripts were analysed through inductive data analysis (McMillan & Schumacher, 2014). Key words or phrases were identified, labelled and clustered as codes to form categories and themes, which were compared and triangulated with evidence from the observation schedule. Audio-recordings from the classroom observations were transcribed verbatim. The section that follows triangulates results from the PSAT questions, interviews and the class observations.

FINDINGS AND DISCUSSIONS
Microsoft Excel spreadsheet was used to calculate the independence t-test for the pre-test and post-test of the two groups. Below is a table representing the results of the calculations of the pre-test scores for both the experimental group and the control group.

	Control Group..	Experimental Group
Mean	21.07143	21.14286
Variance	14.11672	22.41812
Observation	42	42
Hypothesized mean difference	0.071	
df	77.974	
t Stat	0.077	
P (T<=t) two-tail	0.9391	
t Critical two-tail	0.177	

Table 1: t-Test: Two Sample Assuming Unequal variances for Pre-Test

From Table 1, t = 0.071, df = 77.974, p = 0.9391. The t-critical two tail is 0.177 at p> 0.05.

The interpretation of this is that, since the t-critical is greater than the t-statistics at p>0.05, there is no statistically significant difference in the achievement of the two groups in the pre-test. This means that, the two groups were at the same level on the topic electricity and magnetism. Testing the null hypothesis and answering the first research question, the post test scores for the two groups were analysed. The Table 2 below presents results of the post-test scores.

	Control Group	Experimental Group
Mean	40.04762	66.92857
Variance	48.29036	91.04355
Observation	42	42
Hypothesized mean difference	26.881	
df	74.944	
t Stat	4.758	
P (T<=t) two-tail	0.0006	
t Critical two-tail	3.758	

Table 2: t-Test: Two-Sample Assuming Unequal Variances for Post-Test

From Table 2 above, t-stat = 4.758, df = 74.944.p> 0.05 and t-critical two tail = 3.758. The interpretation of this result is that since the t-critical two tail is less than t-statistics, there is therefore a statistically significant difference between the post-test scores of the experimental group and the control group. The null hypothesis which states that: implementing differentiated instructional strategy has no significant effect on the performance of learners in physics achievement test is rejected. Even though a statistically difference was established using the t-test, the following table was used to further confirm the difference.

	Control Group	Experimental Group
Mean	40.04762	66.92857
Variance	48.29036	91.04355
Observation	42	42
Hypothesized mean difference	26.881	
df	74.944	
t Stat	4.758	
P (T<=t) two-tail	0.0006	
t Critical two-tail	3.758	

Table 3: Description of groups' performances in pre-test and post-test

From Table 3, the analysis shows that although a statistically difference was established using the t-test, Table 3 further confirms the difference. Even though the means of the two groups were almost the same for the statistics in the pre-test, the statistics in post-test shows that the experimental groups mean improved significantly. The intervention helped the learners in the experimental group to improve their marks. This finding is in agreement with Dosch and Zidon (2014) study which found that the group which participated in differentiated instruction significantly outperformed the nondifferentiated group in the combined assignments and the exams.

Teachers and learners' experiences with differentiated instruction

The findings from the qualitative data (interview and classroom observation) are presented under the following themes:

Learners experiences with differentiated instruction

Responses from the interview showed that learners enjoyed the lessons in which differentiated instructions were implemented. The learners were more engaged, showed a positive attitude towards the subject and were able to retain more information than when they were exposed to traditional teaching methods. This finding is consistent with the finding of White (2015) in his study who indicated that students enjoyed the lessons when they were taught through differentiated instructions and were more engaged in the lesson than never before. Furthermore, this finding resonates with what was observed in the classroom. The bi-weekly classroom observation revealed that, learners were more engaged in the teaching learning process when differentiated instruction was implemented. This finding implies that when learners are involved actively in the lesson, their level of interest in the subject increases.

Teacher's experiences with differentiated instruction

When the teacher was interviewed about his experiences with differentiated instructions, he narrated:

> "*I think I was able to meet the needs of my diverse learners when I implemented the differentiated instructions.*
> *"Differentiating instructions for my learners during the intervention provided them with more ownership, and increased commitment to their work".*

This finding is in agreement with Pablico, Diack and Lawson (2017) study which indicates that implementing differentiated instruction improves learner's engagement and academic achievement. The teacher summed up as he narrated:

> *"The intervention allowed me to increase my learner's involvement in the lesson, created lessons that challenged the high achievers in my class as well as the slow learners who had difficulty learning, as I group learners in a variety of ways."*

Thus, it created a more co-operative classroom environment which freed them up to work with other learners and groups of learners in ways they had not been able to do. This finding also resonates with the study by Konstantinou-Katzi, Tsolaki, Meletiou-Mavrotheris, and Koutselini (2013) who found differentiated instruction effective in improving learners' performance as well as in enhancing learner motivation and engagement, and learners becoming more interactive and lively in the classroom environment.

CONCLUSIONS

Evidence from both qualitative and quantitative data shows that the science learners performed better when they were exposed to differentiated instructions. Although, implementing differentiated instruction is quite challenging, nonetheless, the success of learners when differentiated instruction is implemented is worth the cost. This study therefore makes a number of contributions to help teachers become familiar with the strategy and better understand teaching strategies and guidelines to support differentiated instructions in their science classrooms.

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“I told my mother to mulch the plants!” Exploring intergenerational influence in generating pro-environmental actions, through the development of a 'joint-action space' in an urban farm

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Abstract

Environmental education (EE) aims to nurture informed and active citizens who are engaged in sustainable socio-ecological practices. However, research suggests that approaches focusing on providing information about the environment, especially when used within formal school contexts, only lead to elevated environmental concerns, and not sustained action. Studies point out that an exclusive focus on children undertaking environmental actions leaves out a range of environmental issues where attention and support of adults is needed. Most adult-oriented EE is information-based, which does not readily support pro-environmental actions (PEA). Recent EE approaches in schools emphasize action-competence instead of knowledge, where students feel empowered to act in their local communities. Extending this approach, the potential of intergenerational-influence, where students catalyze parents' PEAs (rather than the usual transmission of values from adults) is a promising, but under-researched, direction to address environmental issues. In this school-based study, we explored the development of action-competence, particularly the processes that lead up to such competence, by facilitating an urban farming project (40 students, 12-13 years old, tracked for 10 month). We studied students' interaction with environmental entities closely, taking an analysis approach inspired by: 1) recent work highlighting the affective-aesthetic appeal of environmental entities, and 2) embodied cognition models. Based on this data and analysis, we show how meaningful and embodied encounters with nature, based on participation, contribute to the enhancement of students' environmental 'action-space'. More interestingly, sharing of these 'action-spaces' with adults, through various social experiences, motivated adults to participate in PEAs. We propose that sustained PEAs in adults can emerge from the development of a 'joint-action-space', where dynamic and participative interactions between students and elders lead to students' motivations transferring to adults.

Keywords: farming; intergenerational-influence; joint-action space; embodied cognition

INTRODUCTION

Studies show that environment education (EE) based on providing information about environmental issues have been unsuccessful in seeding collective and impactful pro-environmental actions (De Young, 1996; Hungerford & Volk, 1990; Steg & Vlek, 2009). Acknowledging the role of affect, context and socio-cultural factors in motivating actions, researchers have now shifted the emphasis from providing knowledge to interventions based on practices encouraging pro-environmental 'action-competence' (Barrett, 2006; Jensen, 2002; Jensen & Schnack, 1997).

Direct and embodied experience of the environment has been argued to be an important process in developing action competencies (Bonnett, 2004; Bai, 2013). The primacy of experience in developing pro-environmental sensibilities is well supported by recent theories in cognition, which suggest that sensorimotor interaction is central to shaping one's behaviour and thought processes (Glenberg, 2010; Glenberg, Witt, & Metcalfe, 2013; Hutchins, 1995). Furthermore, the role of the community in supporting action competence is supported by studies showing that perceiving events enacted by others activate the same structures that direct one's own actions (Knoblich & Flach, 2001; Sebanz, Knoblich, & Prinz, 2003). This mechanism allows others' actions to become part of one's action repertoire. Feelings of empathy are also argued to arise from a similar capacity, where perceivers automatically resonate others' actions and intentions (Decety & Ickes, 2011). These processes together support the formation of complex co-operative actions (Knoblich & Sebanz, 2008). In the context of environment education, the implications of such embodied, motivational processes in encouraging pro-environmental practices merit more research (Hards, 2011; Turner, 2011). As social animals, humans are naturally motivated to form strong interpersonal relationships (Baumeister & Leary, 1995), though this motivational process is not well understood.

Drawing on recent environment education literature focusing on actions, as well as embodied cognition literature focusing on sensorimotor mechanisms underlying cognition, our study sought to understand how embodied interactions gives rise to social initiatives, particularly through intergenerational influences. Our results highlight the role of artefacts such as plants, insects and compost in mediating collaborative actions at the community level.

RESEARCH METHOD

The study is based on an urban farming project in a school in Mumbai, conducted with 40 students of grade VIII. The terrace of the school served as the site for farming, and sessions were held for one and-a-half hours every week. The study is exploratory, and based on an interpretative framework and qualitative techniques. Thematic analysis was done through creating codes for relevant episodes of the interview transcripts through an iterative process with a co-researcher. Sessions on the farm were video-recorded, and students were asked to maintain their personal farm journals. The researcher maintained field notes along with a co-observer. Interviews with parents (depending on availability) were done to ensure the validity of the student data. Students usually worked in groups of 3-4. One student from each group was interviewed (total 14 interviews). The focus of the study was an exploration of students' evolving motivation towards farming, their relationship with different artifacts on the farm, and instances that provided the impetus for larger perspectives, or actions away from the farm site. The project spanned 10 months, covering 26 sessions.

FINDINGS

Over the course of the project, students developed deep attachments to the plants, as well as the place, as they saw them grow with time. Based their actions, and responses, the following themes were found to be particularly salient:
a) Somaesthetic interactions
b) Instances of *enchantment*
c) Motivational triggers such as the feeling of challenge, autonomy and feedback.
d) Actions away from the site in the form of intergenerational influence

In this paper, we focus on the episodes of intergenerational influence, which were seeded through artifacts of practice (such as leaves, cardboard planters, seeds etc) on the farm. The instances were analysed from the view of the students as well as parents.

1) Student initiatives

Students reported diverse ways in which their immediate community became involved in different activities related to the farm. Often, students would describe their interactions with parents based on their experiences on the farm. They would make associations with plants grown at the farm and try to grow some at their house too. Many students took saved seeds and saplings from the farm to grow at their home, as illustrated below,

> *"We usually buy lemongrass from the market, but then I saw we are growing so much here. I told my parents that we can grow some too. So I took a stalk from here, and have planted it in my balcony..." (LK)*

> *"I have just grown a sapling of Bhindi, because I have seen Bhindi is growing well here... I have tried it. It is the process of growing." (AM)*

> *"I told my parents we should grow tomatoes because I liked it. That day, I ate a tomato here. Then I went back home and had a tomato that my dad had bought, I could taste the difference between both of them. So, this was very sweet and really fruity, juicy, that was really 'kadak' (hard) and it was really hard to have it. I usually don't like eating tomatoes raw, but the farm one was nice!" (SM)*

Students reported trying out related activities such as composting, leaf-collection, mulching and recycling, often drawing their parents into the discussion or physically helping them out. To illustrate, a student explains how she told her mother to mulch plants after observing the process at the farm.

> *"Usually my mom grows plants in a bucket, so she just pours all the soil. After I had attended first 3 or 4 sessions here, my mom had bought a small rose, and she just took the soil and manure and just put it. So, I told that don't do it like that, put a layer of leaves and then the soil, and it will grow well. So, she tried that and our rose plant has many roses now... They say it* (terrace farming) *is giving me a nice experience. And like, they also didn't know about mulching... what actually it is, but now they are learning it from me." (AM)*

The student felt proud of being able to 'teach' her parents that they seemed unaware of. The prospect of sharing new methods and ideas with her parents led her to participate in various farming activities with a lot of interest. Similarly, another student describes how he convinced his mother to stop discarding cardboard boxes so that he could get them to make planters on the farm,

> *"I wanted to make planters, so at home I said, 'Mummy, don't throw any piece of cardboard in the garbage'. First mummy did not... she ignored it. She would still keep it beside the dustbin. So I told her you should not do it, so she said "ok, ok". Then after the second warning she also helped me to segregate it. I kept it in my veranda, and brought them to school." (NM)*

Students' urge to try out some of the farming activities at their homes led parents to take more interest, and support their child's interests. Some parents helped students compost at home, or save cardboards, bottles and other materials that could be used on the farm, instead of disposing them. Others maintained an active interest in the development of the farm, even if they were not able to help directly. The location of the terrace farm, open to public view from other high-rise apartments around the school, provided visual feedback to spectators who could see different events unfolding at the farm. For instance, one student described how his father was observing the farm regularly,

> *"I can see the farm from my house, so have showed it to my dad. We even zoom in through the camera and take pictures of the farm sometimes... Now, I water the plants at home everyday because I want to see them grow like they are growing here..." (DV)*

Such interest on behalf of elders also seem to have nurtured an active sense of ownership and participation from the students. Some students also secured small spaces around the residential societies to start a community garden, and found support from individuals who were already interested in such activities. One student shared her plans of starting a small garden in her own residence area,

> "*So, we were able to get permission from the chairman of our building and we chose a spot. I was so happy to see that, you know, even the youngest of the kids, who go to nursery, are coming and picking up small lumps of mud and putting it. I was very happy. I will be very very determined to actually make a good garden of the one in our society, because I will kind of miss all the weekends we spent here." (AM)*

It was especially interesting to note that senior citizens, who usually have had prior experience of growing plants, were eager to help the students in various activities. Such instances also helped in community building, as students' expanding 'action space' could be shared among other disparate individuals (such as older people) having similar interest, and this overlap seemed to have motivated them to explore more activities in this space. For instance, a student remarked,

> *"Earlier when my grandmother used to mention it* (gardening)*, it wasn't a topic of much interest to me because I did not know anything about it. So I used to just avoid this topic. But now that I have seen so much happening and it is so exciting, so I have started to help my grandmother out. In fact, when I told her about all this* (terrace farming)*, then she got hyped means totally hyped. On the same day, she did not tell me, she went to the nursery, bought a few saplings, seeds, pots, mud everything and she brought it home. Now, we are growing a lot of stuff." (AN)*

2) Parents' perspective

Parents' viewpoints regarding their children's involvement on the farm, as well as their own initiatives if any, were also sought to validate the responses of students regarding the activities at home. Most parents had come to know about the terrace farming initiatives through their children. They felt that the children were visibly excited about the project, and used to explain to them whatever was happening at the farm in vivid detail. The following anecdotes describe what parents heard from their children,

> "*He often tells me things he did as it's* (terrace farm) *his favourite topic now. My son and his friends had made some shelter for their plants and he did not stop talking about it.*" *(SSM)*

> *"My child would speak about the farm very often at home. I think she was really excited to describe how they made manure using cow-dung, cow-urine, jaggery etc." (RDM)*

> *"Very often she would get some vegetables grown at the terrace like brinjal, chillies, spinach and ajwain. She was quite excited about it." (MHM)*

> *"She wasn't too interested initially, but one day she came and told me how she loved the smell of lemongrass. After that, she took more interest in the gardening activities..." (LKM)*

Most of them felt that their children seemed to take more interest in their natural surroundings in different ways. For instance, many started growing a few plants at home,

> *"He wants to be with plants all the time. We already have few plants at home and now he is keen to shift them all in new house. We are planning to make small vertical ladder-type planters in our new home to support his passion..." (KNM)*

> *"She tried growing Lemongrass, Tulsi, and Fenugreek... She is very keen to grow more plants." (YSM)*

Others mentioned seeing more tangential, positive outcomes,

> *"My daughter actually saw the process of growing vegetables. She understood the effort involved and does not waste her food now." (RJM)*

> *"He has become keen on using wet waste to make manure. We save all greens, wastage in a bag for him. He also regularly waters the plants himself, and does that mulching he learnt in school..." (NMM)*

Some parents mentioned restrictions in the residential societies as a deterrent for growing plants in their balcony. However, a majority felt inclined to support their children, and felt the activity as being a good way to bond with each other,

> *"I am planning to take initiative to start terrace gardening in our own building terrace. I have joined pinterest to know more about planting" (KNM)*

> *"I was curious so I started helping her out. I also planted Tulsi and Kadipatta." (RDM)*

> *"He wants to know more so he discusses with his grandparents about natural fertilizers and other things to grow plants better" (SSM)*

Some parents even joined the terrace farm sessions at school as volunteers, to get hands-on experience. There are many such instances of environmental actions seeded through students' actions. These illustrate how artefacts of practice such as planters, seeds, compost etc. can mediate and expand the sphere of shared actions and motivations across generations.

DISCUSSION

The expansion of the farm experience to wider activities in the community, in spaces away from the farm site, is a significant focus of our study. This widening process is key to effective environment education, as the farm experience is designed as an illustrative case of interacting with the environment directly, and thus developing a caring attitude towards nature. Since most such widening activities were done in groups, we postulate that activities where joint-action is a central component have the ability to generate pro-environmental motivation, particularly to engage with and expand the possibilities of farming work. This is partly because as Marion Godman (2013) argues, social motivations seem to form a distinct factor contributing to joint-actions, apart from shared intentions and representations. The following diagram elucidates a proposed model of motivation seeding joint-action.

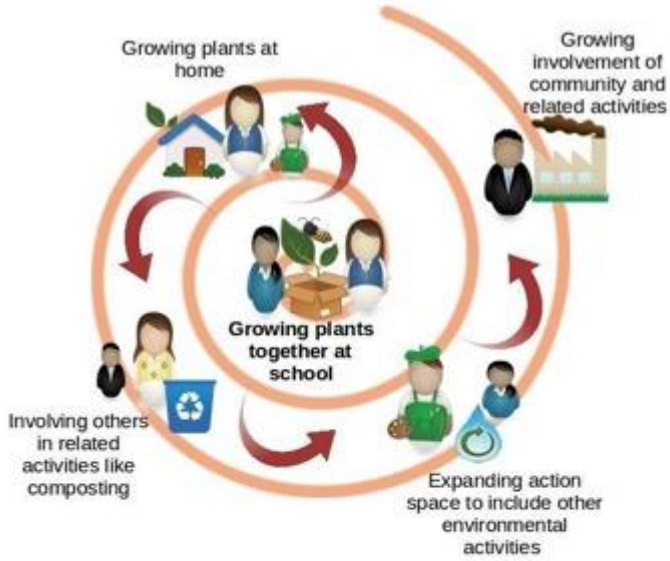

Fig 1: A proposed spiral model of motivation, where sustained engagement with the core activity motivates participants to involve and expand their action space. In this case, growing plants on the school terrace led to concern in related aspects such as composting, seed-saving etc, and also facilitated growing participation of other individuals.

There is a need to explore the potential of school spaces as spaces that can seed community-based actions, by activating students' interest and engagement with environmental and local issues. Designing such interventions based on sustained joint-actions is an important challenge in developing action-based curricula for environment education.

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Gender Issues in Teen Technology Use to Find Health Information

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Abstract

Teens need and want information about health issues. Even though teens tend to prefer asking people for help, increasingly they access digital resources because of the Internet's availability, affordability, and anonymity. Teen health information interests vary by age, gender, social situation, and motivation. Several issues also how teens access and seek that information. This paper discusses several issues related to teen technology use for seeking health information, and offers recommendations to insure optimal library services to address health information needs of all teens.

INTRODUCTION

Teens need and want information about health issues. Even though teens tend to prefer asking people for help, increasingly they access digital resources because of the Internet's availability, affordability, and anonymity. Teen health information interests vary by age, gender, social situation, and motivation. Several issues also how teens access and seek that information. This paper discusses several issues related to teen technology use for seeking health information, focusing on gendered issues, and offers recommendations to insure optimal library services to address health information needs of all teens.

To investigate this issue, the author reviewed the professional literature available through several database aggregators: CINAHL, ERIC, ejournals, Academic Search, and Dissertations Abstracts. Because the advent of social media has expanded the dissemination and interaction with health information, the author limited the review to research published since 2007. The author focused on the population of youth between 12 and 18 years old within the United States. Furthermore, the author focused on information seeking behaviors more than information receiving efforts; that is, intentional information seeking rather passive consumption of other-initiated information disseminators.

TEEN INFORMATION SEEKING BEHAVIORS

Seeking health information is a normal teen task, part of their maturation processes. Such seeking is part of teens exploration of themselves and the world around them (Agosto & Hughes-Hassell, 2006). The range of health information sought by teenagers demonstrates varied needs: illnesses, accidents, chronic conditions, STDs including HIV/AIDS, nutrition, fitness, sexual activity, pregnancy, and mental health issues. The most popular topics deal with sexual health and drugs (Eysenbach, 2008).Teens tend to seek information out of need or fear, such as a personal problem, rather than as a proactive effort to be healthy, such as eating nutritionally (Larsen & Martey, 2011). Nor did they tend to look for pain management advice (Henderson, et al., 2013); it should be noted that those who did seek such information tended to be female risk-takers or self-medicators. As another instance, teens seldom used the

Internet to find contraception or abstinence information. On the other hand, they would look for information that might avoid "genes as destiny" syndrome or counteract past poor health choices. Some may also seek health information to address some kind of social stigma that is health-based, such as acne (Lariscy, Reber, & Paek, 2011). However, a lack of guaranteed privacy makes teens wary about accessing LGBT or HIV information (Magee et al., 2012).

Mental health provides an interesting lens for information seeking. A third of teens experience mental health difficulties, and more than ninety percent of them search for help online because they are more comfortable seeking information anonymously, and they are also technologically comfortable. Such online assistance can lower mental health stigma (Burns, Durkin, & Hons, 2009). Girls are more informed and communicative about mental issues, while boys feel that they will suffer social stigma if they seek help; the expectation of youthful masculinity is such that boys are supposed to deal with programs by themselves (Beamish et al., 2011). Nevertheless, youth are cautious about computerized therapy, so mental health professionals need to learn how to engage teens effectively online (Stallard, Velleman, & Richardson, 2010). In researching online suicide prevention communities, Greidanus and Everall (2010) discovered that trained crisis interveners provided social support and referrals for offline services. Successful online teen help-seekers started supporting their traumatized peers online, thus developing an online support community. In another study of online mental health services, Havas et al. (2011) found that teens wanted a website that targeted them, which included self-tests and anonymous help.

Barriers to Health Information

Several barriers to health information exist (Yager & O'Keefe, 2012). Teens can be ignorant about some aspects of health and do not have a sound knowledge base on which to determine the validity of health advice. Nor does it help that filtering software further limits students' access to valuable online health information (Gray et al., 2002). Some teens are struggling readers or may have language barriers. Even so-called digital natives may have technology deficiencies or have poor physical access to technology. Those in rural areas have the added problem of the "last mile" of hard-cable Internet connectivity. Rural populations are also more likely to lack a connection with health professionals (Boyd et al., 2011), although teens in general do not know how to choose and contact health professionals independently from their parents (Eysenbach, 2008; Manganello, 2008). Teen males are particularly sensitive to issues of social stigma or acceptance as well as gossip (Lariscy, Reber, & Paek, 2011). Personal educational background also impacts information seeking strategies. In addition, attitudes and expectations about health are culturally contextually; for instance, in some cultures, health is a private concern, and in other cultures, hospitals are a place to die rather than to get well (Rushing & Stephens, 2011). In addition, notable subgroups at higher risk in terms of health information seeking include youth with special needs such as disabilities, GLBT, teenage parents, rural youth, illiterate teens, poor teens, and teens of color (e.g., Latinas) (Dobransky & Hargittai, 2012; Roncancio, Berenson, & Rahman, 2012).

Decision-Making

In terms of the health information decision-making process, teens intentionally seek information in order to solve a problem that challenges personal abilities (Cornally & McCarthy, 2011). Girls in particular prefer interpersonal interaction, and want information about and support from service providers, which becomes a strengthened relationship with health professionals later on (Santor, 2007; Ybarra & Suman, 2008). On the other hand, health professionals sometimes discount the social and emotional ramifications of teen's health problems, which drives teens to peers and the Internet for advice (Meyer et al., 2011). Overall, teens tend to prefer seeking information informally from friends and family; next in preference are formal school-based sources. Both sources are generally preferable to the Internet (Dowdy, 2012; Whitfield et al, 2013). Interestingly, at the same time that school-based sex education was provided less often, teen use of the Internet increased (Jones & Biddlecom, 2011); nevertheless teens often questioned the reliability of online information about sexual health, especially males.

Even if teens obtain accurate, valid health information, there is no guarantee that they will follow that advice (Ye, 2010). Part of teen's growing independence is their realization that they can make decisions for themselves, even if those decisions are not in their own best interests.They also tend to have less faith in adults, and want to challenge them as well as assert their own individual authority, a situation that particularly applies to teenage boys (Eysenbach, 2008). To that end, then, librarians can leverage this window of opportunity to help teens gain expertise in analyzing information, synthesizing it, and acting on it with discernment for themselves (Bergsma, 2008).

Technology Impact

Proportionally, teens use the Internet more than any other age group; three-fourths of older teens seek online because of its convenience, anonymity (fear of stigma), affordability, social networking opportunities, and potentially personalized information (Edwards-Hart & Chester, 2010). They also like online self-tests and anonymous help (Burke & Hughes-Hassell, 2007). Unfortunately, younger teens are less apt than older teens to seek online health information, including on sexual topics, even though they experience greater risks if sexually active (Pierce, 2007). On the other hand, online information may be inaccurate (including from peers), and teens often have poor searching and evaluation skills (Skopelja, Whipple, & Richwine, 2008). Particularly since health issues constitute only five percent of all information that teens seek online, and may have limited health savviness, then it can be even harder to discern the quality of Internet-delivered health information (Eysenbach, 2008). In a study of teen health literacy by Ghaddar et al. (2012), researchers found that exposure to credible sources of online health information was associated with greater health literacy, which can serve as a useful strategy for librarians to employ. Furthermore, youth tend to generalize the quality of Internet sources rather than compare and prefer specific sites based on relative authority (Eysenbach, 2008). Sometimes there may be too much information to sift through, and other times there is a dearth of information (e.g., few online resources address deaf issues). In addition, access to digital resources remains inequitable, as noted above, and filtering software limits information seeking in schools. Issues of privacy and confidentiality also exist (Burke & Hughes-Hassell, 2007).

It should be noted that the motivation for seeking health information impacts the searching strategy. For instance, as sexual activity increases, information becomes more relevant and needful (Whitfield et al, 2013). As another example, teens are more likely to view pro-drug websites than anti-drug websites, even in the face of strong anti-drug media campaigns, although girls were more likely to view the anti-drug sites. Teens who have had been given prior drug prevention information are more likely to be curious and seek drug information.

Youth with drug-using friends and who have more unsupervised time are more likely to use the Internet, and to access pro-drug digital resources. They tend to want to find information that confirms their existing stances (Belenko et al., 2009).

When teens do find useful health information, they are more likely to improve and strengthen relations with health professionals. Interestingly, teens and other people will search for health information even if they intend on seeing a health professional because it helps them feel more prepared to discuss health issues with medical personnel. Patients may also search for health information after meeting health professionals in order to confirm the new knowledge (Bell, Orange, & Kravitz, 2011; Eysenbach, 2008).

GENDER ISSUES

Several gender issues emerge from teen health information seeking practices. Females are twice as likely as males to seek health info online, largely because of male peer norms and perceptions of male sexuality, which translates into denial of health problems (Beamish et al, 2011; Gahagan et al., 2007). On the other hand, females have less access to technology, and less technology skills, than males have (Lorence & Park, 2007). Females are more likely than males to seek information on behalf of family or close friends (Abrahamson et al., 2008; Zhao, 2009). Females are more concerned than males with violence and victimization relative to sexuality information Goldman & McCutchen, 2012). Girls are less likely than boys to view pro-drug websites (Belenko et al., 2009). On the other hand, girls are more likely than boys to seek information about weight loss, and they often use unhealthy practices learned online such as binge self-purging (Lax & Berenson, 2011; Smith, Massey-Stokes, & Lieberth, 2012).

EDUCATORS' ROLE IN SEEKING HEALTH INFORMATION

Educators can serve as an important mediator in teen health information seeking behaviors, several of which were noted by Crutzen (2010). Here are recommendations derived from the literature: identify teens' health interests; Locate/provide social media sources (Lariscy, Reber, & Paek, 2011); provide developmentally appropriate health websites (Burke & Hughes-Hassell, 2007); provide community resources referrals; provide health-related programming; teach how to search; teach how to evaluate information; teach/facilitate health literacy, and collaborate with health educators; identify health information mediaries; tailor communication to teens: use text messaging, promote word of mouth, use videos (Crutzen et al., 2008); personalize information (Burke & Hughes-Hassell, 2007); incorporate self-tests; use incentives; use reminders;link health issues; link with community-based interventions; align with cultural and gender expectations.

An interesting approach to addressing teen health information is to train teens as peer health Internet navigators. Peer coaching also improve self-efficacy and reinforces the concept of networked intelligence (Eysenbach, 2008).

Some ineffective approaches include: one-size-fits all, discussion boards, ask-the-expert "walls," and health eduction that does not address social influences. At the least, librarians need to understand the developmental and social cognitive issues behind information seeking behaviors (Paek & Hove, 2012). The more that they can connect with youth, gain their trust, and personalize the information task, the more effectively librarians can serve teens (Ye, 2010).

CONCLUSION

Teens want and need health information, and increasingly seek that information online. However, they need help in navigating the information universe and evaluating found resources. Educators also need to teach all teens health literacy. Because girls are more likely to seek such information for themselves and their associates, educators need to ensure girls' physical and intellectual access to technology and digital resources, especially as girls serve as intermediaries to the needed health information. This role as intermediary can also empower girls and help them gain self-efficacy and self-confidence.

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XVIII IOSTE SYMPOSIUM

Future educational challenges from a science and technology perspectives.

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Dealing with a Learning Problem in Genetics: “Mendel as the Enemy of Genetics no. 1”

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Abstract

The traditional lecture, where a lecturer presents, summarize, explain etc. the course content, is a common practice in biology higher education. The purpose of this study is therefore the possibility of the lecture as a mean to deal with a central learning problem in genetics. An experienced teacher and researcher sees a learning problem in the gap between scientific development concerning genomes and the more simple "one gene - one phenotype" relation and laws of inheritance, founded by Mendel. The question is how the lecturer tries to overcome the learning problem as part of the content structure of the lecture in a fruitful way. The study is inspired by lesson study in its arrangement. The lecturer tests his lecture structure on two different student groups in an iterative way with reflections in between. The focused learning problem is tested in the final exam and the results from both student groups are compared. Despite the elaborated structural changes in the lectures, the majority of students do not pass the question about how gene complexity is involved in phenotypic changes. The results bids a discussion about how we create learning problems and how to abandon Mendelian genetics and conventional presentations of content.

Keywords: genetics; higher education; lecture; Mendel

INTRODUCTION

Biology teaching in higher education is characterised as based on concepts and principles about biological structures, functions and processes (Anderson & Hounsel, 2007). The lecture as teaching format, where concepts and principles traditionally have been presented, has since long been documented as an ineffective form for learning (Ramsden, 1997). Lecturing has even been described as a threat in keeping students in science education (Powell 2003) and as an activity from which students remember hardly nothing (Wiemann, 2007). In a survey done by Marbach-Ad (2004) with approximately 400 students majoring in biology, one of the major difficulties student encountered during first year of college in biology were heavy workload and difficulties concerning the instructors’ teaching methods and style. However, the traditional lecture, where a lecturer presents, summarize, explain etc. the course content, still exists as common practice in biology higher education.

In parallel, there is a rapid development in different areas of biology. For example, different genome projects have pushed the development rate at which researchers have been discovering the genetic basis of a wide range of conditions (Jegalian, 2000). Part of biology is carrying out experiments on a genomic scale. Techniques in systems biology aims to predict the behaviour of biological systems based on the set of molecules involved and interactions between them. The norm was, already back in 2006, to studying pathways, complex interactions or even entire organisms from a molecular biology perspective (Aloy and Russel, 2006).

A common situation in higher education in biology is therefore that a lecturer has to deal with a rapid development of content in the format of a lecture, at the same time as dealing with a traditional teaching content that new knowledge is supposed to build upon.

Purpose and question

The study builds on a teacher that is concerned in addressing a gap between the intended content, supposed to be taught according to the textbook, and the content he, as teacher and researcher, wants the students to reach and to understand in genetics. The textbook content explains inheritance as based on particulates instead of genomic systems. The ambition of the lecturer is to show a more complex picture of the relations between gene and phenotype (or characters). This gap is seen as a learning problem, since scientific development has reached far beyond a simple "one gene - one phenotype" relation and the laws of inheritance founded by Mendel. The purpose of this study is therefore the possibility of the lecture as a mean to deal with a central learning problem in genetics. The question is how a lecturer tries to overcome the learning problem as part of the content structure in a fruitful way.

Method

The study is inspired by lesson study in its arrangement but involve one lecturer and the author. Demir, Sutton-Brown, and Czerniak (2012) mean that an advantage of lesson study is that the method does not require major reforms or demanding educational revisions. It is enough for a group of colleagues to discuss a "research lesson". However, in order to successfully implement the method, organizational support and preparedness for reflection and change is required. Cerbin and Kopp (2006) discuss opportunities and challenges in completing lesson study at college level, as well as lesson study as a model for pedagogical knowledge development. They highlight the aspect that most university teachers are not trained to study their own teaching or students' learning. Lesson study as a process offers a systematic method and framework to help study teaching and learning in their own classroom, they mean.

The study is based on two iterative cycles, and involves two different study groups that will have approximately the same kind of lecture in genetics. The reflections of the lecturer are recorded before and after the lectures and the lectures are as well recorded with video tape, which are partly transcribed and translated to English by author. The author is also present as observer during the lectures.

The lecturer has extensive experience in research and more than 20 years of teaching with different kinds of students (beginners, different programmes, more advanced etc.). He knows, by experience, what kind of difficulties students may encounter regarding an understanding of genetics. One problem regarding the course preconditions is lack of time. Over a period of 15 years, a decrease of time allocated to classical genetics has been reduced to about a third. Lecturing is therefore seen as the most available option. The lecturer identifies the learning problem in a first cycle of planning, which he will address in a lecture in genetics in two different study groups. The lecturer then restructures a lecture he has given before, in order to make the learning problem more visible for the students. We evaluate the student responses and activity during the first lecture and the lecturer restructure the content in the next lecture. The focused learning problem is tested with a question in the final exam and the results from both student groups are documented and compared. (The lectures are also supplemented with web-based quizzes, exercises, and calculations, material that are not part of this study).

Ethical considerations

The lecturer has signed an informed consent. Processing of the material has taken place in accordance with applicable legislation and good research practice. Measures have been taken to protect the lecturer's integrity. The results are not including any citations from students or other material that could be traced to individual persons. Only formal, but anonymous, grades on exams that are public material are used.

RESULT

The question is how a lecturer tries to overcome the learning problem as part of the content structure in a fruitful way. The learning problem is to understand that the relationship between genotype and phenotype is complex and multidimensional as well as to understand different mechanisms behind various inheritance patterns.

Structure of first lesson

In order address the question of complexity, the teacher first starts with reproduction and continues with Mendel and laws of inheritance. The lecturer then attempts to challenge different patterns of inheritance in his lectures by explicitly saying that he will do so, and by showing different patterns and contrasting them. He also begins the lecture by setting the title of this text "Mendel as genetics enemy no 1", which is intended to function as a provocation in relation to the textbook (where Mendel is described as a founder of genetics).

The lecturer:

> *This old man [the lecturer shows a picture of Mendel] I usually call the "enemy of genetics number 1, that's Gregor Mendel as you recognize and why do I say like this? It is a bit of a joke, but nevertheless, it is partly because this man made sure that we have quite preconceived ideas about how inheritance and genetics take place.*

The lecturer continues with Mendel's first and second laws and how they developed the 19th century view of inheritance as an "essence" to a view of inheritance as particularized. The lecturer takes inheritance of Mendel's peas as an example. Then the lecturer returns to the expression:

> *Why the genetics enemy no. 1? Yes, it has affected genetics for a very long time to have that model in sight that characters depend on one gene. What this lecture is about to end up in, is that the inheritance is quite complex in most cases and the inheritance is an expression of the whole genome. There is a lot of interaction that takes place in the genome, and we also have an environment that affects the genome. You can think of a gene in the genome. The primary environment is the other genes in the first place and then the external environment. This means that a gene never works alone. However, Mendel made every effort to show that the gene is completely lonely, is a particle that appears again and again in the offspring, that's why I call him the genetics enemy no. 1. The model, the view of genetics from Mendel, is slowly eroding down, to be replaced by a more complex image where you look at the entire genome as an apparatus, interplay between different genes, the interaction between different genes.*

In comparison, in the textbook in the chapter devoted to Mendel and his inheritance pattern reads “The laws of inheritance as articulated by Mendel remain valid today; his discoveries laid the groundwork for all future studies of genetics” (Sadava, 2011, p. 258).

The lecture content is logically presented. The learning problem, that the relationship between genotype and phenotype is more complex than the Mendelian laws gives the impression of, is pronounced explicitly and is being built up gradually in terms of content. The lecturer explains gradually more complex patters of inheritance, starting with Mendel’s peas, and ending with inheritance of eye colour, the colour of iris.

Reflection
The example with eye colour came at the end of the lecture, but student activity clearly aroused. They started to talk to each other and ask questions. The lecturer decided to restructure again and put the example of eye colour in closer proximity to the example of Mendel’s peas.

Structure of second lesson
The lecturer has talked about reproduction, Mendel’s first law, inheritance as particulate and Mendel as the genetics enemy no1:” We imagine that all of our properties may be due to one or a few genes”. The lecturer continues with Mendel's crosses of peas and round and wrinkled seeds:

> *Looks very easy and good, you have so clear characters. Generation after generation if you continue to cross, it will be nothing but round and wrinkled. This was true of all the traits he used. However, if we make it more complicated, if we look at our own eyes, the iris colours. This is something you can discuss. For in old course books in elementary school you may have learnt that brown eyes are dominant over blue. In this case it can be said that Mendel's explanation is handed down, passed on from generation to generation to ‘look at our eyes, they are really good examples of inheritance, of Mendel's inheritance’. You get clear characters, blue and brown. Then there are some strange things here [the lecturer shows a picture of different colours of the iris], suddenly it turns up green iris. Brown eyed sometimes get blue-eyed or completely different colours, a little grayish. Are there clear classes of eye colours? Can you have sharp boundaries between these? Maybe there possibly [point at the picture] ... If we look close to the pupil, these brown rings, that little brown streak. Are there any sharp characters? To answer that, I'll get back to it, later. How can it really be with eye colour? Is it as it says in old textbooks that it is like Mendel's peas, or?*

Then the lecturer goes through different patterns of inheritance. Instead of building logically on successively more complex patterns, he contrasts two very different inheritance patterns that engage the students in the beginning of the lecture.

Reflection
The lecture is more structured around contrasts. Recombination is followed by what may happen when recombination goes wrong. Mendel's laws are followed up immediately with examples where they cannot apply. Students ask questions, are active, the content concerns them.

Exam results
However, the exam results are not positive. The majority of students do not pass the question about how gene complexity is involved in phenotypic changes. Actually, as low as 20% (of

58 students doing the test) pass from the first lecture and 40% (of 32 students doing the test) from the second lecture. The test result from the restructured second lecture is slightly better (where the different patterns are, among other things, brought in closer proximity in time). The test results indicate that the majority of students do not abandon their particulate understanding of genetic inheritance.

DISCUSSION

The purpose of this study is the possibility of the lecture as a mean to deal with a central learning problem in genetics. Since this is a case study, we cannot draw any general conclusions. It is also possible to question what the students actually learn from a lecture and if the lecturer is explicit enough. The lecturer himself reflect on the lack of formative assessment, and comprehending student knowledge first at the end examination. You may as well question lesson study as a method. “Although lesson study is very useful for helping new teachers join the profession and for teachers to develop pedagogical-related knowledge, its effectiveness is less clear when teachers have to understand a new epistemology for new forms of learning”(Oshiba *et al*, 2006). Lesson study may be uncomplicated for the ordinary lecturer to use. However, the other side of the coin is that the lack of a theoretical view of what knowing and learning mean, leads to a less sharp distinction of the learning problem or actual learning object. Nevertheless, the results bid a discussion since the results indicate a more complex situation than a rather simple question of a lecturer restructuring a teaching content, for two reasons.

For one thing, what the lecturer takes for granted. When dealing with relations of the genome, its expressions and phenotypic characters, knowledge about the molecular relationships within a cell is vital. The lecturer means that he treat the molecular level as a “black box”, because these structures and processes the students should have dealt with before. Sometimes science need “black-boxes” because phenomena are too complex or that we only need to know its input-output (Latour, 1987), but when we teach, this habit of “black-boxing” might obstruct student learning, for example knowing about genome structures and functions. In Marbach-Ad (2004) survey, students also complained about instructors taking previous knowledge for granted. That means we as teachers may be too disposed to treat the content of previous courses as “known”. A study done by Lewis and Wood-Robinson (2000) investigated the knowledge and understanding of genetics amongst 482 students nearing the end of compulsory education. The study showed a poor understanding of the processes by which genetic information is transferred and a lack of basic knowledge about the structures involved like gene, chromosome, and cell. That means that students that enter college/university studies in biology may need more support in grasping basic processes, than we may offer.

Another thing is what the students might take for granted, namely the relation between gene and character. One reason, the lecturer means, is how the simple laws of Mendel dominate all kind of teaching, this is also referred to as the continued use of the unit–character concept of the gene (Allen, 2003). Bowler (2016) also write how Mendel’s laws helped to clarify how characteristics are transmitted from parent to offspring, but that Mendel didn’t suggest any mechanism for the relation between particulars within the germ cells and the resulting characters. I mean that Mendel could rather be seen as an example of knowledge at advanced level, since the relationships he illustrated belongs to exceptions, and using Mendelian schemes of crossing, for example, are used when studying organisms where no genetics are known. Is that a content for basic level genetics? Stern and Kampourakis (2017) also mean that teaching of genetics at school should shift from the focus on the teaching of Mendelian genetics to a different curriculum. However, as this study suggests, we lack knowledge about how to structure content in a fruitful way that takes into account the development and knowledge of biological processes. Mendelian genetics may be straightforward to use, to call genes "the gene for blue eyes" and show a simple scheme of transmission. The problem is the consequences, to what kind of understanding this lead.

CONCLUSIONS

This case study bids a discussion about how difficult it might be to challenge student's preconceptions of genetic phenomena. The possibility of the lecture as a mean to deal with central learning problems in genetics seems to be a hard road to travel. At the same time, what kind of content is actually taught? I mean that we need to question the conventional historical, logical presentation of genetic content as, for example, expressed in any common textbook in biology. Maybe "the learning problem" actually is the way we structure the content. Possible solutions could be to focus on different models of explanation (Gericke and Hagberg, 2007), or first teach about the genome as a whole where genes are implicated in our development in complex networks and processes, which in turn result in how we come to be (Stern and Kampourakis, 2017) or focusing on students' engagement in epistemic practices (Jiménez-Aleixandre and Crujeiras, 2017). At least we thoroughly need to reconsider abandoning the conventional presentation of content in genetics and focus on contrasting challenges for learning. One problem is the high regard that is expressed concerning Mendel, as "the founder of genetics", Mendelism and that we should have a "… considerable measure of respect and admiration for his remarkable insights" (Hartl and Orel, 1992). However, if Mendel is constantly used as a foundation of the understandings of genetics, we as teachers help in perpetuating an idea of relations between genes and characters as a one-one relation that is no longer valid. Mendel may not be the *genetics* enemy number one, but as this study suggests, maybe the enemy of genetics *education*.

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An Investigation of the Relationship between Understanding of Socioscientific Issues and Pedagogical Content Knowledge about Socioscientific Issues

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Abstract

Teachers' pedagogical content knowledge for socioscientific issues and understanding of socioscientific issues emerge as significant components shaping their practices about teaching socioscientific issues in the classroom. The purpose of this study is to explore the relationship between teachers' pedagogical content knowledge for socioscientific issues and their understanding of socioscientific issues. Participants of this study were 102 in-service biology teachers. Data was collected through an open-ended questionnaire called the Pedagogical Content Knowledge for Biological Socioscientific Issues. Data was analyzed using the rubric that helps to accommodate the responses to each question in one of three different categories: inadequate understanding, eclectic understanding and, reform-based understanding. These categories were scored 0, 1 and 2 points respectively. The results of the the correlation between the teachers' understanding of SSIs and PCK-SSIs assessed. Bivariate relationships among the variables revealed moderate and significant positive relationship between understanding of SSI domains and PCK for SSI. Also, the analysis of the data showed that total score of understanding of SSI and PCK for SSI is strong, significant and positive. Teachers' understanding of SSI in classroom, SSI practice and SSI in science education are more related to PCK for SSI than knowledge about SSI. Also, total score of understanding SSI may be predictive of PCK for SSI.
Keywords: biology teachers, pedagogical content knowledge, socioscientific issues

INTRODUCTION

It is generally accepted that democratic societies in the new century necessarily need science-literate citizens who have an understanding of the workings of science thus enabling them to engage in a critical dialogue about the political and moral dilemmas posed by science and technology and arrive at considered decisions (Osborne, Collins, Ratcliffe, Millar, and Duschl, 2003). Such a vision entails that, in school science, students should not only learn about conceptual knowledge of subject matter and scientific processes but also about how to use this knowledge for making decisions about complex societal and personal issues with conceptual, procedural and/or technological associations (Sadler, 2004). To this end, it is generally accepted that addressing socioscientific issues (SSIs) in the classroom provides an appropriate context for focusing on several components of scientific literacy (Sadler, 2004). Several researchers advocate that SSIs can be used as an effective context for learning science knowledge and skills in the classroom. SSIs can serve as a basis for understanding science content (Klosterman and Sadler, 2010) and nature of scientific knowledge. SSIs instruction can also promote an increase in students' interests and motivation towards science (Dori, Tal, and Tsaushu, 2003), their development of argumentation practices (Venville and Dawson, 2010) and moral reasoning (Lee, Chang, Choi, Kim, and Zeidler, 2012). Since the recognition of SSIs as valuable learning contexts for achieving scientific literacy, there have been a growing body of research on developing effective strategies and curricula for integrating SSIs into science instruction. Despite the important progress achieved in the field, there are still significant challenges in terms of transferring SSIs into the science classroom. Teachers play a key role in bringing new approach/ideas into the classroom. Literature review showed that the factors related to teachers determine quality of SSI teaching in the classroom. Teachers' belief about science teaching (Lee and Witz, 2009**)**, understanding of SSI (Sadler, Amirshokoohi, Kazempour, and Allspaw, 2006), self efficacy with regard to SSI teaching (Saunders and Rennie, 2013) and understanding of pedagogical content knowledge for socioscientific issues (PCK for SSI) (Van der Zande, Akkerman, Brekelmans, Waarlo, and Vermunt, 2009) are fundamental components having impact on the effectiveness of SSI teaching. In this regard, teachers' PCK for SSI and understanding of SSIs emerge as significant components shaping their SSI practices in the classroom (Barrett and Nieswandt, 2010; Oulten, Dillon and Grace, 2004). To this end, the purpose of this study is to explore the relationship between teachers' PCK for SSI and understanding of SSI.

METHODOLOGY

Participants of this study were 102 in-service biology teachers. Data was collected through an open-ended questionnaire called the Pedagogical Content Knowledge for Biological Socioscientific Issues (PCK-BSSIs) (Han-Tosunoglu and Lederman, 2016). The instrument was developed based on Shulman's PCK model and consists of three different parts. The first part of the questionnaire features questions to reveal participants' science teaching orientation. This part contains questions asking participants to indicate their degree and area, gender and school type.
The second part of questionnaire contains eight questions to assess teachers' understanding of SSI. These questions target to get information about four domains: knowledge about SSI, importance of SSI in science education, importance of SSI in science classroom and SSI practice.

The third part of the questionnaire aims to assess teachers' understanding of teaching SSIs and contains four different scenarios; about diet and obesity, vaccination, genetic engineering, and gene therapy. Each scenario is followed by 14 open-ended questions related to the scenario. These questions target to get information about five domains of knowledge: knowledge of curriculum for SSI teaching, pedagogical knowledge for SSI teaching, subject matter knowledge for SSI teaching, knowledge of students for SSI teaching and knowledge of school. These scenarios and questions were geared towards helping participants reflect on their understandings and practices of SSIs teaching. The participants were asked to choose one of the scenarios and answer the related questions. As the nature of the questions were similar for all four scenarios, the responses of the participants were analyzed independent of the scenario.

Data Analysis

Data was analyzed using the rubric developed by Han-Tosunoglu and Lederman (2016). The rubric for instrument helps to accommodate the responses to each question in one of three different categories: inadequate understanding, eclectic understanding and, reform-based understanding. These categories were scored 0, 1 and 2 points respectively. To assess teachers' understanding of SSIs, second part of the instrument were analyzed and each participant's total score were calculated for each theme and each part. Similarly, the total score of teachers' PCK-SSIs were calculated in the third part of the instrument. At the last step, the correlation between the teachers' understanding of SSIs and PCK-SSIs were assessed using statistical methods.

FINDINGS

This study focused on the relationship between teachers' understanding of SSI and PCK for SSI. As such, firstly, the bivariate relationships between total score of PCK for SSI and understanding of SSI domains were analyzed using Pearson product moment correlation. Then, the researchers calculated the correlation coefficient between total score of SSI understanding and PCK for SSI. At the last step, the relationship between total score of understanding of SSI and domains of PCK for SSI were assessed using Pearson product moment correlation.

Bivariate relationships among the variables, as Table 1 shows, revealed moderate and significant positive relationship between understanding of SSI domains (knowledge about SSI r=0,454, importance of SSI in science education r=0,542, importance of SSI in science classroom r=0,548, SSI practice r=0,540) and PCK for SSI.

Table 1. Bivariate Correlations for Understanding of SSI domains and total score of PCK for SSI

Understanding of SSI domains	**r**
Knowledge about SSI	0,454**
Importance of SSI in science education	0,542**
Importance of SSI in science classroom	0,548**
SSI practice	0,540**

**p<.01

Also, the analysis of the data showed that total score of understanding of SSI and PCK for SSI is strong, significant and positive (r=0,63) (Table 2).

Table 2. Bivariate Correlations for Understanding of SSI and PCK for SSI

	Understanding of SSI	PCK for SSI
Understanding of SSI	1	.63**
PCK for SSI		1

**p<.05

Lastly, as shown in Table 3, data analysis revealed a moderate and positive correlation between total score of understanding of SSI and the domains of PCK for SSI (knowledge of curriculum r=0,329, Pedagogical knowledge r=0,538, subject matter knowledge r=0,329, knowledge of students r=0,378, knowledge of school r=0,378).

Table 3. Bivariate Correlations for domains of PCK for SSI and total score of understanding of SSI

Domains of PCK for SSI	**r**
Knowledge of curriculum for SSI teaching	0,329**
Pedagogical knowledge for SSI teaching	0,538**

Subject matter knowledge for SSI teaching	0,329**
Knowledge of student for SSI teaching	0,378**
Knowledge of school for SSI teaching	0,378**

**p<.05

As seen in Table 1, teachers' understanding of SSI in classroom, SSI practice and SSI in science education are more related to PCK for SSI than knowledge about SSI. Also, total score of understanding SSI may be predictive of PCK for SSI. Table 3 indicates that the domain of pedagogical knowledge for SSI teaching is more related to understanding of SSI than the other domains.

CONCLUSIONS

Reform documents such as the Next Generation Science Standards (NGSS; Achieve, Inc., 2013) call for SSI teaching. These standards imply that SSI instruction needs to be included in science classroom within content knowledge. Further, related research indicate that SSI teaching has become an important means for improving scientific literacy. It is without doubt that effective SSI teaching depends on teachers' understanding, skills and knowledge regarding SSI teaching. In this regard, the argument that guided this study was that teachers' understanding of SSI and PCK for SSI are significant and related factors influencing the quality of SSI teaching. Findings of the study revealed that there is a moderate and positive relationship between teachers' SSI understanding and PCK for SSIs. The study revelaed that understanding importance of SSI in the classroom is most related domain to PCK for SSIs. This domain focused on teachers's understading of why SSIs teaching is important for the students. It is clear that understanding, analyzing and awareness of SSIs teaching is more stronger predictor for PCK for SSIs than knowing what are SSIs. In a similar vein, teachers' knowledge about how to transfer SSIs into clasroom is linked to understanding of SSIs.These relationships imply that special attention should be payed to teachers' understanding of SSI in pre- and in-service education of science teachers concerning SSI-based science education.

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XVIII IOSTE SYMPOSIUM
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Augmentation of Environmental Education Using a Forest Management Game to Stimulate Learners' Self-Discovery

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Abstract

Currently, there are forest problems as a global problem. In order to solve forest problems and realize a sustainable society, it is important for children to learn vegetation succession. However, vegetation succession occurs on a large time scale and cannot be experienced. Solving this problem will qualitatively improve environmental education for children. We developed a forest management game where learners can experience forest management in a virtual environment. This system intends to experience vegetation successions by managing forests where vegetation successions occur for hundreds of years. We propose the following learning support system. It is possible to discover the importance of forest management. It is possible to discover a dominant relationship between plants. It is possible to discover the ideal state of the forest. Through evaluation results, we confirm that this system is effective for learners themselves to discover the importance of forest management. It also confirms that this system is effective for learners themselves to discover the dominant relationship between plants, the ideal state of the forest. In this paper, for environmental education, we introduced a learning support system. We describe the contents of the current system and the results of our evaluation.

Keywords: sustainable society, learning support system, vegetation succession, forest management, virtual forest

INTRODUCTION

In order to solve many of the issues currently facing forests worldwide, as well as to move toward a global, sustainable society, it is important for children to learn about vegetation succession. However, because vegetation succession changes over long periods of time and includes a variety of factors, it is difficult for children to learn about this concept only from textbooks. Even if children do field work, for example, it is still difficult to fully observe vegetation succession and its related changes. As such, devising an effective way for children to experience interactive learning about vegetation succession will qualitatively improve their environmental education.

Following a literature review of previous studies related to using games for learning (Squire and Klopfer, 2007), we developed a forest management game in which learners can experience related concepts in a virtual environment. This system allows users to experience vegetation succession by managing forests where this succession has occurred over hundreds of years.

A prototype system was developed and evaluated as an effective component of early-stage learning support for the management of forests in virtual environments (Kawaguchi, et al., 2017, Kawaguchi, et al., 2017), in an effort to create interest in vegetation succession. Some limitations, however, included that it was difficult for learners to discover the hierarchy of relationships among plants, ideal state of the forest, and the overall importance of forest management. Following, the system was revised to address and remedy all three of these limitations.

Within the context of environmental education, we introduced the following game as a learning support system for children's environmental education.

FOREST MANAGEMENT GAME

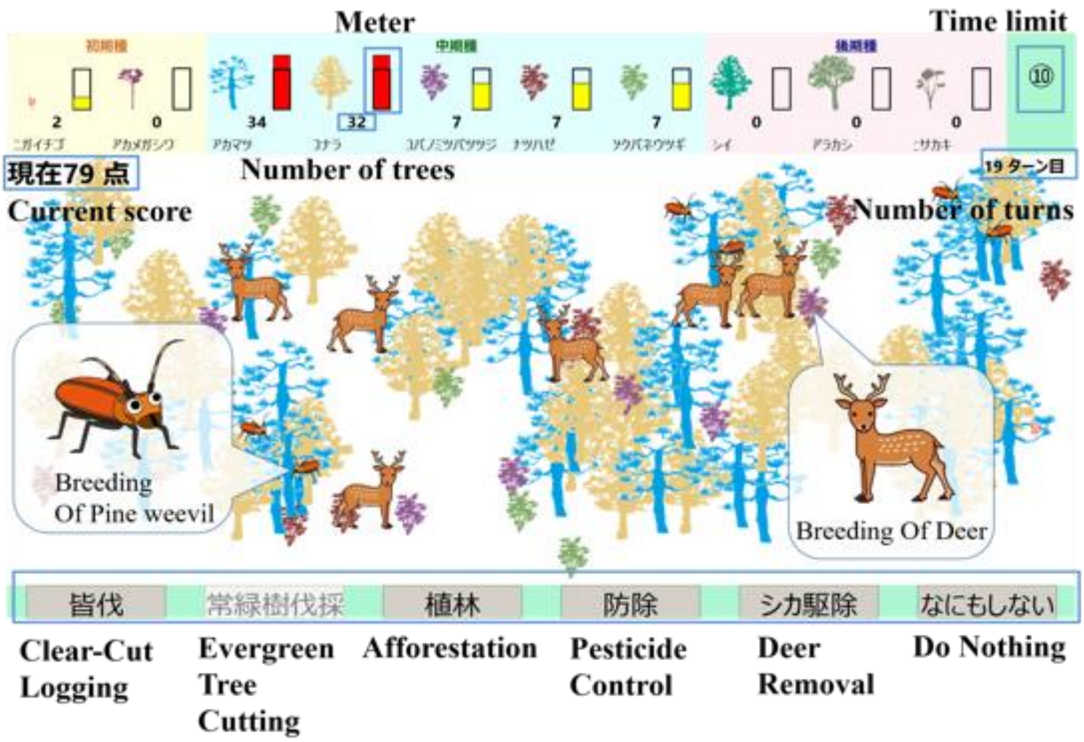


Figure 1: Screenshot of game.

Fig. 1 shows Screenshot of game. In the virtual forest within this proposed system, 10 species of plants are divided into early-stage species, middle-stage species, and late-stage species. Learners can manage their own forest (including animals and insects) for a simulated period up to 300 years. The learner manages 20 turns with a limited time of 15 seconds per turn, using one of the following six kinds of management methods per turn: clear-cut logging, Evergreen tree cutting, afforestation, deer control, pest control, or do nothing. At the end of one turn, the vegetation will increase or decrease depending on the management method chosen, the influence of feeding and/or damage, and the plants' hierarchical relationships. The state of the learner's forest is compared with the ideal state and the relevance between these two numbers is displayed as a score. For each plant species, if the ideal number and the actual number are the same, the learner gains 100 points. Conversely, if the learner does not manage their forest effectively, the score decreases and could eventually reach 0 points. For example, if learners do not select evergreen tree cutting as an action, then late-stage species will increase. As late-stage species increase, light does not reach small plants, so early-stage species and middle-stage species will decrease (i.e., as an effect of plants' dominant/subordinate relationships).

The following attributes of the virtual forest are displayed on the game screen, in order to monitor forest conditions: number and type(s) of plants, relationship between the ideal number and current number of each plant type, forest area to manage, time limit, and number of turns. Through this gamification, learners can discover the influence of forest management on vegetation succession as well as the wide-reaching importance of forest management itself. Fig. 2 shows system flow. Table 1 shows Plant-event relationship matrix.

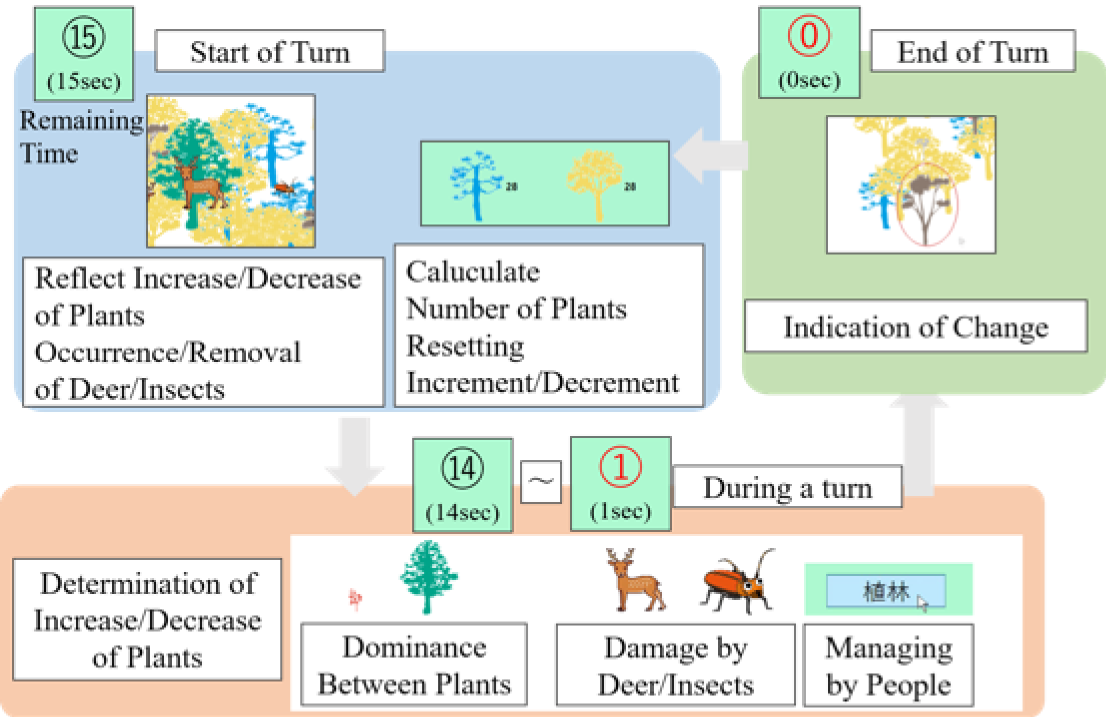


Figure 2: System flow.

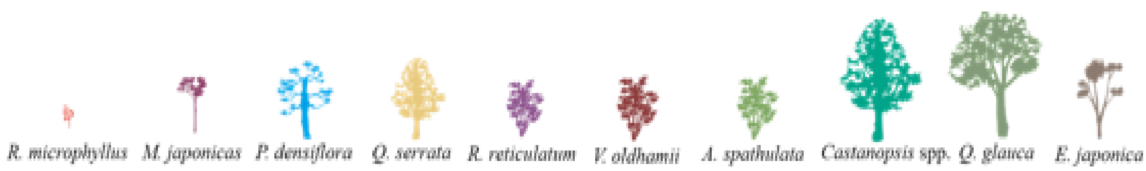
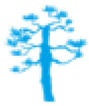
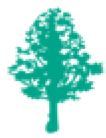


Figure 3: Types of plants.

Table 1: Plant-event relationship matrix.

Plants / Events								
Clear-Cut Logging	+5	+5	→0	→0	→0	→0	→0	→0
Evergreen Tree Logging			+5	+4	+4	→0	→0	→0
Afforestation			+4	+3	+3			
Pest Control	+5	+4	+6					
Deer Removal	+3	+3	+3	+3	+3	+1	+1	+1
Do Nothing	-3	-3	-2	-2	-2			

EXPERIMENTAL EVALUATION

Evaluation method

Participants: 16 students (5 boys and 11 girls, all between 11 and 12 years old) from an elementary school in Kobe, Japan
Experiment Date: December 18-21, 2017
Process: Four people were tested each day after attending a session that explained the outline of the forest management game. Each learner played the game—using a separate personal computer—six times in total: four times during lunch break and two times after school. During the game, learners were asked to remember what kind of changes occurred in the forest and which management methods that they used.

Evaluation Results

Results from the 16 learners playing the game six times each were summarized following the testing period. The first and sixth average points of each learner were evaluated using the Tukey test. This method can be used on raw data or in conjunction with an analysis of variance to find average that are significantly different from each other.

Table 2: Trial average and dispersion scores.

	First	Sixth
Average	50.8	69.5
Dispersion	560.5	73.4

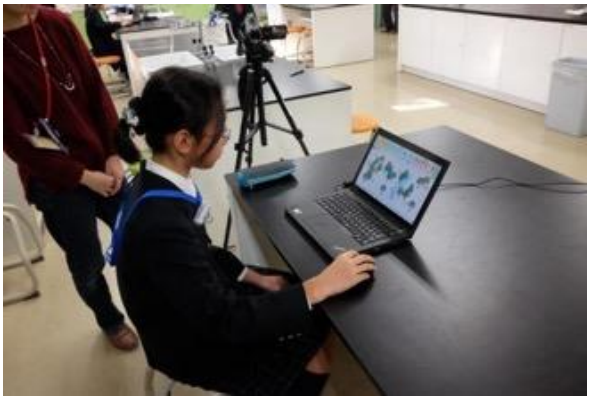


Figure 4: Experimental environment.

As a result, the difference between the first and sixth average points was viewed as statistically significant, at the 5% level. Table 2 shows trial average and dispersion scores.

From the viewpoint of learning support, this rise in the average point of each user shows that the game was successful in helping the users learn about vegetation succession. Based on the above results, we confirm that this system was effective for learners to independently discover the importance of forest management and hierarchical relationships among plants within a forest's ideal state. Fig. 4 shows Experimental environment.

CONCLUSIONS

Within the context of environmental education, we introduced a gamified learning support system for children's environmental education to assist in self-discovery regarding the importance of forest management, the hierarchy of relationships among plants, and the ideal state of a forest. As a result of the experiment, the mean points of all learners increased to a statistically significant degree, indicating that there was a learning effect. Based on these results, we confirm that the proposed system was effective for its intended purpose.

ACKNOWLEDGEMENTS

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Development of Design Elements of a Socio-scientific Issue Curriculum Unit for Fostering Students' Argumentation for Persuasion: Case of the 'Rice Seed-Based Edible Vaccine for Japanese Cedar Pollinosis' Curriculum Unit

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Abstract

Socio-scientific issues (SSI) are complex social issues related to science and scientific technology. Crucial to science education is a student's ability to make sense of SSI that address multiple, competing values. This study presents design elements for a socio-scientific issue curriculum unit in order to foster students' argumentation for persuasion, based on the instructional model by Friedrichsen, Sadler, Graham, and Brown (2016). In this research, the focal SSI is the development of a genetically modified organism (GMO), a rice seed-based edible vaccine for Japanese cedar pollinosis. In our proposed curriculum, students first learn the scientific background of cedar pollen allergies and GMOs (i.e. scientific ideas and practice). Next, they encounter five arguments for and five arguments against the development of a rice seed-based edible vaccine for Japanese cedar pollinosis (i.e. social connections). They develop a matrix to clarify the complex relationships between these statements. Additionally, students improve upon their matrices by sharing them with one another (using ICT). Then, they present proposals that will persuade those with a viewpoint that opposes their own (i.e. a culminating experience).

Keywords: Socio-scientific Issue, Argumentation for Persuasion, Design Elements

1. THEORETICAL BACKGROUND

1.1 Socio-scientific Issues

Socio-scientific issues (SSI) are complex social issues related to science and scientific technology, ones that involve diverse values (Sadler, Romine, & Topçu, 2016). A student's ability to make sense of SSI that address multiple, competing values is thought to be crucial to science education (e.g. Kolstø, 2001; Zeidler, 2015). Kolstø (2001) observes that citizens' decision-making abilities are important to a democratic society, and as such, it is important to build citizens' capacity to engage in diverse perspectives around SSI. Furthermore, Zeidler (2015) states that SSI is a conceptual framework that can be applied to science-education theory, research, and practice, with the objective of fostering scientific literacy. Therefore, researchers have argued that scientific literacy can be improved by incorporating SSI into science education.

1.2 Socio-scientific Issues and Argumentation for Persuasion

Argumentation, as a research topic, has attracted increasing attention in science education (Lee, Wu, & Tsai, 2009). Erduran, Ozdem, and Park (2015) note that learning and teaching argumentation is an educationally significant goal. Berland and Reiser (2009) identify three objectives of learning argumentation: (1) sense-making, (2) articulating, and (3) persuading. Of these three goals, they view persuading to be the most important. Furthermore, Berland and Reiser (2009) find that students seldom attend to the third goal of persuading. This finding suggests that although learning argumentation for persuasion is important, it can be difficult for students.

What kind of contribution can SSI research make to the practice of learning argumentation for persuasion? Existing SSI studies focus on improving students' argumentation skills through SSI-based scientific education (Kolstø, 2001; Zeidler, 2015). For example, Zeidler (2015) argues that students must be able to make reasoned judgments about scientific data based on multiple values. He contends that when students attempt to make reasoned judgments, they improve their argumentation skills.

However, no existing SSI studies have focused on learning argumentation for persuasion. Extending the results of current SSI studies, we believe that this study contributes to—and encourages the expansion of—the SSI literature on teaching and learning argumentation skills for persuasion.

2. PURPOSE OF THIS RESEARCH

This study develops design elements for an SSI curriculum unit whose purpose is to promote students' argumentation for persuasion, based on the instructional model by Friedrichsen et al. (2016). SSI research places emphasis on developing design elements as well as on developing an instructional model. Design elements serve to realise instructional models as educational practice (Presley et al., 2013; Friedrichsen, Sadler, Graham, & Brown, 2016). When design elements are both specific and effective, they contribute significantly to educational practice. This study uses transgenic rice containing peptides from Japanese cedar pollen allergens as an SSI case example. This topic is intensely debated in Japan and is therefore a socio-culturally authentic topic for students. In this study, we propose and elaborate on a set of design elements for use in instruction.

3. THE INSTRUCTIONAL STRATEGY

In the instructional model proposed by Friedrichsen et al. (2016), teachers must first decide what SSI to focus on in the lesson (the focal issue). Friedrichsen et al.'s model identifies three components of students' learning experiences related to the chosen SSI: social connections, scientific ideas and practice, and information and communications technology (ICT). In order to negotiate focal issues, students must learn about the surrounding scientific ideas and practices and about the social complexities of the focal issue. It is desirable to scaffold students' use of ICT so they can share such content among themselves, thereby improving their understanding. In the final phase of our curriculum unit, we propose two integrated activities that builds upon previous learning. In Friedrichsen et al. (2016), these integrated activities are referred to as the culminating experiences.

4. DESIGN ELEMENTS

4.1. Focal Issue

In this research, we selected the development of a GMO, a transgenic rice containing peptides from Japanese cedar pollen allergens, as the focal issue. Japan's Ministry of Health, Labor and Welfare found that over 25% of Japanese people suffer from cedar pollen allergies (2011), making it a significant public health challenge in Japan. Therefore, we believe students will be familiar with this issue.

4.2. Social Connections, Scientific Ideas and Practice, Information, and Communications Technology

In our proposed curriculum unit, students first learn the scientific background of cedar pollen allergies and GMOs (i.e. the scientific ideas and practice). Next, they learn five sets of arguments for and five sets of arguments against the development of transgenic rice containing peptides from Japanese cedar pollen allergens, totalling ten social standpoints (i.e. social connections). Table 1 lists these ten standpoints: arguments from five types of stakeholders in the approving position (doctor, rice farmer, scientist, patient, and pharmaceutical company) and arguments from five types of stakeholders in the opposing position (doctor, rice farmer, scientist, patient, and citizen group).

The students develop a matrix in order to clarify the complex relationships between these statements. Figure 1 shows an example of a matrix that might emerge from this curriculum. In this matrix, approving stakeholders are enumerated in the vertical row, and opposing stakeholders are enumerated in the horizontal rows. The conflicting points are noted in the cell where they intersect. For example, the matrix shows a conflict over treatment technique between the approving doctor and the opposing doctor. Additionally, students improve the quality of the completed matrix by sharing them with one another (an example of using ICT). Figure 2 shows students using Google spreadsheets to compare their matrices with those of other groups. Finally, the whole class develops a new, shared matrix.

4.3. Culminating Experiences

Once students have learnt about the standpoints involved in the debate over transgenic rice containing peptides from Japanese cedar pollen allergens, students decide if they are for or against the rice's development. Then, they make proposals to persuade those with a standpoint that opposes their own (i.e. the first culminating experience).

Subsequently, students evaluate the persuasiveness of their proposals. Students create a proposal review sheet; using the proposal review sheet and the above matrix, they learn about effective and ineffective persuasion. Figure 3 shows an example of a proposal review sheet. In

Table 1 Five approving stakeholders and five opposing stakeholders in the debate over a rice seed-based edible vaccine for Japanese cedar pollinosis

Approving	Opposing
Doctor	Doctor
Rice farmer	Rice farmer
Scientist	Scientist
Patient	Patient
Pharmaceutical company	Citizen group

Figure 2 Students using Google spreadsheets

the box on the left side, students are asked to write their own proposal. In the middle parenthesis,

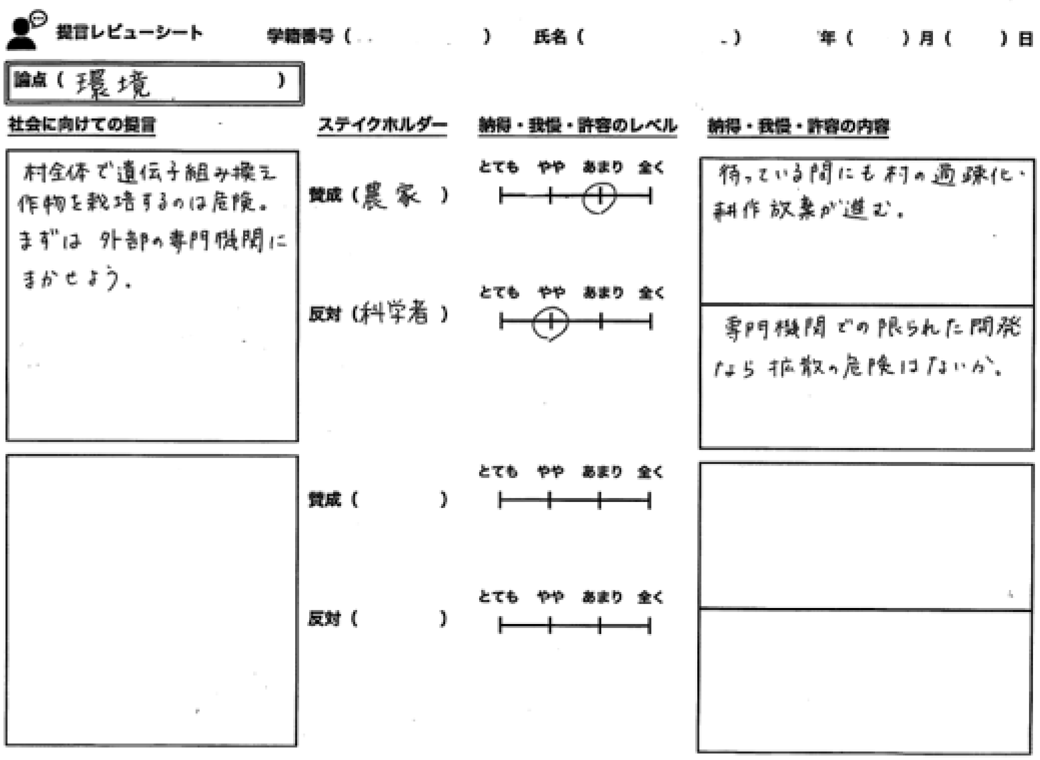

Figure 3 An example of proposal review sheet

they are asked to enter the conflicting stakeholder in the conflict point dealt with in the proposal. The number line in the center invites students to evaluate to what extent each stakeholder is convinced in four stages, with the left-most value indicating ‘very convinced’ and the right-most value indicating ‘not entirely convinced’. The square on the right contains a description of how the proposal persuaded the target stakeholder. Students use this sheet to visualize the contents and persuasiveness of their proposal. This evaluation activity allows students to reflect on and improve the quality of their proposal. Finally, students once again develop proposals based on what they have learnt (i.e. the second culminating experience).

5. CONCLUSION AND FUTURE WORK

The authors were able to develop the design elements for a socio-scientific issue curriculum unit to promote students’ argumentation for persuasion based on the instructional model proposed by Friedrichsen et al. (2016). The next step of this research is to implement an SSI curriculum unit that incorporates these design elements and to evaluate whether such a unit can improve students’ argumentation for persuasion.

ACKNOWLEDGEMENTS

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Using Effective Learning Experiences in Physics To Develop the 21st Century Competencies and Student Outcomes

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Abstract

To make the learning of Physics more authentic, engaging and visible for the students, they are exposed to investigative group hands-on activities. This align with studies that suggest that concrete learners make greater improvement in subject mastery with more reflective (Saunders & Sheperdson, 1987) and positive attitude (Lawson, 1995) in Science learning. We designed activities where students work in groups cooperatively, to facilitate discussion and presentation using White boarding. The process of the activities fits into the 5E Learning Cycle Model. To help students relate to circuit design questions and make their learning more visible and achieve deeper understanding, we built the circuitry for the Foutan board activities. This activity is an adaptation of the Foutan board activity used by Cornell University "Xraise Outreach for CLASSE" Wilson Lab (CNS Institute for Physics Teachers 2011 Revised). Our data-logging activities expose students to technology that are being adapted pervasively in our work place and homes. The students use sensors, semiconductors and electronic data analysis gadget, developed in Singapore, to capture the physical data and processed the collected data. This aligned with the information skills of the 21st Century Competencies. Students are more confident in forming and communicating explanations and display a higher level of academic self-efficacy through keener interest and motivation. Students' survey feedback showed on average above 3.2 of 4 where 4 is highly agreeable, with standard deviation of 0.55-0.65. 91.7% of the responses agree favourably to the survey. Our survey thus shows that our students felt more confident to question, clarify and reflect on their learning; the hands-on activities helped to spur their interest in the topics; they can relate better to real world application and the activities help them have a clearer understanding of the Physics concept than through the usual approach to learning these topics.

Keywords: 21st Century Competencies and Student Outcomes; concrete learners; cooperative learning; multiple intelligences; 5E Learning Cycle Model

INTRODUCTION

Our research study used a mixed method approach. With both quantitative and qualitative data, we aim to be able to provide both a statistical analysis of findings as well as to tap into participants' perspectives. Data was collected through a questionnaire administered to Secondary 3 students (n = 155) and Secondary 4 students (n = 139). This questionnaire consists of six questions grouped into three domains related to the research focus of 'joy of learning' to foster e*ngaged learners*, *life-long learner*s and learners involved in *meaning-making*. Two focus group interviews with six students were also conducted to collect students' perspectives on their learning experiences.

Procedure: Inquiry-based activities and whiteboarding
A total of nine inquiry-based activities will be carried out by our Upper Secondary students over 2 years (three activities in Secondary 3 and six activities in Secondary four). After performing a series of three of these inquiry-based activities, the students will do whiteboarding as a learning process and as a presentation format of their findings. Pictures with brief descriptions of six of the inquiry-based activities: 'Faraday's law of electromagnetic induction',

'Bouncing ball', 'D.C. motor', 'Tension Protractor', 'Speed of sound' and 'Light-dependent resistor' are in Annex A. Student worksheet examples for three inquiry-based activities: 'Cartesian diver', 'Transformer' and 'Force on cart' are in Annex B.

The students worked in collaborative groups of four to carry out the tasks as specified in the inquiry-based activity worksheets. As mentioned above, the students will present their findings and explanations to the class at the last session after three activities via whiteboarding (Yost, 2003). The instructional sequence of the inquiry-based activities follows closely the BCSE 5E inquiry model to enhance student learning (Bybee, 2006).

The *Engagement* phase was already done for students as they can make connections between their past and current learning experiences, from their prior conceptions. The students were taught the concepts in earlier lessons.

For *Exploration* phase, each task provides experiences for students so as to probe student's prior understanding, to generate new ideas, explore questions, and conduct an investigation. Here the members in a group would jointly perform the task and note their observations.

The *Explanation* phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding and process skills.

As the students show the class their whiteboards and explain their findings from data collected or problem solution, they are immersed in the Explanation, Elaboration and Evaluation phases.

In the *Elaboration* phase, the subsequent questions in the tasks challenge and extend students' conceptual understanding and skills. Through new experiences, the students develop deeper and broader understanding, more information, and adequate skills. Students apply their understanding of the concept and abilities by conducting additional activities. During their presentation, they are to share their responses to the deeper probing questions.

The *Evaluation* phase encourages students to assess their understanding and abilities and allows peers and teachers to evaluate their classmate presenters' progress toward achieving the learning outcomes. The students listening to presenters can post questions or their viewpoints to encourage deeper probing. The teacher may occasionally ask questions, probing the student's understanding and directing the student's learning process.

IMPLEMENTATION

Data collection and analysis: Questionnaire

At the end of each whiteboarding, the students were asked to complete a questionnaire known as "Reflection on the authentic learning activities". This six-item questionnaire based on a 4-point Likert scale of '1 for strongly disagree', '2 for disagree', '3 for agree' and '4 for strongly agree' was used to collect data on students' perception of their joy of learning covering three domains of '*engaged learner*' (items 1 and 4), '*meaning-making*' (items 2 and 6) and '*life-long learner*' (items 3 and 5) (Annex C).

For our statistical analysis, we computed the mean score for each item (μ) and used the **STDEV.P** function of EXCEL to find the standard deviation (σ), followed by the **Coefficient of Variance** (CV). We also computed the average dimension mean (μ) and used the **STDEV.P** function of EXCEL to find the standard deviation (σ), then the **Coefficient of Variance** (CV). This analysis will provide an indication of the impact the inquiry-based activities and whiteboarding have in fostering students' joy in learning that is meaningful, engaging and promotes life-long learning dispositions.

Three free-response questions in the questionnaire were used to further collect students' written feedback on their learning experiences. Students were asked to reflect on the physics concepts they learned, what they found interesting and what they still had questions on.

Data collection: Focus group interviews

To gain deeper insights into our students' perceptions of 'doing Science' and their learning through the inquiry-based activities, we carried out Focused Group Interviews with three Secondary 3 and three Secondary 4 students. We took reference to the practical guides from Williams & Katz (2001) as we prepared our questions for the FGIs. The guiding questions for the interviewers are:

1) What do you think of the white boarding activities? How does it spur your interest in Science?
2) Is there any area that you felt can be improved? How do you think the activities can be more engaging for the purpose of learning? For example, the activity on sound; ping pong ball, transformer, solenoid, Cartesian diver?
3) "I can relate better to real world application through this activity." is one of the feedback questions. To what extent do you agree/disagree with this?
4) "The activities help me to have a deeper or clearer understanding of the Physics concept taught in class." is a survey question. To what extent do you agree/disagree with this?

RESULT AND DISCUSSION

Analysis: Questionnaire

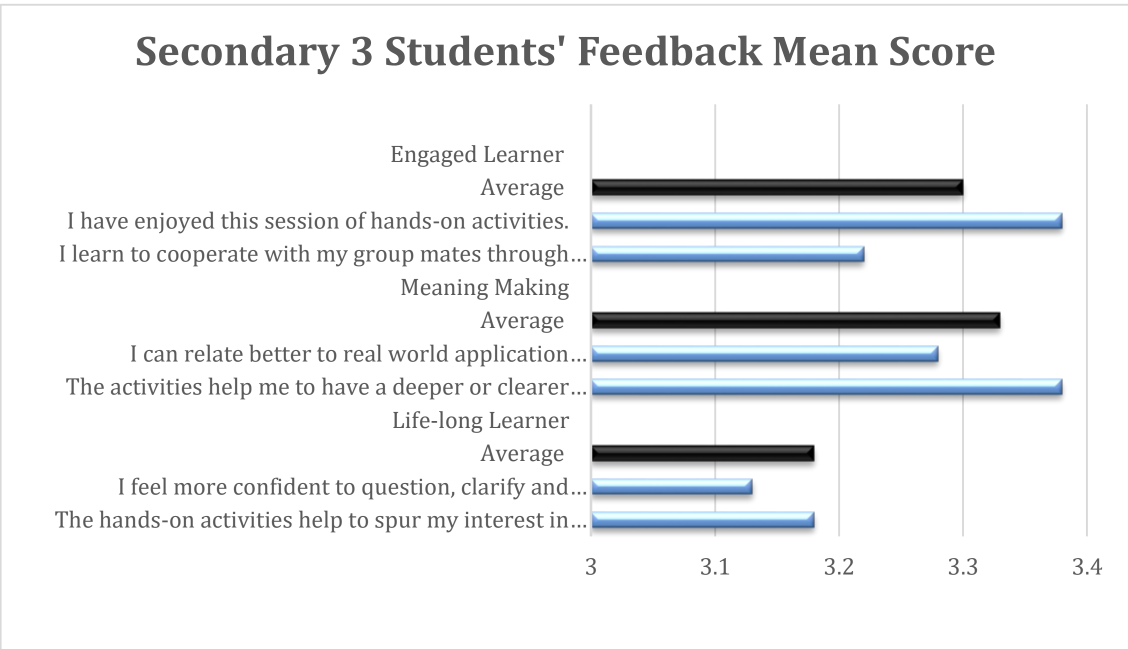
The questionnaire was administered to our Secondary 3 (n = 155) and Secondary 4 (n = 139) physics students. The data obtained as well as the computed information is illustrated in the tables and charts below. Table 1 and Chart 1 is for Secondary 3 students and Table 2 and Chart 2 is for Secondary 4 students.

Table 1. Secondary 3 students' feedback: mean, standard deviation and coefficient of variance

	mean	Stdev	CV	1	2	3	4	Total
Engaged Learner								
I have enjoyed this session of hands-on activities.	3.38	0.52	0.16	0	4	85	58	147
I learn to cooperate with my group mates through the activities.	3.22	0.57	0.18	1	14	90	43	148

average	3.30	0.55	0.17					
Meaning-Making								
I can relate better to real world application through this activity.	3.28	0.58	0.18	8	10	84	53	155
The activities help me to have a deeper or clearer understanding of the Physics concept taught in class.	3.38	0.58	0.17	1	5	84	58	148
average	3.33	0.58	0.17					
Life-long Learner								
I feel more confident to question, clarify and reflect on my learning through the activities.	3.22	0.57	0.18	0	16	93	39	148
The hands-on activities help to spur my interest in the topic(s).	3.13	0.70	0.22	6	23	74	48	151
average	3.18	0.64	0.20					

Chart 1. Secondary 3 Feedback Mean Score by item and dimensions

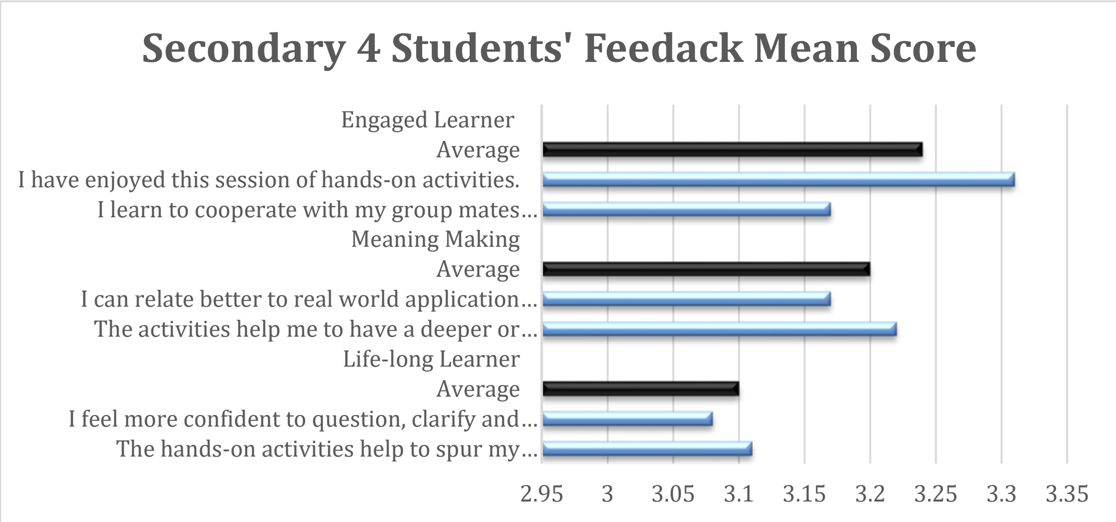


The Secondary 3 students' feedback showed mean average of 3.18 and above for the three dimensions of 'engaged learner', 'meaning-making' and 'life-long learner' out of 4 where 4 is highly agreeable, with standard deviation of 0.55-0.64 and Coefficient of Variance (CV) of 0.17-0.20. The low CV indicates the data is highly reliable since it is significantly below 1.00, considered as low-variance.

Table 2. Secondary 4 students' feedback mean, standard deviation and coefficient of variance

	mean	Stdev	CV	1	2	3	4	Total
Engaged Learner								
I have enjoyed this session of hands-on activities.	3.31	0.59	0.18	1	6	81	51	139
I learn to cooperate with my group mates through the activities.	3.17	0.65	0.20	2	13	83	41	139
average	3.24	0.62	0.19					
Meaning Making								
I can relate better to real world application through this activity.	3.17	0.65	0.21	1	17	78	42	138
The activities help me to have a deeper or clearer understanding of the Physics concept taught in class.	3.22	0.58	0.18	0	12	85	42	139
average	3.20	0.62	0.20					
Life-long Learner								
I feel more confident to question, clarify and reflect on my learning through the activities.	3.08	0.55	0.18	0	16	96	27	139
The hands-on activities help to spur my interest in the topic(s).	3.11	0.70	0.22	2	21	76	40	139
average	3.10	0.63	0.20					

Chart 2. Secondary 4 Feedback Mean Score by item and dimensions



The Secondary 4 students' feedback showed mean average of 3.10 and above for the three dimensions of 'engaged learner', 'meaning-making' and 'life-long learner' out of 4 where 4 is highly agreeable, with standard deviation of 0.62-0.63 and Coefficient of Variance (CV) of 0.19-0.20. The low CV indicates the data is highly reliable since it is significantly below 1.00, considered as low-variance.

The responses from the Secondary 3 and Secondary 4 groups of students shows that the mean scores for "I have enjoyed this session of hands on activities", "The activities help me to have a deeper or clearer understanding of the Physics concept taught in class" and "I can relate better to real world application through this activity" are the three highest item scores for both groups. This shows that our objective of creating a more meaningful and enjoyable experience of science learning for our students has been well received. It also suggests that the students can relate better to how data is being collected and analysed for more meaningful discussions to take place.

The responses from the Secondary 3 and Secondary 4 groups of students shows that the mean scores for "I feel more confident to question, clarify and reflect on my learning through the activities" and "The hands-on activities help to spur my interest in the topic(s)" are the two lowest item scores for both groups. This shows that our objective of fostering dispositions for life-long learning is less well received compared to engaging learning and meaning-making.

The written feedback from students generally collaborated with the scores in the questionnaire items. The following are examples of students' written feedback related to being engaged in their learning and the process of meaning-making:

> *"I found it interesting to capture data and apply the concepts to practical issues."*
>
> *"Whiteboarding activities and presentation in the lab as well as applying theory to explain real life scenario interesting."*
>
> *"This provided a hands-on experience that is refreshing from the usual pen and paper theory, and also gave us a chance to learn new things through observation and practical learning."*

Analysis: Focus group interviews
The Focused Group Interviews (FGI) with 2 groups of students comprising of three Secondary 3 and three Secondary 4 students respectively provided salient points on students' perception of their learning experiences (Annex D).

Students reflected positively to being given the opportunity to engage with their peers and teacher in discussions and using their knowledge of Science in real-world and STEM-related applications. The following are some examples from the FGIs on students' perceptions of their learning:

> *"Actually I find it a good classroom environment to actually share ... more opportunity for you to discuss ideas in the whiteboarding activity, students can just shout out their ideas, their viewpoints then can start a new discussion."*

> *"It is more interesting and more fun and it is something not really seen before. For example, the Cartesian diver, I think that was the first time I got to know what it is about. I also dive deeper into the world of Science and how these amazing things work."*

> *"It is a step in the correct direction. Perhaps a bit more real life example like engineering applications. Then insert that into the questions."*

CONCLUSION

Quantitative and qualitative evaluations of the intervention showed that our students developed a better understanding in the Physics topics. They were more confident in forming and communicating explanations and they showed a higher level of interest and motivation. Students found the inquiry-based activities and whiteboarding learning process interesting and meaningful. In particular, they enjoyed and found meaning in "the sharing of our classmates" and "hands-on activities". Comparing with normal classroom instruction, they noted that the intervention "provide a hands-on experience that is refreshing from the normal pen-and-paper theory" that afforded them deeper learning opportunities: "I was able to see how physics concepts learnt in classroom can apply to real life" and to "dive deeper into the world of Science and how these amazing things work".

The activities have also made a positive impact on the Secondary 3 and the Secondary 4 students in the three dimensions related to joy of learning: meaning-making, engaged learner and life-long learner. In particular, students found that the inquiry-based activities and whiteboarding provided opportunities for them to deepen their learning and apply their knowledge in real-world applications.

Reflecting on the feedback given by students and on our observations, we have the following considerations as guiding points for our review on Areas for Improvement:

1. Review the time allocated for the various tasks;
2. Provide more time for group preparation for the presentation;
3. To review the questions to include some authentic engineering application:
4. Keep a record of the possible levels of responses from our students and list down some effective guiding questions for them so that the lessons are scaffolded for different ability learners;

5. Track the number of students who graduated and continue to pursue a STEM related education or career as an indicator of success for our programme.

With our inquiry activities and whiteboarding process to promote stronger link between theory and practice of the scientific approach, our students are more engaged in a collaborative environment to use questions to deepen their understanding. This classroom approach also serves as a basis for developing a greater interest in STEM. We have also observed an increase in participation in our informal STEM-related programme, with students enrolling for our cohort enrichment activities and more participants for the various STEM competitions. Students have also expressed a greater joy in learning from these opportunities provided, were more confident in forming and communicating explanations and attained a higher level of interest, curiosity and motivation. It is also encouraging to see them trying to draw connections between physics concepts and the physical phenomena happening around them.

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Discursive interactions in small-group work: is there any difference between scientific and non-scientific tasks?

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Abstract

This work presents part of the data obtained in an interventionist study carried out in Brazilian primary school, which the aim was to explore the effects of a dialogic approach to teaching-learning. Here, it is discussed the analysis of the small-group discursive interactions across four tasks with different foci on the scientific content and design. Utterances coming from six groups per task were systematically coded and statistically analysed in order to seek differences in the code occurrences among the tasks. Our results do not show any relevant difference, what leads us to conjecture some hypothesis and implications. Firstly, the primary science language might not require any specialisation in relation to other disciplines, or, secondly, the coding scheme might not be grained enough to highlight the distinctiveness of the scientific language. Moreover, our findings suggest that the noticing of the substantive structure of science by primary students does not occur by chance, and so teachers should play an important role in explicitly addressing these specified science-related aspects.

Keywords: Dialogic teaching; Primary science; Science language; Small-group work.

INTRODUCTION

In the last 30 years, much research has focused on the role of language in science education, and more recently it has developed under the terms scientific literacy and argumentation (Lee, Wu, and Tsai, 2009). Sutton (1998) divides the language focus of those studies into two categories: one that presents language as the way to describe knowledge for transmission and another that emphasizes its interpretative dimension that results in meaning. Lemke (1990) and Wellington and Osborne (2001) discuss the distinctiveness of the language of science in terms of the syntax and the semantics; the first related to the grammar structure, specialised words and logical connectives, and the latter dealing with the precision of meanings. The call for being rigorous is a prerequisite based on the scientific canonical standard and method (Mammino, 2010).

Moreover, scientific thinking employs a reasonable amount of abstraction and idealization that is partly achieved by language, replacing verbs and adjective by nouns (Hodson, 2009). This abstraction is also treated by Evagorou and Osborne (2010) through the case of scientific language, which allows the hierarchical representation of imagined entities. Yet, Lemke (1998) enumerates other aspects such as symbols, images, values and actions that are also embedded in any language.

For many years, traditional science teaching has reinforced the emphasis on verbatim definitions based on fixed terms (Hodson, 2009) and algebraic relationships. However, departing from the studies highlighted above, many scholars have proposed that learning science is like learning a new language and for this reason teachers should provide guidance to students about the role of language and give them opportunities for extended talk during the lessons (Driver, Asoko, Leach, Scott, and Mortimer, 1994; Hodson, 2009; Lemke, 1990; Mortimer and Scott, 2003; Sutton, 1998). These discursive moments are important for students to use the appropriate words, think about their meanings and relationships, and learn to reason within science (Wellington and Osborne, 2001).

Here, the need for more discursive interactions in science lessons is based on two main aspects; the first is that the *difference* that emerges in discussions is what drives explanations: "when people differ in their understandings, there is a need for them to explain their ideas to one another" (Ogborn, Kress, Martins, and McGillicuddy, 1996, p. 20). The second, closer to argumentation, points out that discursive interactions make it possible to interweave discourse and content, which in the case of science is the "coordination of evidence and theory to support or refute an explanatory conclusion, model, or prediction" (Osborne, Erduran, and Simon, 2004, p. 995).

So, the potential distinctions between the non-scientific and scientific language during small-group activities in primary school marks the scope of this paper. The data presented here comes from a three-month interventionist project to explore the adoption of a dialogic approach in Brazilian school culture. To do so, the research design involved a three-month professional development programme that included one half-day workshop and twelve two-hour sessions in a fashion of a co-inquiry teacher-researcher partnership. The sessions were divided into three modules: the first module focused on group work and ground rules for talk; the second module paid attention to knowledge building on the topic of evaporation; and in the third, teachers were invited to plan, deliver and reflect on their own lessons. The participants formed a group of three upper-primary teachers (year 5, age 10-11) and sixty students from the same public school.

In order to look for differences in group talk in relation to the tasks' content, four tasks were selected in which six groups participated. More objectively, the research question addressed in this paper can be framed in the following way: what are the similarities and differences (if any) in the group talk regarding the type of the task?

METHODOLOGY

This research builds on dialogic pedagogy, which focuses on the role of language in improving the quality of education (Calcagni and Lago, 2018; Mercer and Dawes, 2014); such a focus has shown positive impact on on students' learning and participation (Resnick, Asterhan and Clarke, 2017). In this context, small-group work plays an important role if effectively employed under certain circumstances. For instance, when students express contrasting opinions, justify the difference and attempt to find a resolution, small-group work promotes knowledge gains (Howe, 2014).

One of the programme aims was to foster productive group talk during eight tasks. Each task started with a briefing session intended to establish *ground rules* for talk, which can serve to regulate the group work (Warwick, Mercer and Kershner, 2013). The modelling of the use of these rules is related to the role of the teacher as a *guide on the side*, in which they should provide just contingent intervention to maintain student engagement in dialogue. In the following, the tasks under scrutiny and the coding method are briefly described.

Tasks description

All the four activities might be framed as tasks with high-level cognitive demands, as they present interpretive claims and allow multiples solutions (Sohmer, Michaels, O'Connor and Resnick, 2009). Another characteristic is that the tasks are interactive; they promote substantive dialogue on the same topic by building on partners' contributions through arguing, defending, confronting and challenging (Chi, 2009). In fact, the task formats entail a great amount of student talking and thinking and were designed to allow them to develop their own points of view. In the following subsections, we briefly outline the selected tasks. Tasks 3 and 4 are the tasks that convey science content.

Task 1 – Hot air balloon

In the first task, the group was presented with a situation in which a child is flying over a forest in a hot air balloon, and, in a certain region without trees, this child sees one smaller ball moving towards another bigger one. The children were instructed to think together to build as many ideas as possible that can explain this movement. The group should write down each of their ideas in a full sentence.

Task 2 – Unexplored island

In this task, the group was presented with a new situation (adapted from Luxford and Smart, 2009) in which they would join a group of explorers to sail to one recently discovered island. The group was told to pack just three of twelve pre-selected items, such as compass, matches, money, computer, amongst others. They had to decide which three items to take on board in the exploration and write down one completed sentence with at least one reason that explains their choice.

Task 3 – Light and shadow (Science)

This task is known as talking points and was adapted from Dawes (2012). In this task format, the group receives a worksheet with a series of ten statements that are not necessarily correct. The students should talk amongst themselves to decide if each statement should be marked as true, false or the group is unsure. For instance, they analysed sentences such: "Light can be made from electricity", "Shadows are always the same shape as the thing they are next", or, "You can get coloured shadow".

Task 4 – Evaporation (Science)

In this task, the group had to build an explanation regarding the topic of evaporation based on observations (SPRinG, n.d.). Firstly, the teacher made a handprint by dipping the palm of their hand in the water and pressing it onto the blackboard. Secondly, the teacher poured some liquid perfume into a dish and told the students to act as smell detectives. They should put up their hands when they smell the perfume. Then, the group had to discuss some questions (for example: "What do you think has happened to the water?", "What do you think has made the water go?", or "What was similar about the handprint disappearance and the perfume spreading?") and agree on the best answer to each question.

Coding

The data presented in this study comes from the recording of group talk during the above four different tasks, in which six groups participated. The discussions were recorded, transcribed in verbatim form, and analysed through a protocol, which drew on coding schemes for classroom dialogue from the literature (Hennessy et al., 2016). The unity of analysis is at the utterance level.

The resulting scheme contains 10 categories divided into three contexts (content, task and other) with six of those categories applied to highlight discursive functions for content (invitation, dialogic invitation, contribution, dialogic contribution, follow-up and dialogic evaluation). The categories are mutually exclusive, and therefore each utterance was assigned one code. For inter-reliability purposes, two judges independently coded three episodes and the pairwise percent agreement over the 10 categories varied between 89.06% and 98.44%, with a mean agreement across categories achieving an acceptable 94.64%.

Table 1: Coding scheme

Context	**Code**	**Definition and Examples**
CONTENT	1. Invitation	Code when there is a request for facts, opinion (without grounds), examples among others. *Examples: John? Say, John? What is going on, here?*
	2. Dialogic invitation	Code when there is a request for reasoning, reflecting, speculating, building on, positioning, clarifying, agreement or consensus. *Examples: Why? How do know this? Say more… What else? Do you agree?*
	3. Contribution	Code for lecturing, stating facts or examples, repetitions, stating opinions or expressing ideas without grounds. *Examples: Heat and wind. It evaporates.*
	4. Dialogic contribution	Code when a current or previous contribution is followed by reasoning, expanding, elaboration, building on, referencing back or beyond. *Examples: Vapour rises up and makes clouds.*
	5. Follow-up	Code for quick evaluations, simple reactions, agreement or querying. *Examples: I see; Right; Yes, No, I agree, It is not vapour, I don't think so*
	6. Dialogic evaluation	Assessing status of answer by stating it is wrong and followed by justification. *Examples: No, It will get humid.*
TASK	7. Instruction	Code when talk is about task-related procedures: reading out the instructions or answers, spelling out words for others, negotiating writing or reading. *Examples: Go, It is me; Your turn; She writes; Is it your turn? Write down.*

OTHER	8. Off-topic	One talks about something that is not related to the task or topic of discussion. *Examples: recorder, nails, hair, friend, travel, go out, handwriting, jokes*
	9. Other	Interaction is not covered by any of the other categories. *Examples: I think that I know, It evaporates because…,*
	10. Indecipherable	Interaction is either inaudible or indecipherable. *Examples: See notation in the transcript.*

Given the interest of the overall programme, engagement in academically productive dialogue will be operationalised as relatively high occurrences of the dialogic codes. Here, the focus is to search for variations in the codes' occurrences among the scientific and non-scientific tasks.

RESULTS

Again, the data presented in this paper come from the recording of the discussion of six groups while they participated in four different tasks. As each task did not last for the same duration, the comparisons of the codes absolute occurrences amongst the tasks would not be appropriate or precise. For this reason, the analysis consists of the *relative frequency of each code in relation to the total number of utterances in each episode*, which is understood here as one whole discussion recorded. In order to find the aggregated result per each task, the average frequency and standard deviation of each code were calculated among the six groups.

Moreover, the results are divided into two main aspects: the context of talk and the discursive functions. Firstly, the entire discussion is considered, and the relative codes frequencies presented measure the number of utterances related to content (aggregated of codes 1 to 6, applied when students are talking about the content of the task), task (code 7, when the topic is about task-related procedures) and other (codes 8 to 10 to highlight off-topic conversation or meaningless or indecipherable utterances). Secondly, the analysis focuses on talk regarding the task content – here, we present and analyse separately the relative frequencies of codes 1 to 6. In this latter case, the relative frequency is obtained for those utterances related to content.

In total, 24 episodes were coded (6 groups participating in 4 tasks). On average, one episode consisted of 194 utterances and lasted for 14.36 minutes. Analysing the episodes divided into the two kinds of tasks, an average non-scientific episode accounted for 175 utterances and 11 minutes, while a scientific episode comprised 212 utterances and 17.34 minutes.

Context

Overall, no difference was found in the codes' frequencies between the non-scientific and scientific tasks (Figure 1). Around half of the utterances was about content (0.51 ± 0.15 SD and 0.56 ± 0.13), just under a quarter accounted for task (0.24 ± 0.11 and 0.24 ± 0.04) and almost another quarter was assigned as other (0.25 ± 0.12 and 0.20 ± 0.11). Curiously, and making explicit the diversity of codes' frequencies throughout the tasks, the scientific tasks presented the highest (0.67 for task 3) and lowest (0.45 for task 4) frequencies for content, while the non-scientific tasks showed the highest (0.28 for task 1) and lowest (0.20 for task 2) frequencies for task.

The low variation in frequencies of each code between the two kinds of tasks is reflected in the ANOVA single factor analysis. There were no significant differences between non-scientific and scientific tasks (*p*-value = 0.39 for content; 0.94 for task; and 0.34 for other).

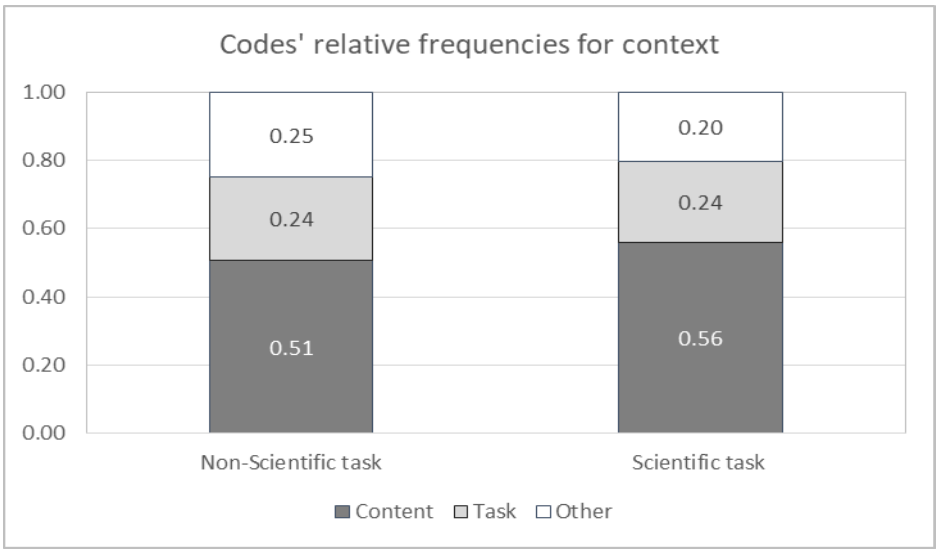

Figure 1.

Discursive function

Here, there was no statistically significant difference in the codes that represent discursive functions between non-scientific and scientific tasks; the p-value ranged from 0.054 for invitation, to 0.792 for dialogic contribution (Figure 2).

Contribution was the most common discursive function employed in both kinds of tasks, accounting for more than half of the utterances related to content (0.58 ± 0.14 and 0.64 ± 0.21, considering contribution and dialogic contribution together). Invitations accounted for around 20% and 25% of the talk and were divided slightly equal into ordinary and dialogic ones (respectively 0.13 ± 0.07 and 0.11 ± 0.04 for non-scientific tasks, and 0.08 ± 0.04 and 0.12 ± 0.05 for scientific tasks). Dialogic evaluations were very rare in both cases, comprising just one percent of the utterances (0.01 ± 0.01).

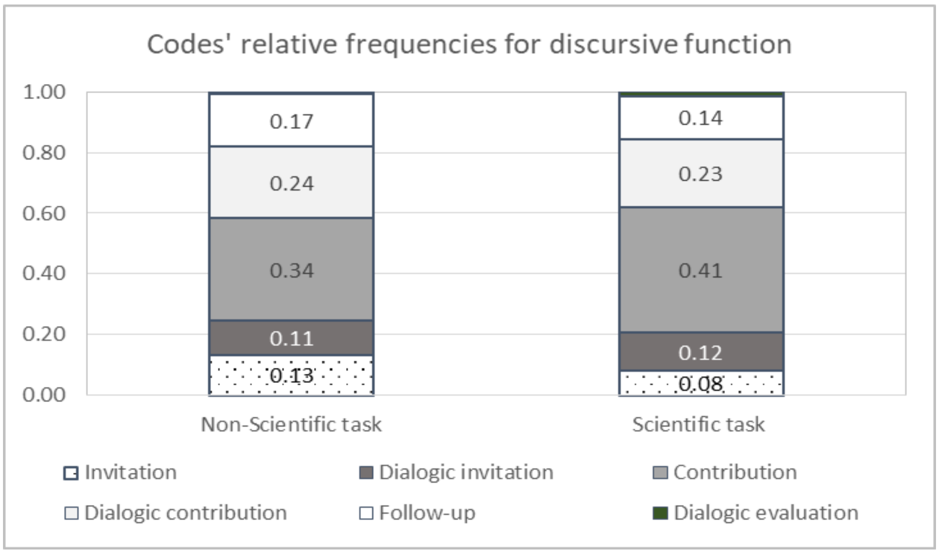

Figure 2.

DISCUSSION

Firstly, it is worth noting that small-group work is a classroom arrangement where students can actively talk and think, exposing their views to challenges and criticisms. The episodes analysed here comprise moments in which students freely interact for 15 minutes and present, on average, one utterance every five seconds, on average. This experience is totally different from whole-class teaching, where students are not allowed to engage with others students' ideas so frequently and are always under the vicarious presence of the teacher (Galton, Hargreaves, Comber, Wall and Pell, 1999; Howe, 2010). Findings from this same project that are not yet published, show that while students pose questions in around 25% of their utterances during group-work, this discursive function is seldom employed by them in whole-class teaching, accounting for only one percent of their utterances.

However, much research has also shown that small-group work needs to overcome some challenges in order to be considered effective (Baines, Blatchford and Chowne, 2007). This aspect has emerged clearly in our data, as students were actually engaged with the content of the task for only half the time. Moreover, even when they were talking about the topic in the discussion, around one-quarter of the utterances were assigned as follow-up, which is the category for quick evaluations, simple reactions, agreement or querying and does not convey deep meanings. So, working on some strategies to promote productive interactions during small-group work is required.

Regarding the fact that neither difference was found in the group talk during the non-scientific and scientific tasks, we highlight three tentative explanations. Firstly, one might argue that the coding scheme is not fine-grained enough to highlight the distinctiveness of the scientific language. It is true that the scheme was built on other studies focused on the analysis of classroom dialogue in general; however, it is possible to speculate that there would be more occurrences of content, dialogic contribution and dialogic evaluation in science lessons as these codes reflect reasoning based on evidence and argumentation.

Secondly, the primary science language might not require any specialisation in relation to other disciplines; that is, many studies have shown the pervasive role of argumentation in Mathematics, History and Philosophy classrooms (Gregory, 2007; Schwarz and Baker, 2016), as well as in everyday situations among adults or children (Arcidiacono and Bova, 2013; Schär and Greco, 2018). This might point out that in primary school when students are still developing their basic language skills and vocabulary, the more refined character of the language of science is not accessible yet.

Thirdly, it is important to explore the role of talk in the knowledge building processes in collaborative situations. Barnes (1976, 2008) discusses the relationships between developing understanding and the various kinds of talk. In particular, he differentiates two functions of talk: in the first, called presentational talk, the speaker's attention is focused on the presentation of their ideas to an audience or to themselves, in a which requires them to organise their own thoughts. That is, it manifests a kind of finalised reasoning. On the other hand, exploratory talk occurs when the speaker is building their thoughts; trying out ideas, evaluating the sense that others make of them, and arranging new information. This kind of talk deals with drafted ideas and, it is supposed to be the language of the knowledge building process. If we accepted this assumption, during the collaborative tasks' students may present much more of this hesitant and incomplete talk rather than the presentational talk; this latter would be more associated with the precise language of science.

In addition, ethnographic studies have shown that the construction of science within scientific laboratories resembles, in many aspects, argumentations amongst lawyers or politicians (Schwarz and Baker, 2016). So, considering the meaning-making process is made through an interpretive activity involving talk in a science lesson, it might be expected that a lot of exploratory talk would be going on. In this sense, the distinctiveness of the language of science would appear more explicit in the writing of papers and reports rather than in genuine talk.

CONCLUSIONS

Our results on small-group interactions in primary school have not suggested a distinctive role for scientific language. We have briefly discussed some points that might explain this result. If this is true, it might be said that students do not spontaneously manifest the particularities of the scientific language by chance; that is to say, the participation in dialogic activities about scientific content does not guarantee the proper use of the science language. Therefore, this work reinforces the suggestion that teachers or curriculum materials should play an essential role in explicitly addressing these science-related aspects of language (Hodson, 2009; Larraín et al., 2017). More specifically, this means that during discursive interactions, teachers should act as a discourse guide while modelling the proper use of scientific language, making reference to its distinctive nature, and providing activities that work on these aspects (Hodson, 2009; Mercer, 1995).

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XVIII IOSTE SYMPOSIUM

Future educational challenges from a science and technology perspectives.

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Pre-service Teacher Health Literacy: Understanding, Development, Significance Aspects

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Abstract

It is without doubt, that education is one of the main social factors having influence on health. Health education is most effective at school, because it reaches a man at his most receptive period of life - childhood and adolescence. A demand to live a healthy life is formed not only by family, but also by school. Teachers' role in health education process is very significant, therefore, their health literacy and health competence are the main components realising health education at school. During the studies at university preservice teachers in one way or another develop health competence, however hopefully not enough attention is paid to this, and study process poorly contributes to health literacy improvement, health competence formation. A qualitative research was carried out, by which it is sought to ascertain university students', preservice teachers' position on health literacy question. In the research participated two Lithuanian university pedagogy study bachelor programme students (101 respondents). For data collection 5 open questions were used, data were analysed using a quantitative content analysis type, when a code system is defined, calculation results are presented in the form of tables. It has been stated, that students' health literacy basically is related to the knowledge about health, healthy way of living, personal example to live a healthy life. A traditional attitude to health literacy improvement possibilities is noticed. Non-formal health education activity is slightly accentuated, the importance of emotional, spiritual health and health care is almost not emphasised.

Keywords: qualitative research, health literacy, pre-service teachers, university students

INTRODUCTION

Health conception and evaluation are not unambiguous matters. Every person's life quality is closely related to health (health quality). World health organisation (WHO) defined health as an individual's "physical, psychic and social wellbeing, and not only the absence of disease" (http://www.who.int/about/mission/en). It is known, that health is determined not only by inheritance, environment, but also by way of living (about 40-60%). Not in vain, one of the main purposes of European policy strategy "Health 2020" is all people health improvement and health inequality reduction.

Research show (Zagurskienė & Misevičienė, 2008; Rapolienė, Eigėlytė, Gedrimė, Norkienė, Sąlyga, & 2017), that Lithuanian health literacy is quite low, there is lack of information both concretely about diseases and in general, how to form healthy living habits, how to finally live a healthy life. A similar situation is in teacher population as well. Research show, that good or sufficient health literacy is typical for only 28.8% of teachers, while insufficient health literacy is typical for 42% of teachers, and for 29.2% – doubtful health literacy (Kalinkevičienė, Česnavičienė, & Ustilaitė, 2016). The earlier research carried out in Lithuanian senior form students' population showed that students do not get enough information on health questions at school, health events are also very rare. The students themselves think, that very little attention is paid to healthy living questions at schools, very often the information they have is controversial (Lamanauskas & Armonienė, 2012). It is obvious, that teacher health literacy and health competence are two main factors directly influencing students' health literacy, forming healthy lifestyle habits. The researchers define, that teacher health literacy has an undoubted influence on effective health education (Byrne, Pickett, Rietdijk, Shepherd, Grace, & Roderick, 2016; Peterson, Cooper, & Laird, 2001), teacher's knowledge, abilities, skilfulness, personal example and other. Speaking about university students one can state, that their health literacy is also of great concern. For example, it has been noticed, that students' knowledge about healthy lifestyle significantly differs from its practical implementation (Pelegrimaitė, Vaitkevičius, & Bakanovienė, 2011).

In the international context health literacy research occupy an important place. Basically, it is agreed, that teachers play an important role in delivering health education to empower students with skills for healthy living (Cheng & Wong, 2015), at the same time it is accentuated a need to improve teachers' health literacy. Schools are considered to be settings for both health education and health promotion (Jourdan, Samdal, Diagne, & Carvalho, 2008). It is emphasised a need for health promotion to be placed on the preservice teacher education curriculum (McNamara, Moynihan, Jourdan, & Lynch, 2012). Also, an attitude is held, that all teachers must have adequate health knowledge and understanding in health literacy and health competence field (Apostolidou & Fontana, 2003).

In general, health literacy research in Lithuania are poor, very spread out in interdisciplinary scientific literature, not consecutive. There is lack of research, grounding pre-service teacher health literacy level, discussing study improvement questions at university on the aspect of health literacy promotion and so on. Teachers mostly work with children and youth. As it is known, the behaviour of young people and their way of living dramatically change in the process of growing up and going through various age periods. Some of them (e.g., adolescence) is a very risky life period, when negative aspects of living like smoking, alcohol and drug use and other can occur. So, teachers are qualified health literacy education characters, whose one of the functions is to provide the learners with the necessary self-expression devices, to form possibilities for acquiring abilities and skills, necessary for continuous health literacy improvement (Šveikauskas, 2005). On the other hand, in Lithuanian national health conception it is stated, that education institutions are priority health strengthening places, in which the efforts of pedagogues, parents and school, public health care specialists are unified, forming proper children and youth attitude to health, improving their health literacy and promoting healthy living. Health literacy, as a separate literacy form, becomes more important for social, economic, and health development, and teachers get a special role promoting health literacy for children and adolescents.

Thus, the main research *aim* was to ascertain university students', pre-service teachers' position on health literacy question. It was sought to find out how students understand health literacy, healthy living, what students' health literacy improvement possibilities they discern, how they value personal abilities in the health field and how they perceive teacher health literacy importance in an education process. It is hopeful, that empiric research results will help to effectively improve university studies regarding students' health literacy development, and also will allow giving some insight on health education improvement in general.

METHODOLOGY OF RESEARCH

General Research Characteristics

This is a pilot study in a qualitative research. Such research is specifically recognized as "basic or generic qualitative research" (Merriam, 1998), because it has the essential characteristics of qualitative research (e.g., eliciting meaning, researcher as data collection and analysis instrument, and rich description). On the other hand, such research generates "words, rather than numbers, as data analysis" (Mack, Woodsong, MacQueen, Guest, & Namey, 2005, p.2).

The research was carried out in January 2018. Research participants' verbal agreement was received before the research. The research is grounded on the attitude, that students' opinion and evaluation research are important, because they allow establishing urgent problems and clarifying the already known ones, foreseeing study improvement possibilities. Investigation into opinions is an effective means seeking to initiate changes, in this case, to improve university study quality. It was taken into consideration, that qualitative research (qualitative research method application) are very suitable for investigating health and health related problems, they are increasingly widely used in the scientific research related to health (Pope & Mays, 1999; Sandelowski, 2000).

Instrument

The instrument prepared by the researchers was used in the research, which included five major open questions/tasks.

- How do you understand teacher health literacy? Comment, please.
- What does healthy living / healthy lifestyle mean to you? Comment, please.
- How to improve students' health literacy? Comment, please?
- Evaluate (describe) your abilities, necessary to find information about health, understand it, evaluate and apply?
- What significance do you think teacher health literacy has, educating (teaching) students to live a healthy life?

Questions include general students' understanding about health literacy and healthy living, health literacy improvement, personal ability evaluation.

Research Sample

Bachelor students, pre-service teachers from two Lithuanian universities – Siauliai university (89 students) and Lithuanian university of educational sciences (12 students) – participated in the research. In total, 101 students (83 female and 18 male) took part in the research. The above-mentioned universities are the main institutions training science teachers in Lithuania. For the formation of sample, non - probability purposive research group formation method was chosen, when the people included into a research group are the most typical in respect to the researched quality.

Table1. Information about respondents.

Study programme	Course	*N*
Primary and preschool education	2	10
Social pedagogy	2	9
Special pedagogy and logopaedics	1; 3; 4	47
Physical education and sports pedagogy	1; 2; 4	15

Preschool and primary education	1	6
Education	4	4
Primary education	2; 3	10

Referring to Morse (1994), the sample of 30-50 participants is suitable for such kind of research. Qualitative sample size may best be determined by the time allotted, resources available, and study objectives (Patton, 1990). According to Creswell (1998), a range of 20-30 participants is acceptable for qualitative samples. So, the attitude is held that such sample is sufficiently representative in a qualitative research and allows drawing particular conclusions.

Data Analysis

Research data were expressed in writing. The obtained respondents' answers were coded. The most frequently repeating semantic units were grouped until the initial groups called sub-categories appeared. In the second stage the sub-categories were combined into categories. The qualitative research data were processed using content analysis, when in the informative array essential characteristics are distinguished; the interrelationship with other categories/themes/dimensions is sought. Thus, data are analysed choosing an inductive method- from separate, special towards a more common perspective (Luobikienė, 2000). The obtained verbal data array, referring to conventional *content* analysis methods, was analysed in three stages:

- multiple answer reading and analysing;
- semantically related answers and "keywords" are sought;
- semantic unit interpretation and coordination.

A quantitative content analysis type was chosen, when code system is defined, calculation results are presented in the form of tables. In order to guarantee data analysis reliability, semantic unit distinction and later on grouping was carried out independently by two researchers. In the later stage, the researchers were looking for a consensus due to sub-category attaching to categories. Co-ordination and proof-reading went on in two stages. One-week break was made between the first and the second co-ordination stages. The co-ordination degree was higher than 95%. Miles and Huberman (1994) state, that it is enough for the reliability of data to find correspondence percentage higher than .70.

RESEARCH RESULTS

Having analysed the respondents' expressed opinions about teacher health literacy understanding, three categories were distinguished: *Teacher health knowledge, Teacher health education abilities, Teacher personal example* (Table 2).

Table 2. Teacher health literacy understanding.

Category	*N* (%)	Subcategory	*N* (%)	Subcategory components	*N* (%)
				Knowledge about health, knows about it	16 (11.0)
		Knowledge about health care	26 (17.9)	Knows how to strengthen health	5 (3.4)
				Knows requirements about children's health	2 (1.4)

Teacher health knowledge	56 (38.7)			Knowledge about health care	2 (1.4)
				Knowledge about first aid provision	1 (0.7)
		Knowledge about healthy lifestyle	19 (13.2)	Knows healthy lifestyle peculiarities /healthy living	18 (12.5)
				Teacher's knowledge about the harm of bad habits for children	1 (0.7)
		Knowledge about diseases	10 (6.9)	Knows about disease prevention in advance	8 (5.5)
				Knowledge about diseases	1 (0.7)
				Knowledge about health disorders	1 (0.7)
		Knowledge about active activities	1 (0.7)	Teacher's knowledge about sport and active activities	1 (0.7)
Teacher health education abilities	53 (36.1)	Education process management	27 (18.4)	Able to convey/spread/share health knowledge visually and instructively	12 (8.2)
				Carries out children's education about healthy living	6 (4.1)
				Able to convey information about health to children	6 (4.1)
				Able to find medical information (information about health) in various resources	3 (2.0)
		Education content management	26 (17.7)	Understands information related to health	10 (6.8)
				Understands what health is	7 (4.8)
				Knows about healthy nutrition habits	4 (2.7)
				Knows health care questions	3 (2.0)
				Able to understand health factors	2 (1.4)
Teacher personal example	22 (15.0)	Interest	12 (8.2)	Interested in health questions	8 (5.5)
				Interested in healthy living	4 (2.7)
		Healthy living	10 (6.8)	Propagates healthy lifestyle	4 (2.7)
				Able personally to live healthy and active life	3 (2.0)
				Eats healthy food	2 (1.4)
				Able to follow hygiene norms	1 (0.7)
Not clear/very little understandable sphere				Do not understand, very little understand	15 (10.2)

Note: Totally, 146 semantic units were distinguished

The first category *Teacher health knowledge* (38.7%) has the biggest significance. Teacher *knowledge about health care* (17.9%) (knowledge about health, knowledge how to strengthen it and take care of it, knowledge about requirements for children's health, first aid), *knowledge about healthy lifestyle* (13.2%) (healthy lifestyle peculiarities, about the harm of bad habits for children), *knowledge about diseases* (6.9%) (disease prevention in advance, health disorders), *knowledge about active activities* (0.7%) are accentuated here.

The second category *Teacher health education abilities* (36.1%) is of great significance as well. Teacher *education process management is accentuated* (18.4%): teacher carries out students' education about healthy living visually, is able to find medical information about health and to convey it to students. Teacher *education content management* is accentuated (17.7%): teacher understands information about health, has knowledge about healthy nutrition habits, health care questions, health factors.

The third category *Teacher personal example* (15.0%) demonstrates, that teacher has to be personally interested in health, healthy living questions and personally propagate healthy lifestyle and personally live a healthy and active life, eat healthy food.

The distinguished categories te*acher health knowledge* (38.7%), *Teacher health education abilities* (36.1%), *teacher personal example* (15.0%), obviously show, that students understand teacher health literacy as teacher's knowledge about health, ability to convey it to students and to be a personal healthy living example for them.

Quite a big part of students (10.2%) point out, that teacher health literacy for them is *not clear/a little understandable sphere.*

Having analysed respondents' expressed opinions what personally for them healthy living/healthy lifestyle means, three categories were distinguished: *Good health*, *Active physical activity*, *Life quality* (Table 3).

Table 3. Healthy living / healthy lifestyle understanding.

Category	***N* (%)**	**Subcategory**	***N* (%)**	**Subcategory components**	***N* (%)**
Good health	87 (51.3)	Nutrition	57 (33.7)	Healthy nutrition	48 (28.4)
				Balanced nutrition	8 (4.7)
				Sticking to your diet	1 (0.6)
				Healthy and happy man	3 (1.7)
		Emotional stability	9 (5.3)	Positiveness and good mood	2 (1.2)
				Balanced physical, emotional health	2 (1.2)
				Emotional stability	1 (0.6)
				Meditation	1 (0.6)
				Self-care	5 (2.9)

		Hygiene	8 (4.6)	Proper hygiene skills, hygiene maintenance	3 (1.7)
				Proper, quality sleep	5 (2.9)
		Rest	7 (4.1)	Proper rest	2 (1.2)
		Health care		Health care	2 (1.2)
			4 (2.4)	Constant health care	2 (1.2)
		Regime	2 (1.2)	Proper day regime	2 (1.2)
Active physical activity	43 (25.3)	Sport	31 (18.3)	Going in for sports regularly	14 (8.3)
				Physical activeness	17 (10.0)
				Active leisure time	8 (4.7)
		Active activities	12 (7.0)	Active lifestyle	4 (2.3)
Life quality	40 (23.4)	Wellbeing	25 (14.7)	Good wellbeing	20 (11.8)
				Healthy attitude to life	3 (1.7)
				Listening to organism's demands	1 (0.6)
				Longer and healthier life	1 (0.6)
		Self-care	15 (8.7)	Not having bad habits	10 (5.8)
				Conditioning	3 (1.7)
				Universal self-care	2 (1.2)

Note: Totally, 170 semantic units were distinguished

The first category *Good health* (51.3%) demonstrates, that for the biggest part of students healthy living, first of all, means healthy, balanced *nutrition* (33.7%), sticking to a diet. It is obvious, that such students' attitude to healthy living is formed by the information having lately appeared in the media and television about food structure quality and preservative, sugar and other food additive and food processing technology harmful effect on human health. *Emotional stability* (5.3%) has a weak expression in understanding structure: happiness, positive, good mood, balanced physical and emotional health, emotional stability, meditation. This is a very important part of healthy living. Lately, rapid changes taking place in all human life and activity spheres, life pace becoming faster, psychic human health becomes very important. As *Good health* components students accentuate *hygiene* (4.6%) maintenance, *rest* (4.1%), *health care* (2.4%) *regime* (1.2%).

The second category according to significance is *Active physical activity* (25.3%). For the students the most important here is *sport* (18.3%) and active activities (7.0%) i.e. going regularly in for sports and active lifestyle and leisure time.

The third category *Life quality* (23.4%) has also a similar significance. Students understand life quality as *good wellbeing* (14.7%), i.e. healthy attitude to life, ability to listen to organism's demands, longer and healthier life and *self-care* (8.7%), i.e. not having bad habits, conditioning.

Having analysed students' opinion, how one could improve students' health literacy, two categories were distinguished: *Study process improvement* and *Non-formal health education activity* (Table 4).

Table 4. Students' health literacy improvement possibilities.

Category	*N* (%)	Subcategory	*N* (%)	Subcategory components	*N* (%)
Study process improvement	76 (65.6)	Lectures	54 (46.7)	More lectures about healthy living / health	34 (29.5)
				Seminars about health care	16 (13.8)
				Preventive lectures	3 (2.6)
				Lectures about diseases and their prevention	1 (0.8)
		Study subject	14 (12.1)	Compulsory study module	6 (5.2)
				Organise additional teachings for students	6 (5.2)
				Specialised courses	2 (1.7)
		Conferences	5 (4.3)	Prepare students' conferences	5 (4.3)
		Additional study activities	3 (2.5)	Healthy nutrition principle propagation	2 (1.7)
				Teach how to provide first aid	1 (0.8)
Non-formal health educational activity	40 (34.4)	Events	37 (31.8)	Arrange public discussions	10 (8.6)
				Various events on these questions	8 (6.9)
				Project activities /actions	6 (5.2)
				Various educational occupations	5 (4.3)
				Various active occupations	3 (2.6)
				Consultations with specialists	3 (2.6)
				Organise healthy living days	1 (0.8)
				Film review and discussions	1 (0.8)
		Self-education	3 (2.6)	Self-education	3 (2.6)

Note: Totally, 116 semantic units were distinguished

The first category *Study process improvement* (65.6%) has the biggest significance. In this category students' suggestions, related to *lectures* (46.7%) were revealed. Students think that their health literacy would improve if there were more lectures about healthy living, health, about diseases, their prevention, seminars about health care and so on. In students' opinion, their health literacy would improve implementing a special or compulsory study subject (12.1%), participation in conferences (4.3%), *additional study activities* (2.5%).

The second category *Non-formal health education activity* (34.4%) has a smaller importance than the first category. In students' opinion, very important here are non-formal *events* (31.8%): discussions, project activity, educational activities, consultations, healthy living days, film reviews and discussion and so on. Only a small part of students think that *self-education* (2.6%) could improve their health literacy.

Having analysed students' opinion about their abilities, necessary to find information about health, to understand it, evaluate and apply, three categories were distinguished: *High abilities*, *Satisfactory abilities* and *Average abilities* (Table 5).

Table 5. Personal abilities to find information about health, to understand it, evaluate and apply.

Category	***N* (%)**	**Subcategory**	***N* (%)**	**Subcategory components**	***N* (%)**
High abilities	99 (73.0)	Informational abilities	73 (54.2)	Able to find information in the internet when I need it	45 (33.8)
				Able to find information in various articles, books and other.	20 (14.6)
				Can select actual and useful information	8 (5.8)
		Analytical abilities	14 (10.1)	Interested in this sphere additionally	4 (2.9)
				Abilities in this sphere are good	4 (2.9)
				Able to understand the importance of healthy living	3 (2.2)
				Able to evaluate buyable products	1 (0.7)
				Able to systemise information	1 (0.7)
				Make self-analysis	1 (0.7)
		Help search	12 (8.7)	Consultations with doctors when it is necessary	7 (5.1)
				Apply to a family doctor when it is necessary	5 (3.6)
Satisfactory abilities	22 (16.1)	Information perception	13 (9.5)	Abilities in this sphere are satisfactory	6 (4.4)
				It is difficult to perceive if the information found is true	4 (2.9)
				Not interested in health questions in-depth	3 (2.2)
			9 (6.6)	Abilities to find information about health are poor	6 (4.4)

		Information search		It is difficult to select necessary, proper information	3 (2.2)
Average abilities	15 (10.9)	Informational abilities	15 (10.9)	Abilities on health questions are on average	10 (7.3)
				To evaluate information on health topic is very complicated	5 (3.6)

Note: Totally, 136 semantic units were discerned

The first category *High abilities* (73.0%) shows that students highly value their abilities, necessary to find information about health, to understand it, evaluate and apply. Subcategory *Informational abilities* (54.2%) shows, that students are able to find actual and useful information in the internet, in the articles, in the books. Subcategory *Analytical abilities* (10.1%) shows that students are interested in health and healthy living, understand their importance, are able to analyse and systemise information, evaluate buyable products. Subcategory *Help search* (8.7%) shows that if there is a necessity, students are able to search for help, applying to the doctors.

The second category according to significance *Satisfactory abilities* (16.1%) shows, that part of the students their abilities, necessary to find information about health, to understand it, evaluate and apply value satisfactorily. Students point out, that it is hard for them to perceive if the information found is true, it is difficult to select the necessary, proper information or they are just not interested in health questions.

The third category *Average abilities* (10.9%) shows that only a small part of students think, that their abilities to find information about health, to understand it, evaluate and apply are on average, because to evaluate information on health topic is rather complicated.

Having analysed students' opinion, what significance teacher health literacy has educating (teaching) students to live a healthy life, two categories were distinguished: *Positive significance* and *Students' health competence education* (Table 6).

Table 6. Teacher health literacy significance in the education process.

Category	***N* (%)**	**Subcategory**	***N* (%)**	**Subcategory components**	***N* (%)**
Positive significance	73 (65.1)	Manifold/ diverse significance	58 (51.1)	Significance is very big	48 (42.4)
				Has positive significance	6 (5.3)
				This is very important and useful	2 (1.7)
				Has a great influence on students	2 (1.7)
		Encouraging significance	16 (14.0)	Encourages students to be interested in health questions	8 (7.0)

				Encourages students to live a healthy life	7 (6.1)
				Important preventive function	1 (0.9)
Students' health competence education	40 (34.9)	Knowledge provision	24 (21.0)	Provides knowledge about health	14 (12.3)
				Introduces students to healthy living	5 (4.4)
				It is important to teach children to live a healthy life	3 (2.6)
				Forms understanding about healthy living benefits and importance	2 (1.7)
		Behaviour formation	12 (10.4)	Forms positive attitude to healthy living	4 (3.5)
				Propagates healthy lifestyle	3 (2.6)
				Helps to form healthy nutrition habits	3 (2.6)
				Makes students interested in health care	2 (1.7)
		Motivation formation	4 (3.5)	Motivates students to eat healthy food	3 (2.6)
				Motivates students to do sports	1 (0.9)

Note: Totally, 114 semantic units were discerned

The first category *Positive significance* (65.1%) has the biggest significance. Students' answers allowed thinking, that teacher health literacy significance for students is *manifold / diverse* (51.1%), because it is very significant, has a positive effect, has a big influence on students. Teacher health literacy has *encouraging significance* (14.0%), because teacher encourages students to be interested in health questions, to live a healthy life.

The second category according to importance is *Students' health competence education* (34.9%). Students' answers allowed stating, that in this category the most important part is *knowledge provision* (21.0%) for students. Teacher, having proper health literacy, can convey knowledge to students about health, to introduce healthy living to them, to teach children to live a happy life, to form understanding about healthy living benefits and importance. Teacher health literacy is of great importance to students' *behaviour formation* (10.4%). Teacher can form students' positive attitude to healthy living, form healthy nutrition habits, engage in health care.

CONCLUSIONS

The carried-out research results allow stating, that students understand teacher health literacy as teacher health knowledge possession, health education abilities and teacher personal example. Teacher must have knowledge about health, diseases, healthy lifestyle, sport and active activity benefits. Teacher has to be able to convey this knowledge to students managing education process and education content. Teacher should set a good example to his students, has to be interested in healthy living and to live a healthy life. On the other hand, for not a small part of students, teacher health literacy is not a clear/*little understandable sphere*. One can think that such position is influenced by general educational preparation.

For the students healthy living/healthy lifestyle first of all, means good health, active physical activity and life quality. Students especially accentuate healthy nutrition, sport, good wellbeing. Emotional condition, health care, psychic health make a small part in the healthy lifestyle understanding structure.

The research results revealed students' opinion on how one could improve students' health literacy. The majority of students think that their health literacy would improve having improved the study process, i.e. giving more lectures about health, healthy living, diseases, implementing additional study subject or special courses. Part of the students think that non-formal health educational activity would improve their health literacy: discussions, project activity, educational activities, consultations and so on. Only a small part of students think, that self-education could serve in a good way. It is obvious, that basically conservative/extensive way is accentuated, while non-formal health education activity (and especially self-education) occupies significantly a small part.

The biggest part of students their abilities, necessary to find information about health, to understand it, evaluate and apply value high (the bigger part is related to internet possibilities and usage). They think, that they can find proper information, analyse it, and if necessary, consult the doctor. Not a small part of students their abilities, necessary to find information about health, to understand it, value satisfactorily. It is difficult for them to perceive if the information found is true, they are interested very little in this sphere and so on. Only a small part of students value their abilities in this sphere on average.

The research results allow stating, that all students understand the importance of teacher health literacy, educating (teaching) students to live a healthy life. The majority of students think that teacher health literacy has positive significance. Most often it is manifold / diverse and encouraging i.e. has very a huge influence and significance on students, encourages them to be interested and to live a healthy life. A big part of students think, that teacher health literacy allows teacher to successfully educate students' health competences: provide knowledge, form behaviour, motivation.

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XVIII IOSTE SYMPOSIUM

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Towards a Pedagogy of Hope: Irony and Emergence in Science Education

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Abstract

Although functional scientific literacy is now an accepted part of scientific curricula there is still uneasiness in a pedagogy integrating social values and everyday experiences with science concepts. These problems go beyond pedagogical skills and have deeper roots in epistemology of science, Human philosophy and Enlightenment rationality. A critical realist approach argues for ontological realism, epistemological relativism and judgmental rationality, i.e. knowledge has rational means of validation. While recognising a distinction between facts and values it sees no dichotomy between fact and value. Its aim is to identify those real mechanisms operating in a causal relationship discovered by studying Nature as an open rather than a closed system. Underlying structures which explain events in the world therefore depend on a complex of interacting mechanisms which presuppose an interdisciplinary epistemology. Using critical realism I explain why human freedom is essential for science practise and why science concepts are interwoven with social justice in understanding the world.

Keywords: critical realism; science pedagogy; social justice

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THE PROBLEM OF SCIENCE AND SOCIETY IN THE SCHOOL CURRICULUM

Historically science in the curriculum has had an uneasy relationship with other disciplines such as the arts and humanities. In the contemporary curriculum the scientific literacy movement (DeHart Hurd, 1998; Roberts, 2011) has recognised that scientific knowledge can underpin our understanding and engagement with social issues. But attempts to connect or integrate science with other disciplines and to give it a base in social justice has met with cultural and epistemological problems, and there is still ambivalence in contemporary scholarship on the matter. Resistance to Enlightenment rationality is one factor; iconic examples stem from the Romantic movement, for example, William Blake's depiction of Newton and scientific determinism as alien to the human spirit, and Tolstoy's coruscating view of science 'Science is meaningless because it gives no answer to our question, the only question important to us, "what shall we do and how shall we live?"' (cited in Bernstein, 1998, p. 38). More recently C.P. Snow's *Two Cultures* (Snow, 2014) of the mid- twentieth century and the *Science Wars* of the 1990s (Ross, 1996) highlighted deep-rooted differences between power-brokers and scholars of the unique epistemological status of science. Scepticism of the role of science in an interdisciplinary education also came from the education community. Hirst and Peters (1970) influential book, *The Logic of Education*, analysed the curriculum as 'forms of knowledge' with distinctive types of test 'for objective claims' (p.63). Hence, terms and concepts which are characteristic of science such as 'momentum', 'electron spin', 'photosynthesis', are irreducibly different from terms such as 'ought' and 'rights' which are in the domain of moral knowledge. That each discipline has terms which are non-reducible to other subjects reflects David Hume's naturalistic fallacy (Hudson, 1969) whereby moral action cannot be inferred from descriptive statements. This particular perspective on science was eloquently and somewhat irascibly framed in depicting the limits of science pedagogy.

> "Science is a discipline concerned exclusively with the reliability that can be attributed to factual ('is') statements as a result of empirical investigation. It is widely recognised that 'is' statements in science cannot be turned into the 'ought' statements of moral discourse. For example, science can fairly accurately judge the consequences of bringing together a number of subcritical masses of U-235 above a densely populated geographical area. It can say, absolutely nothing, however, about whether such an action would be right or wrong." (Hall, 1999, p.15).

In the last thirty years, reforms to the curriculum in many different post-industrial countries have recognised the need to 'socialise' the science curriculum in relation to social and everyday concerns, although Gough (2015) has perceptively noted that recent reforms are often a response to free market policies and values. Trends in globalisation and international competitiveness have also concurrently provided opposing reforms. British government responses to a relatively low position arising from PISA are typified by a government curriculum advisor.

> 'We have believed that we need to keep the National Curriculum up to date with topical issues but oxidation and gravity don't date … we are taking it back to the core stuff.' (http://www.guardian.co.uk/education/2011/jun/12/climate-change-curriculum-government-adviser).

The disjunction of facts from values is both historically and philosophically problematic. It is ironic – and I will return to the case of irony in science - that those scientists most associated with determinism and empiricism in western scientific history expressed their scientific thinking in religious terms in the case of Newton, and teleological terms in the case of Darwin.

> 'So then Gravity may put ye Planets into Motion, but without ye divine Power it could never put them into such a Circulating Motion as they have about ye Sun; & therefore, for this, as well as other Reasons**,** I am compelled to ascribe ye Frame of this Systeme to an intelligent agent. (Isaac Newton, *Letter to Richard Bently (17 Jan 1693)*)

> '. . . Natural selection works solely by and for the good of each being, all corporeal and mental endowments will tend to progress towards perfection.' (Charles Darwin, *The Origin of Species*).

How facts are described are often entangled with values. Simplicity, coherence, plausibility are epistemic values inherent to theory construction (Putnam, 2002). Theories are presupposed by value considerations. Dirac, for example, conceived of physics as infused with the aesthetic and mathematical beauty (Kragh, 2002).

CRITICAL REALISM AND SCIENCE EDUCATION

In describing a pedagogy of hope in the title I use the terms 'irony' and 'emergence' which are not often associated with science education. Take the case of a lump of lead and an oak leaf dropped from a height in the open air. Even on a cool still day the lump of lead will always reach the ground first. Or measure the relationship between pressure and volume of a gas at a fixed temperature. Both are violations of Covering Laws. In the first case the Law of Falling Bodies which only holds true in a vacuum and the second in the case of the Ideal Gas Laws which holds for the ideal state. These laws are cases of closed systems; these are important in science experiments because in measuring the acceleration of bodies towards a large mass such as the Earth, it is necessary to remove all conditions except that being tested for, in this case the Earth's force field, i.e. such experiments take place in carefully controlled closed conditions removed from the vagaries of open systems.

The term 'irony' is often used in literature and literary criticism. Take for example the following haiku where the author is trying to express their feelings of awe about cherry blossom on a Japanese mountainside.

> O O O
> Is all I can say
> About the cherry blossom
> On
> Mount Yoshino

The *irony* here is that language is insufficient to describe this beauty but the only way it can be expressed is using an atrophied form of language. Language, which is the main means for describing the world, is not up to the task in its own terms. Similarly the well-known laws of science inform us about Nature's regularities yet in our daily experience of the 'open' world they do not hold.

Everyone knows that the formula of water is H_2O. Yet this is only the case in very particular circumstances, that of totally pure water produced and analysed in a vacuum. In the world of everyday experience, water from natural water courses, drinking water, rain, all dissolve carbon dioxide and oxygen, solid solutes such as salts, and so forth. Any analysis will reveal a much more complex formulation than H_2O. So the one fact that almost all schoolchildren know is a false description of the water they are used to.

Pure water is constituted by the atoms oxygen and hydrogen. Molecular water is liquid at room temperature and is used to quench flames. However, both oxygen and hydrogen are gases at room temperature, oxygen is essential in supporting combustion and hydrogen is explosive in the presence of a flame. Clearly the chemical and physical properties of the constituents of pure water are different when single and combined, this is an example of *emergence*, water emerges with different properties from its constituent elements, a core concept in a Critical Realist approach.

In explaining natural phenomena in open systems, such as the real world we experience daily, we can understand the entities that constitute the world as making things happen, they have *causal powers* (Chalmers, 1999). Water quenches thirst and flames, large masses like Planet Earth have the power to exert forces on objects but this power is countered by flowing air which in turn has the power to resist the fall of objects.

When *events* take place in open systems they can be understood in terms of interacting mechanisms each of which can be isolated and explained through the closed and isolated conditions of carefully controlled experiments. In a critical realist approach events are *experienced* and described as *actual*. Take, for example, the decay of a pond. The event, i.e. the decaying pond, can be experienced through our senses and perceptions, the odour of bacterial decay, the sight of pond life being exhausted, the disappearance of frogs. These perceptions are the *domain of the empirical*. The *domain of the actual* consists of the event – the decaying pond – and the empirical, our experiences of that decay. Events do not depend on the empirical – they occur regardless of our perceptions of them – but the empirical depends on events taking place. However, to explain the decay of the pond, a series of interacting mechanisms are taking place which are not necessarily observable or perceptual. As well as biochemical mechanisms such as the flow of oxygen, the action of bacteria, there are also social and economic mechanisms such as the provision of resources to maintain the upkeep of the pond. These mechanisms are in the *domain of the real*. Table 1 illustrates the relationship between these domains.

Table 1: Domains within a critical realist approach

	Example	Real domain	Actual domain	Empirical domain
Experience	Sight and sadness at decaying pond	/	/	/
Event	Pond decay	/	/	
Mechanism	Multiple causes behind decay of pond	/		

The reality of these mechanisms is distinctive to critical realism. Critical realism is underpinned by ontological realism and epistemological relativism, the need to distinguish between *what is* or *what exists* (the intransitive dimension) and *what is known* (the transitive dimension). In other words, there is a reality independent of our knowledge of it. Scientific theories aspire to explain natural phenomena as far as possible but are always open to correction and independent validation (judgmental rationality). This holy trinity of critical realism (Bhaskar, 2011) can be represented in figure 1.

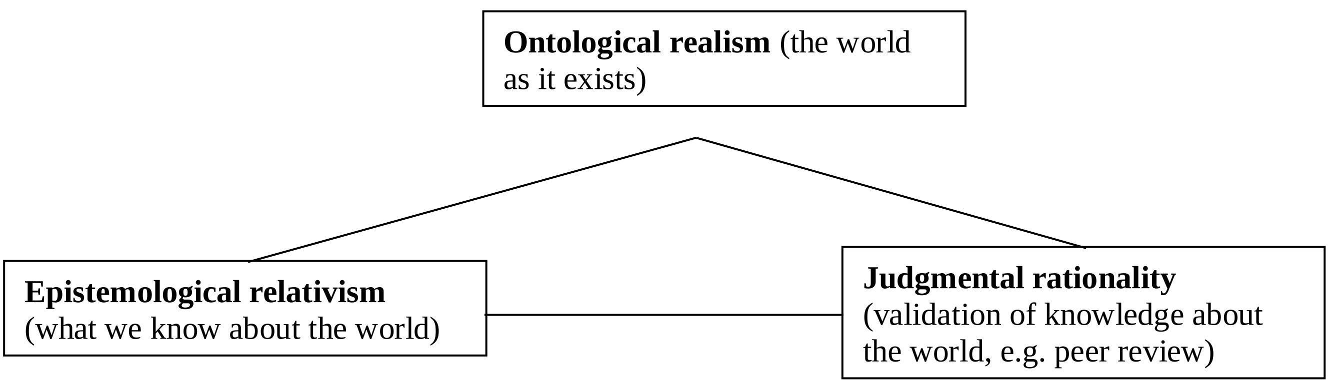

Figure 1: The 'holy trinity' of critical realism

Stratification and emergence

Different strata of being can be conceptualised in terms of the causal mechanisms that cover both Nature and Society. At the most basic stratum, non-living matter is governed by physico-chemical laws and mechanisms, living things by physico-chemical and biological mechanisms; social phenomena by physico-chemical laws, biological laws and social and economic laws such as the laws of self-interest or Marxist theory. Although these strata are governed by laws and mechanisms, they are not determined by them. As I type on the keyboard, I am limited by the constraints afforded by the laptop, by the speed of reaction from brain to hand, blood and sugar supply to my cells but my actions are not determined by them. These strata are non-reducible and emergent. For example, at the social and economic level a school functions according to certain rules: sequences of lessons, curriculum structure. The school consists of people, buildings, books, computers but it is more than the sum of these entities and quite distinct in character (non-reducible) from them just as the properties of molecular water are quite different from its constituent atoms.

IMPLICATIONS FOR PEDAGOGY

Doing science – developing ideas collaboratively, constructing experiments, evaluation of data, drawing on theory, disseminating results for peer review – involves rational and non-rational processes which are emergent and distinct from lower order strata such as physiological and physico-chemical processes. Human freedom to practise science means deploying those causal powers associated with rational thinking. But there is also a more crucial implication. Social mechanisms such as peer review and theory critique recognising what is scientifically reputable, operate in concert with each other: social mechanisms that regulate what can be recognised as scientifically reputable. This freedom to practise science is not unrestrained but entangled with other emergent mechanisms. Human freedom is 'something that belongs in a realm apart from science, but something whose basis would have to be scientifically understood'. (Bhaskar, 2008, p. 112).

Freedoms and commitments to experiment, reflect, gather evidence and enhance our understanding about Nature must be based on certain conditions being present, for example, a healthy diet and working environment, as well as a responsive science community. Science practice cannot be understood when divorced from these conditions. So, to understand events such as hunger, love, war, the various influences on society of science and technology, scientific knowledge is one component among other disciplines. Related questions in pedagogy then flow from this; for example, if doing science depends at one level on a healthy and balanced diet why are such conditions not available to all people? If scientific knowledge helps us to understand the potential devastation caused by dropping a critical mass of U-235 over a city what can be done to prevent this outcome? If we understand the scientific principles of global warming, how it is modelled and the attendant uncertainties which always accompany scientific research why is it so difficult to reach agreement on what should be done?

THE MANUFACTURE OF ALUMINIUM; AN EXAMPLE OF A CRITICAL REALIST APPROACH

To exemplify the pedagogic principles of a critical realist approach to science pedagogy, I want to take an example from a subject often seen as factual when taught in science – the manufacture of aluminium. This example was inspired by an event I witnessed, the collection of aluminium cans at a huge waste dump outside the Brazilian city of Rio de Janeiro. A full explanation of the scientific, social, economic and political processes explaining how the recyclers of Rio, the *Catadores do Lixo*, operate in relation to the manufacture of aluminium can be found in Levinson (2009) and Levinson (2014).

In chemistry examination specifications in the U.K. young people learn about the principles of manufacture of aluminium, namely its extraction from bauxite and purification and electrolysis. Starting from a simple equation many of the social, economic, and political mechanisms which relate to the manufacture can be inferred.

$Al^{+++} + 3e = Al$

In other words, reduction of one mole of aluminium ions produces one mole of elemental aluminium metal. However, there are stories behind each component of this equation. Firstly, aluminium ions, Al^{+++}, are found in the form of aluminium oxide, Al_2O_3, in the mineral bauxite. To extract the ions, bauxite which is mined mainly in Canada, is shipped to Jamaica where it is processed, purified and then electrolysed. To explain why this occurs it is important to understand the relative costs of labour in Canada and Jamaica, the pollution caused by shipping, and some of the devastating effects of purifying alumina.

Aluminium oxide, alumina, is amphoteric, that is it reacts with both acids and alkalis to form salts. It can therefore be separated from other metal oxides, such as iron oxide, by dissolving in concentrated alkali then heating. Given the huge quantities of alumina treated in this way the alkali needs steel containers resistant to leakage. The infra-structure to support such a process is considerably expensive and where the necessary investment falls short disasters can result as occurred in the fatal floods of red mud in Ajka in Hungary in 2010 (Levinson, 2014) and the devastation of rural areas in Jamaica.

As can be deduced from its position near the top left-hand corner of the Periodic Table, aluminium is a small atom, hence there is strong attraction between the small highly charged aluminium ions and the oxide ions. The only way to liberate the aluminium ions as aluminium metal is through electrolysis. To do this the purified aluminium oxide has to be dissolved in an inert solvent, in this case a mineral called cryolite, found off the east coast of Greenland. Now cryolite can be manufactured industrially but in World War II this was not the case. Aluminium is a low-density metal used in aircraft manufacture, hence its crucial importance both to the Allied and Axis powers in WWII. Such considerations prompted the US invasion of Greenland to secure the supply of cryolite for aircraft manufacture, and consequently the environmental devastation surrounding the Greenlandic town of Ivituut which is still a problem today.

Electrolysing aluminium in the global quantities needed means vast supplies of electrical power. Nowadays this is mainly provided through hydroelectricity. Although hydroelectricity does not directly require the burning of fossil fuels it nonetheless results in considerable damage to the environment. For hydroelectricity two conditions are essential, a supply of water taken from flowing rivers, and potential energy: the water falling from a height on to a turbine. In other words, the perfect conditions for hydroelectricity are mountainous wildernesses. In addition, the heat transferred raises the temperatures of waterways damaging the environment of poikilotherms.

Once the aluminium is produced through electrolysis, further problems arise. The carbon anodes combine with molecular oxygen produced at the anode to form carbon dioxide gas, further adding to the greenhouse effect. The halides from the cryolite solvent also react with the carbon anode to form perfluorocarbons which are also greenhouse gases.

Finally, the aluminium recycling centre outside Rio. Twenty years ago, when I first came across the site Brazil was one of the most profligate countries in the world in terms of aluminium waste, particularly drink cans left in streets. Unemployed people with small carts organised to take the cans to waste dumps where they were sorted for recycling. The *catadores do lixo*, the 'rubbish pickers', were paid by the can so the more cans they collected the more they benefited. However, this also led to wars between gangs of catadores resulting in unrest. Furthermore, recycling had impacts. The more aluminium was recycled the less need for primary aluminium from producer countries like Jamaica. So, recycling in Brazil had effects on the Jamaican economy. Secondly, recycling itself involved stripping and revarnishing the surfaces of cans, where the varnish has a toxic vapour.

From this short and condensed account, it can be seen that the implications of aluminium manufacture can only be accounted for through an integrated inter-disciplinary approach where scientific explanations, such as the electrolysis of aluminium oxide, enhance our understanding of the political immediacy of reducing gases, and where the processes of recycling aluminium have global economic consequences. For a full account of the interlocking mechanisms involved in the manufacture of aluminium see Levinson (2014).

CONCLUSION

Where the teaching of science is based on empiricist or naïve realist assumptions, those most prevalent in school science curricula, then difficulties in linking science to social justice and human emancipation become insuperable. Critical realism provides an epistemological basis – the role of science in the real open world – which enables teachers to draw the world, a critical and informed perspective on science and its links to social justice, through a pedagogy of hope.

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XVIII IOSTE SYMPOSIUM

Future educational challenges from a science and technology perspectives.

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Climate Change: Alternative Use of Technological Resources in a Brazilian Science Teaching Program

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Abstract

In 2016 The Urban Climate Change Research Network (UCCRN) of the National Aeronautics and Space Administration (NASA) and Columbia University invited technicians from the Rio de Janeiro City Hall to participate in a training workshop to share best practices for building climate resilience. From this meeting, another project was also proposed in the educational area. The Program "Education in Times of Climate Change" is an initiative that aims to connect, through teleconferences, professionals, and specialists of natural sciences area, with teachers and students of the public system of the Rio de Janeiro City. These technicians should prepare presentations on the actions they were carrying out for the teachers of the municipal network. Teachers would do the dissemination of this information to their students, using a more didactic approach. Within this cooperation agreement, four conferences were held with the following objectives:

- to make the students aware of the need for researches and actions to preserve the environment;
- to present the effects of climate change on their city;
- to bring knowledge from the experience of professional public managers, regarding climate change and their impact;
- to make a correlation between the topics addressed in school science education and professional activities related to the environment.

While still enjoying the first contacts with the subjects related to these themes, the students have the possibility to have a supplementary information about practical applications of the disciplines that are being taught in their schools, besides having an opportunity to know the problems related to climate change. The present study aims to conduct a research to evaluate the efficiency and capacity of a methodological proposition within this teaching program, considering the use of alternative technological and didactic resources.

Keywords: climate change, conferences, educational resources, natural sciences, technological resources

INTRODUCTION

In 2016 the National Climate Change Research Network (UCCRN) of the National Aeronautics and Space Administration (NASA) and Columbia University invited technicians from a training workshop on sea level rise, urban heat island formation and water quality to share best practices for building climate resilience.

This workshop was part of a partnership between UCCRN, Columbia University, NASA and the City Hall of Rio de Janeiro (PCRJ). From this meeting, another initiative was also proposed in the educational area, in which these technicians could prepare presentations on the actions they carry out within their respective areas of professional activity for the teachers of the municipal education network. Teachers would then do the work of disseminating this information to their students, based on the use of their own teaching techniques, using a more didactic approach that could be related to the programmatic content used in classrooms. The purpose of this initiative was to create a stimulus for young people to develop skills in the area of science and to have an incentive to dedicate themselves to the study of these subjects. The presentations had as prerogative the use of a more simplified language, with didactic approach, that could be understood more easily by the students and teachers. The presentations had to achieve the following objectives: to make students aware of the need to carry out research and actions aimed at preserving the environment; present the effects of climate change on the dynamics of their city; bring knowledge from the experience of professional public managers, regarding climate change and the impact of this process on city management; to make a correlation between the topics addressed in school science education and the future knowledge necessary for the performance of the activities of professionals who deal with the environment.

THE SCIENTIFIC PROGRAM

The name of program was "Education in Times of Climate Change" and brought together teachers from the municipal network and specialists in education and earth sciences from NASA and PCRJ in order to discuss and create new contents and materials for the classroom and scientific dissemination in institutions such as the City Planetarium and Ships of Knowledge in subsequent actions. These buildings were built in nine degraded regions of the city and aimed to provide the local population with the highest computer technology. The coordinator of the program in Rio was Pereira Passos Institute (IPP) which is the statistical and cartographic research arm of the municipal government. In order for the conferences to be oriented to a wider audience, adaptations were suggested that would facilitate the understanding of the themes presented, starting with a more technical language that considers terms used in the professional and academic environment for a more informal, simplified and easier language.

AN ALTERNATIVE PROPOSITION

The third webinar of the series of conferences was held on 10/31/2017, in the Ship of Knowledge Cidade Olímpica, in the district of Engenho de Dentro. On that occasion, an exposition was made related to Urban Rain Drainage and the Coastal Management of Rio.

For this presentation, it was indicated the use of some pedagogical tools and resources that would bring even closer the contents of the high technical content of the subjects taught in classrooms, creating a division of subjects according to the following thematic areas: Geography: water cycle, clouds, air masses, El Niño and La Niña, rain, types of relief, rivers, air streams, global warming, polar regions and mangroves; Sciences: quantities and measurements, water states, earth movements, mechanical and electromagnetic waves, optics, tides, winds and phases of the moon.In order to stimulate this process, a better fixation of the content and the increase of students interest in the subjects exhibited, it was proposed the assembly of online questionnaires and the use of the gamefication resource and Peer Instruction to stimulate learning.

In the late 1980s, theories about what made computer games so attractive to players were developed and how these factors could be used in education to increase student motivation and involvement (Muller 1980, Bowman, 1982). In more recent times, a systematic review of the literature on game-based learning has been undertaken, with a more austere focus on its positive outcomes (Connolly, Boyle, Macarthur, Hainey & Boyle, 2012). It has been noticed a progressive increase in the interest of the use of these experiences in the educational area (Lee & Hammer, 2011), in which the games are presented with the possibility of being used as innovative educational tools. This technique involves the use of game design elements and game features in different contexts (Deterding et al., 2011). The term gamification refers to the set of techniques that incorporates elements of games in everyday contexts and aims to offer opportunities to help schools minimize problems related to student performance (Lee & Hammer, 2011). The technique is not limited to the teaching of games or through them, but by the use of game mechanics as an auxiliary pedagogical tool. In this sense, Domínguez et al. (2013) indicate that the main objective of gamification when applied to education is to use game mechanics to make it more interesting. This approach aims to extract the elements that make the practice of games enjoyable and fun and adapt it so that it can be used in the teaching processes. The Peer Instruction method has the premise of having the student search for information preliminarily by reading about the subject so that he can discuss them with his colleagues later (Mazur, 1997). Therefore, the purpose of this study is to use resources in a scientific outreach program to try to increase students' level of learning and awareness about climate change. Because it was an experimental program, this was perhaps the only opportunity to adopt alternative learning methodologies in municipal public education since the teacher does not have autonomy to use alternative teaching methods, being guided to follow a didactic pattern that is established to the network.

THE RESEARCH

The presentation was made in two distinct phases: the first of the technicians for the teachers and the second, the teachers for the students. The research proposed in the present study follows only the first step. This research aimed to carry out a survey to verify if the characteristics suggested for the experimental model of presentation was approved by the collaborators, allowing to determine what should be maintained, what should be changed or what needs clarification, as the logic described at the Methodological Framework (Chart 9). This research is proposed to determine action guidelines, before moving on to the second phase, where teachers will pass on the information to students.

The aim of the research was to search for answers to the various questions that arise regarding the acceptance of the format that was suggested for the presentation, on an experimental basis. More importantly, these questions were related to the degree of receptivity of the pedagogical methodologies proposed.

The use of these procedures had the objective of obtaining the adequate scientific basis to support all the conclusions obtained.

The qualitative research data were made through questionnaires that were sent to the colaborators at the end of the first stage. For each question there were five response options. An interpretative and comparative analysis of the responses issued by the interviewees were carried out. The Participant Observation was selected because the researcher was the same person that elaborated the presentation and the proposal to use the pedagogical methods. Because of this, we have been careful to keep impartiality in the data collection process.

In qualitative research some topics were investigated: receptivity and autonomy in relation to innovative pedagogical methodologies (active learning and gamification), adequacy of the use of online questionnaires (Socrative Program), adequacy of the use of individual (competitive) or group (collaborative), degree of adherence of the teachers invited to the proposal, correlation between the content of the presentation and the subjects of Science and Geography.

The quantitative research was based on the evaluation of the school grades of the subjects of Sciences and Geography of the eleven Regional Coordinators of Education (CREs). The weighted averages of the bimonthly test of Science and Geography of the classes of Elementary School II (6th to 9th grade), referring to the first two months of 2018, were used as reference base.

RESULTS AND CONCLUSIONS

The objective of this study was to analyze the proposed aspects of a presentation within a scientific program, based on the observation of data and the evaluation of the collaborators, determining the aspects that may be characterized as factors such as the application of alternative teaching methods based on active learning methodologies and learning via electronic means or e-learning.

The experimental methods of today may become institutionalized procedures in the future. However, because of their innovative nature, they must be thoroughly tested and analyzed before they can be effectively implemented.

The quantitative research was carried out in relation to the averages of Sciences and Geography of the classes of Elementary School II (Charts 1 to 8). The analysis indicated that there is a potential margin for improving the school performance of these subjects. This fact evidences the possibility that the proposal presented may serve as a stimulating factor for the learning of these subjects. Of course, the limitations inherent in this type of resource must be considered, which falls within the category of auxiliary teaching tool.

According to the answers extracted from the qualitative research it was possible to extract several observations. The participating group is composed of a local coordinator and five teachers, who have voluntarily joined the program. When comparing the number of teachers in the network, it is observed that there is a huge potential for expansion. In this sense, it is necessary to verify what would be the factors that could promote an increase in the number of participants.

Through the answers to the questionnaire it was possible to carry out an analysis of the degree of knowledge and receptivity of the active learning methodologies by the collaborators. The survey indicated that there is a high degree of acceptance in both aspects, pointing out that there is interest about th use of the methods, which are not new to the team. All participants think that the use of instruction by colleagues and games would help students to be more interested in the subjects. The answers indicated that the majority (67%) think that the use of innovative teaching methods would be appropriate. The result of the questionnaire shows that everyone thinks that both the types of activity (collaborative and competitive) would be adequate, but each type of use depends on the context in which it is inserted.

Most (83%) think that the use of digital technologies is suitable for use in the scientific program. The answers indicated that the majority (86%) think that the use of instruction by colleagues, games and digital technologies would have a great possibility of arousing a greater interest of the students on technological subjects. 57% of the collaborators think that the use of the instruction by the colleagues and the use of games and digital technologies would have a great possibility to awaken a greater students' interest in scientific topics. 43% said there were some reservations. This was the issue on which there was less consensus.

The result of the present study indicated that the pedagogical proposal has the possibility to advance to the second phase of implementation and to promote a greater awareness of the students on the impact of climate change, which will favor the formation of citizens more sensitive to the problems that involve the preservation of the environment. However, the qualifications issued by collaborators must be considered in order to achieve the success of the proposal. The opinions expressed were very useful for the consideration of aspects that need to be considered before proceeding to the second phase, which will indicate whether the proposed objective has been fully achieved. These combined results may also provide elements that will enable future discussions about the convenience of using these methods by the municipal administration.

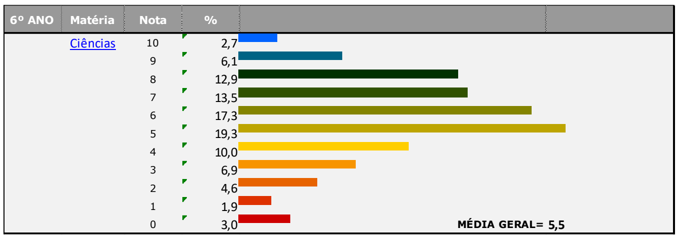

Chart 1: Distribution of Notes and General Weighted Average of the Discipline of Sciences, referring to the 6th year of Elementary School.

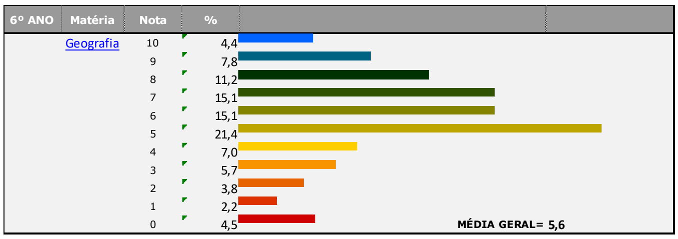

Chart 2: Distribution of Notes and Weighted General Average of the Discipline of Geography, referring to the 6th year of Elementary School.

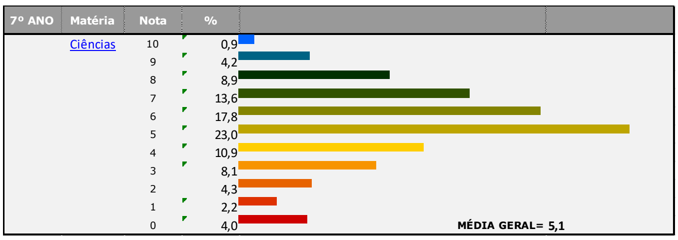

Chart 3: Distribution of Notes and Weighted General Average of the Discipline of Sciences, referring to the 7th year of Elementary School.

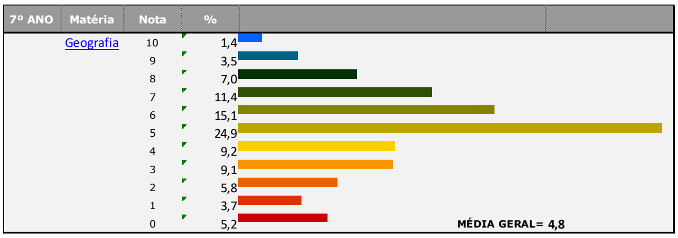

Chart 4: Distribution of Notes and Weighted General Average of the Discipline of Geography, referring to the 7th year of Elementary School.

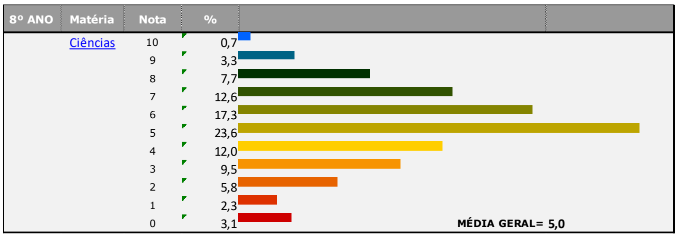

Chart 5: Distribution of Notes and Weighted General Average of the Discipline of Sciences, referring to the 8th year of Elementary School.

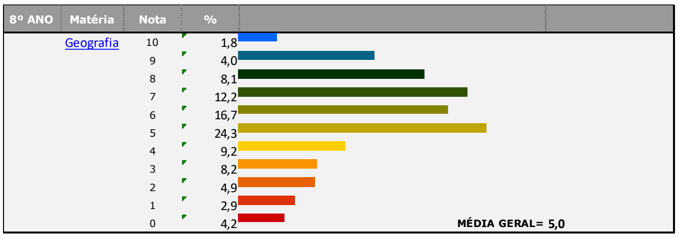

Chart 6: Distribution of Notes and Weighted General Average of the Discipline of Geography, referring to the 8th year of Elementary School.

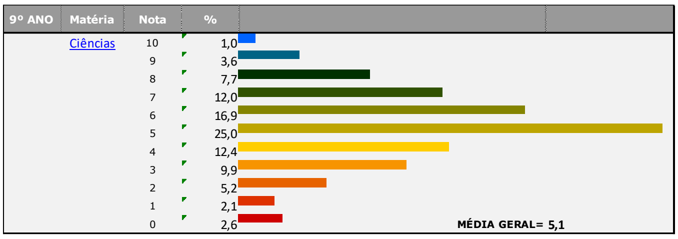

Chart 7: Distribution of Notes and Weighted General Average of the Discipline of Sciences, referring to the 9th year of Elementary School.

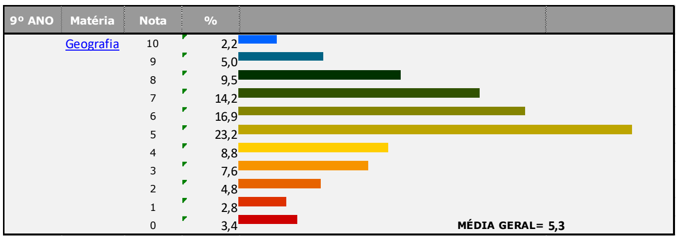

Chart 8: Distribution of Notes and Weighted General Average of the Discipline of Geography, referring to the 9th year of Elementary School.

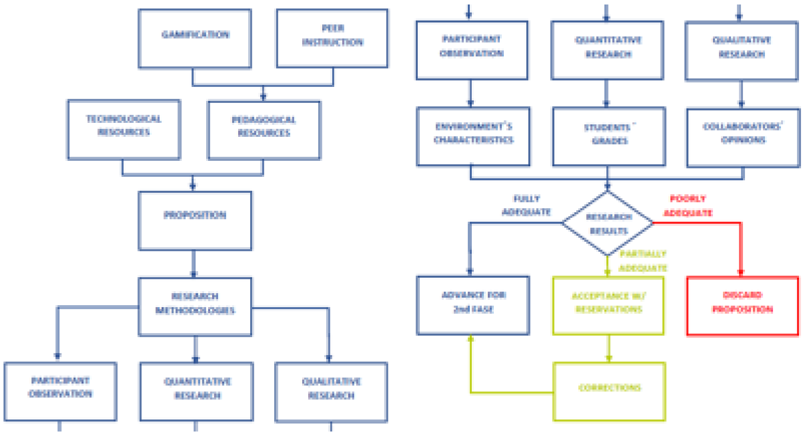

Chart 9: Methodological Framework

Figure 1: View of the Multimedia Room.

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Gender Disparities in Natural Sciences Learning: A Case Study of Student Experiences in Makonde District, Zimbabwe

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Abstract

Globally, gender disparities in science education continue to be a major challenge. Within the realm of gender disparities in science education, the major focus of the investigation was to unravel the nature of the learners' experiences in the learning of Natural Sciences at secondary school level in the Makonde District, Zimbabwe. This study is informed and guided by the theoretical lense of pragmatism. It uses a mixed method research approach to investigate both gender disparities and the nature of learning experiences for a sample of learners (n= 590) studying Natural Sciences at the Ordinary and Advanced levels. Eight teachers from these five schools participated in the study. Quantitative data was collected from learners using a Likert type questionnaire. Qualitative data was obtained through focus group discussions (FGDs)- involving learners, learner and teacher interviews and observations of Natural Science classes. Quantitative data was analysed using Chi-Square Statistics, One-way Analysis of Variance (ANOVA) and Principal Component Analysis (PCA). Qualitative data was analysed usaing a combination of content and interpretive analysis. It was found that in all the five schools, female and male learners' learning experiences were different from each other. Gender stereotyping and discrimination by male students were found to be rife in all the classrooms. It is recommended that teachers should do more in tackling gender discrimination.

Keywords: Gender disparity; gender stereotyping; learning experiences and natural sciences

INTRODUCTION

The problem of gender inequality in educational access and provision continues to to be a major challenge in Africa and the rest of the world (for example, Camfield, 2011; Chikunda and Chikunda, 2016; Chisamya, DeJaeghere, Kendall, and Khan, 2012). From the outset it is important to note that researchers working on gender have struggled with the nuances of terminology often conflating it with sex (Pryzgoda and Chrisler, 2000). Pryzgoda and Chrisler (2000) note that the term sex refers to to the biological aspects of being male and female and gender to the characteristics of being male and female, which are behavioral, social, and psychological. For the present paper, the term gender refers to biological sex differences. Falling under the strand, student understanding and learning in Science and technology education, this study sought to investigate gender disparities and learning experiences of students studying Natural Sciences in selected High Schools in Makonde District, Zimbabwe. The study was spurred by the realization that, globally, in spite of the many initiatives, gender disparities in science education continue to be a major challenge (Larivière, Gingras, Cronin, and Sugimoto, 2013; Jadidi, Karimi, Lietz, and Wagner, 2017). This challenge is much greater for Sub-Saharan Africa, where gender disparities are much wider and have been shown to impede economic growth and empowerment (Radu and Chekera, 2014; Hakura, Hussain, Newiak et al., 2016;). It has been established that sciences learning experiences are related to gender (Jones, Howe, and Rua, 2000; Gudyanga, Adam and Kurup, 2015; Reiss and Mujtaba, 2017). In the case of Zimbabwe, reports by the Ministry of Primary and Secondary Education (2015) the Zimbabwe National Statistics Agency (2013) and the Zimbabwe Schools Examination Council (2015) show that there are gender disparities in both learner performance and choosing to study Natural Sciences at the secondary school level. Contributing towards an understanding the nature and causes of gender disparities in Natural Sciences education, the major focus of the study was to unravel the nature of the learners' experiences in the learning of Natural Sciences at secondary school level. The study was guided by the following questions:

(1) What is the nature of learners' experiences in the learning of natural sciences?
(2) What forms of gender stereotyping are manifested in the teaching and learning of Natural Sciences?

THEORETICAL FRAMEWORK

This study was underpinned by a modified micro, macro and institutional (MMI) theoretical framework adapted from Yazilitas, Svensson, de Vries, and Saharso (2013). We used the framework to study gendered patterns in academic choices, for the Natural Science learners. This theoretical framework was chosen because it enables researchers to get a holistic understanding of gender related issues. It advocates for thorough interrogation of both males and females in the investigation of gender challenges. It is a synthesis from various relevant theories that interrogate and interplay with each other in trying to understand the attributes of gender related issues. These theories include the: Social Cognitive theory (SCT); Expectancy Value Model of Achievement Related Choices (EVMARC) theory; Modernisation theory, Socialisation theory; Gender and Development (GAD) theory; and Education System Characteristics (ESC) theory. For this study the first two theories, that is, SCT and EVMARC are useful in explaining micro factors such as self-efficacy, attitudes, knowledge and expectations. Theories such as Modernisation, Socialisation and GAD can be used to understand and explain macro factors such as access to education, unequal job and career opportunities and poverty. Education System Characteristics (ESC) theory was used as a lense to examine institutional characteristics such as availability of resources- including such learning and teaching gadgets as computers and the smart board, infrastructure and school administration. The theories mentioned here were used to adapt and construct the research instruments which are, the Likert questionnaire, focus group discussion guide and classroom observation schedule; as well as guide data analysis and interpretation.

RESEARCH METHODOLOGY

The methodology employed in this study was the mixed methods research (MMR) and informed by the pragmatism research paradigm. Ponce and Pagán-Maldonado (2015) define the MMR approach as research that intentionally combines or integrates quantitative and qualitative approaches. Pragmatism is viewed as a logical and reasonable way of doing things Cameron (2011). Flexibility is the guiding principle as decisions are based on specific situations and not on preconceived theories, rules and ideas. It is not dogmatic. Every data is useful and purposeful. An explanatory sequential research approach was used. This approach involves first collecting and analysing quantitative data and then collecting and analyzing qualitative data in depth. Creswell and Creswell, (2017) argue that this is the most appropriate approach to use when a research problem is known, but solutions remain elusive. In the context of the present study, solutions to gender disparities and inequalities remain elusive. Figure 1 summarizes this approach.

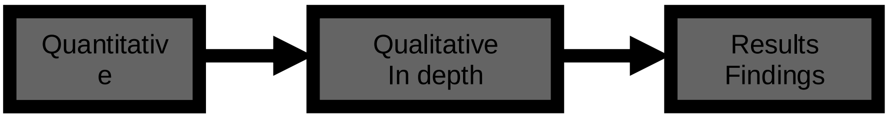

Figure 1: Explanatory sequential research design. Adapted from (Ponce & Pagán-Maldonado, 2015)

Sampling and Data Collection

According Neuman (2013), sampling is the process of choosing a small portion or subset from a defined population with the aim of representing that total population. Makonde District has a total of 108 primary and 59 secondary schools. Out of the 59 secondary schools only 5 offer Natural Sciences up to Advanced Level (A-level). For this reason, these five schools were conveniently chosen for the study. The five schools had a total of 600 learners studying Natural Sciences. Questionnaires were administered by the first author to 590 learners (n= 590) representing 98% of the learners from the 5 schools. Of these learners 60% (354) were male and 40% (236) were female. The average ages of the learners ranged from 16-18 years. It is important to note that the 5 secondary schools in Makonde District had a total of 1500 learners studying Natural Sciences. Qualitative data was collected from 8 teachers through interviews and lesson observations. Four Focus Group Discussions (FGDs) made up of 42 students (24 female and 18 male) conveniently chosen because of their willingness participated through semi-structured interviews guided by three questions. Each FGD had an average of ten participants.

Research Instruments

The Likert Scale Questionnaire (LSQ) was used to collect statistical data through a survey. Several scholars that include Delport and Roestenburg (2011) agree that the Likert rating scale is the appropriate one to evaluate survey data. Gravetter and Forzano (2018) argue that the scale allows for the removal of neutral responses due to laziness, fatigue and time constraints. Appendix A shows a part of the questionnaire. Semi-structured interviews, lesson observations and (FGDs) schedules were used to collect audio qualitative data. The qualitative instruments assisted to obtain a deeper understanding of the extent and nature of gender disparities in the learning of natural sciences.

Analysis Tools

Quantitative data analysis was achieved using the Statistical Package of Social Science (SPSS) Version 23. The organisation, analysis and interpretation of the quantitative data were accomplished through the application of descriptive statistical techniques. We used the descriptive statistical techniques and deemed them sufficient because the research design leaned more towards the qualitative aspect as shown in figure 1. Chi-square, one-way analysis of variance (ANOVA) and factor analysis (CAF) tools were used to analyse the data. The chi-square test of independence was used to determine whether statistically significant relationships existed between the dependant and the independent variables. It was used to explore relationships between variables in an explanatory way. The tool is relevant because the data was of a non-parametric nature. We examined the relationship between gender (male vs.

female) and attitudes or perceptions (agree vs. disagree). The critical value (p) for the test of independence is set at .05. Values less than p are significant and vice versa. If the value is less than the critical value, the null hypothesis is rejected meaning that the relationship between the variables was not due to chance but is influenced by a variable and in this study, it was gender.

ANOVA was also used to test consistency in the number and type of items whose hypotheses were rejected by the chi-square test. This was done by calculating the standard deviation (SD) from the mean score to detect variation within the distribution of items by gender. The principal component analysis (PCA) was used to group together items with similarities of purpose. The analysis for data from both teachers and students were done using the qualitative content analysis (QCA). Grbich (2012) define QCA as: “a systematic coding and categorising approach used for exploring large amounts of textual information unobtrusively to determine trends, patterns of words used, their frequency, relationships, the structures and discourses of communication”.

RESULTS AND DISCUSSION

The evidence that emanates from this study indicates that gender disparities in the learning experiences and study of natural sciences by students is a culmination of intertwined internal (ability, attitudes and self efficacy) and external (cultural and environmental) factors of socio-psychological origins. Table 1 displays that female and male students learning experiences were different from each other. For example, in item 1 here were more male students (54%) against the 21% of the female students who agreed that girls’ ability in natural sciences was lower than that of the boys. The majority of the female students (79%) disagreed with the statement and thus displayed strong beliefs in their ability.

Table 1 Null hypotheses rejected by chi-square test of Independence N=590

Item description		Males n=343		Females n=233		Df	2-tailed significance (p=.05)
		A	DA	A	DA		
1	Girls are not as good as boys.	184	159	49	184	1	.000<p
		53.6 %	46.4%	21.0 %	79.0%		
2	Equal treatment of boys and girls helps in subject choice & performance.	261	76	211	22	1	.000<p
		74.4 %	22.6%	90.6 %	9.4%		
3	Household duties affect my school performance.	127	200	116	115	1	.008<p
		38.8 %	61.2%	50.2 %	49.8%		
9		173	164	84	145	1	.001<P

	Given a choice, I would rather be taught by a teacher of the same sex as myself.	51.3	48.7	36.7	63.3		
13	Knowledge of science does not help me to protect the environment.	36	305	12	219	1	.023<P
		10.6	89.4	5.2	94.8		

		ZT	FT	MT	ZT	FT	MT		
16	Made you believe that the subject was very difficult.	254	60	27	160	45	24	3	
		74.5	17.6	7.9	69.9	19.6	10.5		.040<P

Key: A=agree, DA=disagree, ZT=zero times, FT=few times, MT=many times.

In item 9 over half of the male participants (51%) preferred a male teacher to a female teacher. The gender of a teacher was not a priority of choice of teacher to the female students. They considered the ability of the teacher. The difference in the item responses which resulted in the rejection of the null hypotheses shows that gender influence was apparent in the responses of the participants.

Table 2 shows that ANOVA rejected an equal number of hypotheses items (6) like the Chi-square. ANOVA shows the variation from the mean score by gender. It is apparent from the table that the responses were polarised along gender lines and thus confirming different learning experiences. For example, on item 1 the male respondents were more polarized (499) than the female respondents (408) in their responses. It also means that the percentage difference on those who agreed and those who did not agree with the statement was small.

Table 2 ANOVA: Variation from the mean score by gender

No.	Item description	Gender	N	Std. Deviation	Mean	Sig.
1	Girls are not as good as boys in sciences.	Male	343	.499	1.46	.000
		Female	233	.408	1.79	
2	Equal treatment of boys and girls both at home and school helps in subject choice and performance.	Male	337	.419	1.23	.000
		Female	233	.293	1.09	
3	Household duties after school affect my school performance.	Male	327	.488	1.61	.008
		Female	231	.501	1.50	
9	Given a choice, I would rather be taught by a teacher of the same sex as myself.	Male	337	.501	1.49	.001
		Female	229	.483	1.63	
13		Male	341	.308	1.89	

	Knowledge of science does not help me to protect the environment.	Female	231	.222	1.95	.023
21	The teacher praised a student with lower marks than yours.	Male	339	.877	1.46	.012
		Female	231	.718	1.28	

These are the items out of the twenty-three items which were used as basis for the formulation of interview questions in the qualitative phase.

Table 3 Lesson Observations – Laboratory Practicals

	School 1		**School 2**	**School 3**	**Total**
Number of students	40		42	36	118
Number of groups	5		6	6	17
Gender of group leader	Male	3	3	4	10
	Female	2	3	2	7
Dominant gender	Male		None (Both)	Male	

Male students' domination in the classrooms was very visible in all the lessons observed. Table 3 reveals that group leadership in practical activities that were observed in the three schools was male dominated (10/17) groups. In all the three schools, the teachers did not impose group leaders but left it to the students to choose their leader. The trend of the results of tables 3 was also displayed in the interviews as shown in the following extracts:

Interviewee 1 (Male):

> *When we were created men had muscles and brain. We were made for tough jobs and women simple jobs, washing dishes, sweeping and washing clothes can't be hard, that's what they were created for. Men were created for harder jobs, so women cannot be above the men.*

Deep-rooted gender stereotyping was evident in the following extract.

Interviewee 2 (Female):

> Yes, in my own opinion I prefer both teachers, male and female teachers it's all about experience about the subject and what he/she has in store for me and also whether he/she teaches me to be free to all the teachers and treat them the same and have that same respect and to love them equally whether male or female so to me male and female are okay. It is about whether the teacher can teach or not.

Teacher choice was based on the experience and ability of the teacher and not stereotype beliefs. The results of the study are consistent with the findings from Radu and Chekera (2014) which concluded that the most common gender discrimination was gender stereotyping and it was committed by men.

Table 4 School Profiles by Administration

School Code	**A**	**B**	**C**	**D**	**E**	**Total**	**%**
Gender (Head)	Male	Male	Male	Male	Male	5	
Gender (Deputy Head)	Male	Male	Male	Male	Male	5	
Science Teachers (Male)	2	5	5	3	13	28	9.2
Science Teachers(Female)	2	8	1	0	2	13	4.3
Responsibilities (Male)	4	6	3	8	14	35	11.5
Responsibilities (Female)	2	4	3	4	6	19	6.3

Table 4 demonstrates that all the five schools were not headed or deputized by female professionals. Gender disparities within the school environments were not only confined to school headship but were also visible in other positions of responsibility within school setups. Female teachers in administrative positions such as Head of Department (HOD) and Sports Administrator accounted for 6.3% while 11.5% represented male teachers. The results resonate well with Mutangirwa (2016)'s findings that Zimbabwean women were marginalized in key decision-making positions due to the practice, attitudes and gender stereotypes of those in authority to appoint. The total female science teacher establishment in the five secondary schools was half the establishment of male science teachers. These results reveal that school administrations and teaching structures are heavily biased against the girl child in terms of role modelling and influencing career choices.

CONCLUSIONS

The evidence that emanated from this study suggest that gender disparities in the learning experiences and study of natural sciences by students is a culmination of intertwined internal and external factors of socio-psychological origins. The findings revealed that male and female students' learning experiences were different from each other. Gender stereotyping and discrimination by male students were found to be rife in the classrooms. The results concur with Gudyanga, Adam and Kurup (2015)'s findings on the dominance of boys in physics. That the boys were found to be the main perpetrators of gender discrimination is not only alarming, but suggest that in their teaching teachers should do more to implement approaches that promote gender equity. While schools' policies were not gender biased their practices were found to be gender discriminatory. School administrations and teaching structures were found to be gender biased. The sustainability and progress of a nation's economy is derived from specialized skills of both men and women acquired through science and technology education (STE) training. The limitation of these findings is that they are based on a case study and may not be a true reflection of other districts and provinces of Zimbabwe. The sample size may therefore limit the generalization of the findings.

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APPENDIX A

B6. It is made up of 23 items. Opposite each item you will find opinions from which you are required to (✓) tick in one box

.

		A	SA	D	SD
Perceptions.					
1.	Girls are not as good as boys in sciences.				
2.	Equal treatment of boys and girls both at home and school helps in subject choice and performance.				
3.	Household duties after school affect my performance.				
Benefits of science (Utility values).					
10.	Science helps me to solve problems properly				
11.	New knowledge in science and technology usually bring social benefits to society.				
12.	Science helps me to make sensible decisions.				
Learning experiences. **How many times has your science teacher done or said the following to you.**					
		Zero (0) times	1 or 2 times	Few times	Many times,
15.	Did not praise you when you had done well.				
16.	Made you believe that the subject was very difficult.				
17.	Embarrassed you in front of everyone when you gave a wrong answer.				
18.	Praised you for good performance.				

Improving Science Classroom Interactions through the Integration of Learners' Socio-cultural Background

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Abstract

The study is based on the constructivist epistemology which assumes that in order to understand an individual's interpretations of reality, one has to understand the particular social contexts within which they operate. The paper addresses the question: How does the integration of learners' practices, experiences and beliefs in science teaching influence classroom interactions? Three Natural Sciences teachers were observed as they integrated their learners' socio-cultural practices, experiences and beliefs into their teaching, through the use of real-life scenarios or authentic problems familiar to learners. The teachers used argumentation activities to assist learners to evaluate the authenticity of their socio-cultural beliefs against scientific knowledge or vice versa. Teachers also used group activities, learners' home languages to explain abstract concepts, and drew on learner experiences from their communities. Learner interactions in class were valuable in fostering a sense of belonging or being valued in the class. Consequently, most learners became active participants during the teaching and learning process. Integration of learners' socio-cultural background may support learners from disadvantaged townships in South Africa in conceptualising science concepts in a comprehensible manner, and allow them to realise the utility value of the school scientific knowledge and skills in their lives.

Keywords: Beliefs; classroom interactions; learners' socio-cultural practices;

INTRODUCTION

Recent curriculum reforms in most countries, South Africa in particular, have called for a pedagogy in which every learner has an opportunity to succeed despite their disadvantaged socio-cultural background. Kelly (2007) raises important issues on what counts as science in different contexts, how this can be accomplished through interactions and, most importantly, who participates in this construction of science knowledge. It should be noted that science taught in decontextualised classrooms has been branded as being disconnected from the learners' socio-cultural background, which Kalolo (2015) described as "a depersonalised science" (p. 39). Despite the call to contextualise science teaching and learning through the use of culturally relevant science pedagogy (Gay, 2010; Ladson-Billing, 2014), there is a dearth of research on how this can be implemented in a science classroom, and the important practical benefits of doing so.

LITERATURE REVIEW

Learners' socio-cultural background

Learners' socio-cultural background refers to their socio-cultural practices and experiences which include norms and values, religion and beliefs, socio-economic and political relations and the learners' indigenous knowledge systems (IKS). Learners are exposed to an in-school cultural socialisation process where instructional practices and learning activities do not reflect their cultural-laden modes of learning and knowing, which Aikenhead (1996) referred to as border crossing into the subculture of science. Teachers should acknowledge and integrate learners' socio-cultural ways of knowing largely informed by their own observations, customs and beliefs, which they bring to the science classroom (Gay, 2002).

Importance of science classroom interactions

Sociocultural theory explains how individuals acquire knowledge from when they interact with others, and also how interactions amongst individuals create collective understanding (Mercer & Howe, 2012). Pioneer socio-cultural theorists such as Barnes (1976) and Cazden (1972) emphasised the important role of classroom talk in increasing learners' engagement in the classroom. High quality teacher-learner and learner-learner interactions can be powerful in developing reasoning and improving academic performance in learners, instead of the routine and habitual teacher seeking confirmatory answers from learners (Mecer & Howe, 2012). As such, when teachers use well-thought out and well-formulated questions that guide learning and use of language as a tool for reasoning, the learning process will be more comprehensible to the learners. It has been found that if teachers use certain interactional strategies more often, learners' participation in class and their educational outcomes are likely to improve (Dawes, 2004; Mercer & Littleton, 2007). In a mathematics classroom Kyriacou and Issitt (2008) also found that learner performance improved when teachers questioning is directed at eliciting learners' reasoning and explanations.

The current study is guided by three theoretical frameworks, socio-cultural theory, social constructivist theory and Scott and Mortimer's dialogical interaction. Socio-cultural perspective propounds how human skills are appropriated by individuals (Säljö, 2009), implying that learners' intellectual achievements and failures do not depend on their efforts and discoveries only, but are also the product of culturally-situated forms of social interaction (Mecer & Howe, 2012). As such the knowledge learners possess is as a result of both individual effort and a creation of shared 'property' of the community members who possess cultural tools in both spoken and written language. In this way, Vygotsky (1978) explained the role of language acquisition and use in transforming learners' thinking. Vygotsky emphasised the importance of social interactions in that when learners are involved in joint activities, they gain new understandings and ways of thinking not only for themselves but also for those they interact with.

Social constructivist theory posits that learners learn best when the content relates to their socio-cultural context, which means learning becomes more effective when related to what learners do, experience and observe in their everyday lives (Vygotsky,1986). The purpose of learning science is to help the learners develop scientific knowledge and an understanding of how science works in real life (Okwara, 2016). Therefore the study is also guided by the social constructivist epistemological view that knowledge is not discovered, but is constructed within the minds of the individuals through social interactions. Social constructivism emphasises the crucial role played by social interactions in the learning environment (Putnam & Borko, 2000). Knowledge construction involves socialisation of individuals into the practices of the communities in which they are embedded, hence the importance of the role of learners' socio-cultural background in science teaching and learning. Different communities have their own ways of validating their knowledge claims. Thus, the study assumes that in order to understand an individual's interpretations of reality, one has to understand the particular social contexts within which they operate. The current paper reports on a study that sought to explore how the integration of learners' practices, experiences and beliefs in science teaching influenced classroom interactions. Classroom interactions are crucial in shaping the teaching and learning process in the classrooms (Aguiar, Mortimer, & Scott, 2010). Effective science teaching recognises the role of learners' prior knowledge and experience, and the social environment during the process of knowledge construction (Mavuru & Ramnarain, 2017).

According to Scott, Mortimer and Aguiar (2006) dialogic discourse in the classroom involves teachers and learners bringing ideas together, exploring and working on them. In this case the dialogic discourse juxtaposes views from everyday knowledge and scientific knowledge. Mortimer and Scott also point that ideas from individuals may also be compared, differentiated and new ideas developed, and in this dialogic discourse learners work together whilst each contribute different views, which are then used to construct a single, satisfactory scientific explanation. Dialogic discourse paves way for different perspectives, and learners become aware of their differences in their views, hence there is always room for acknowledgement and understanding of other people's perspectives in the classroom.

This is unlike authoritative discourse which does not provide an opportunity for learners to share their different viewpoints for exploration but rather the teacher gives attention to the school science viewpoints (Scott, Mortimer & Aguiar, 2006). A point to note is that the teacher can ignore or reshape important ideas and questions from learners. If the teacher perceives learners' ideas as helpful in developing school science, he/she (the teacher) can *seize* and *use* them (which is indicative of authority). Authoritative discourse entails non exploration of different viewpoints put forward, which means teachers can simply ignore learners' contributions.

METHODOLOGY

The study employed a qualitative case study research design. Qualitative research is a naturalistic approach that seeks to understand phenomena in context-specific settings, where the researcher does not manipulate the phenomenon of interest (Patton, 2002), but probes for deeper understanding rather than examining surface features (Johnson, 1995). Previous research studies in education have used case-study research design more to explore the processes and dynamics of practice (Merriam, 1998) in order to shed light on a phenomenon, the process, events, persons or things of interest to the researcher (Gall, Gall & Borg 1996). Therefore, the main characteristic of qualitative research is its focus on the intensive study of specific instances – cases of a phenomenon. For this reason, the current study is a qualitative case-study research that allows an in-depth exploration of classroom practices, using multiple forms of data collection (Creswell, 2005).

Sampling

Three teachers from three township schools located in Johannesburg in South Africa were purposively selected because they had shown interest in the study after a professional development programme on the integration of learners' socio-cultural background. The three Natural Sciences teachers had each taught Grade 9 in the same school for at least three continuous years in which they had an opportunity to interact and familiarise themselves with the community. Therefore the researcher considered them to be knowledgeable about their communities. The teachers had a wide range of teaching experience (4–33 years) and age (26–58 years). They came from different ethnic and religious backgrounds but could speak some of the learners' home languages.

Data collection and analysis

The teachers were observed teaching five lessons each while integrating their learners' socio-cultural practices, experiences and beliefs in teaching Grade 9 learners. Teachers taught different sections of human reproduction, energy and circulatory system. Each lesson lasted for 30 minutes. The Reformed Teaching Observation Protocol (RTOP) (Sawada et al., 2002) was used as an observation tool to capture and assess the extent to which classroom instruction used learner-centred teaching (Lawson et al., 2002). Each teacher was then interviewed twice to seek clarifications on unclear classroom episodes observed.

In analysing the video clips of the lessons, Mortimer and Scott's (2003) framework was used to determine the level of classroom interactions. This framework was used as a tool for analysing the various forms and functions of discursive interactions in the science classrooms. This tool, or analytical framework, is based on a sociocultural view of teaching and learning, and consists of five linked aspects: *Teaching purposes*; *content of the classroom interactions*; *communicative approach*; *patterns of discourse*; *teacher interventions*. In this study focus was only on content of the classroom interactions. Analysis of the discourse of science lessons involved an iterative process of moving backwards and forwards through time, trying to make sense of the episodes as linked chain of interactions.
The visual representation of the research design used in this study is shown in Figure 1.

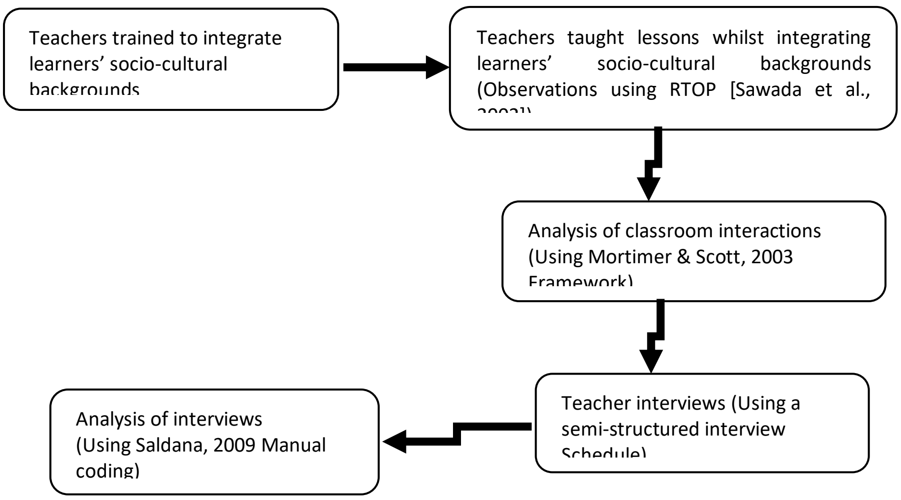

Figure 1: Visual representation of the research design used in this study

FINDINGS

The study answers the research question: How does the integration of learners' socio-cultural practices, experiences and beliefs in Natural Sciences teaching influence classroom interactions? Three key findings are reported on: the teaching strategies teachers used to invoke classroom interactions; the role teachers assumed during classroom interactions; and the benefits drawn from such classroom interactions. Only findings from lesson observations on reproduction are reported. In the different sections' classroom discussions, which ensued, are presented as evidence for the kind of classroom discourse portrayed. The interactions in the reported lesson excepts were considered to be more dialogical than authoritative.

Teaching strategies used to invoke classroom interactions

The teachers' integration of learners' socio-cultural background involved the use of real-life scenarios or authentic problems familiar to learners, which connected science with learners' lives. Teachers drew on learner experiences, and allowed learners to sometimes use their home languages in their explanations. Generally, in all the three teachers' classes, learner interactions were found to be valuable in fostering a sense of belonging or being valued. Consequently, most learners became active participants during the teaching and learning process.

Teacher 1 provided the following real-life scenario when introducing methods of contraception under the topic reproduction:

> *Some pregnant teenage girls abuse alcohol so that they get more financial grant from the government when they give birth to deformed babies. Is it fair? Is it only impoverished communities which are affected by this problem?*

The learners started discussing and sharing their viewpoints in groups and only one group's reponses are reported.

Learner 1:	*Mmm the government must intervene, this is murder and robbery*
Learner 2:	*Mngani (meaning my friend) you can't judge them you don't know their circumstances*
Learner 3:	*No guys you cannot sympathise with those girls! Condoms are in all clinics.*
Learner 4:	*True think of the baby (foetus) which lost a life.*

From the different learners' viewpoints, the teacher asked learners about the opportunities available for these girls to avoid falling pregnant. The learners mentioned abstinence and most of the methods of contraception including some from their traditional beliefs such as jumping over certain shrubs and drinking some concoctions prepared by traditional healers. The issue of abortion was also mentioned as an option and the teacher used this opportunity to discuss ethical and medical issues regarding abortion. Though one learner queried at the end that the problem of poverty still had not been addressed, the concepts that the teacher wanted to teach had already been explored in detail.

During the interviews, the teacher indicated the importance of using real life scenarios and also engaging learners in discussions. For instance, during the lesson some learners were quiet and would not even make an effort to share their views. In this case the teacher assumed that it could be: 1. those learners harboured the same sentiments as the teenagers in the scenario and would not tolerate any criticism; 2. probably they were deeply hurt by the realisation that ethically what the teenagers (their sisters) were doing is wrong, or 3. maybe they felt their family situation was exposed in public. Exploration of such issues not only allowed coverage of scientific concepts but also delved into the learners' socio-cultural background and ethical issues which helped learners deal with real-life situations.

In certain instances, the teachers did not bring in scenarios for discussion, but learners raised sexuality issues of concern to get solutions or explanations to some experiences they encounter in their lives. An example is that of a lesson on menstruation under the topic reproduction. Because the teacher (Teacher 2) had created an environment where learners felt 'safe' to share their socio-cultural practices and beliefs related to science, learners utilised this as an opportunity to find health problems they experienced in their bodies. An example of such a classroom excerpt is as follows:

> Learner 1: *What causes period pains?*
> Teacher 2: *Why are you asking? What do you think is the cause?*
> Learner 1: *There is too much dirt in your body so menstruation is a way of removing the filthy stuff from the body, the body is cleaning itself, my grandmother told me so.*
> Teacher 2: *How does the dirt end up in the body?*
> Learner 3: *Sir, it's coming from some of the junk food we eat.*
> Learner 4: *Mmm... I think the evil spirits could also contribute to this*
> Learner 5: *Do you think one needs to consult with a sangoma (traditional healer) or just go to the clinic?*

The discussion went on with the teacher only asking prompt questions and the learners sharing their viewpoints. The responses show that the learners could not distinguish the reproductive system from the digestive system. In explaining the process of menstruation, the teacher went out of his way to display a chart on the digestive system and another on the reproductive system to assist the learners to discern the difference between the two processes. Learners made attempts to validate what they already knew about sexuality against the scientific concepts they had learnt or tried to relate the scientific concepts to their own life experiences. As a result, the teacher pointed out during the interview that in certain instances it was disturbing to note the level of ignorance and misconceptions that learners display in terms of their reproductive systems. Issues of spirituality were never resolved fully.

In lessons on male reproductive system and circumcision Teacher 3 used argumentation as a teaching strategy to invoke learners to share their socio-cultural practices and how they relate to scientific concepts. The lesson was based on a task that the learners had been given as homework in the previous lesson. It required learners to research on how people with different socio-cultural practices, experiences and beliefs view circumcision and its benefits. The teacher instructed learners to discuss their answers to the question: 'Why is circumcision important in some cultures?' The teacher's questions such as, 'did you ask your parents or any adults at home?' and statements like, 'let's see what you have', are indicative of her commitment to engage learners as members of a learning community and this clearly showed that the lessons were dependent on learners' input.

In explaining the importance of circumcision, learners mentioned different views ranging from traditional and religious to medical aspects that were proffered by different learners, which I thought were attributed to their diverse backgrounds. Based on religion and tradition, learners explained circumcision as a sign of entering manhood and an introduction to adulthood. The learners failed to distinguish circumcision from the traditional practice of initiation which then formed the basis of the argumentation.

Learner1: *Circumcision makes me a man, it separates men from boys.*
Learner 2: *It makes me brave and I can protect my family as the head.*

The learners were referring to the Xhosa traditional initiation that takes place in the mountains where boys are circumcised traditionally in their socialisation into manhood.

Learner 3: *Boys die in the mountains during initiation so why not just go for circumcision in a hospital.*
Learner 4: Ufana nabafazi' (meaning you will be like ladies).

Learner 4 was responding to Learner 3 showing that he was incensed that his socio-cultural practice (initiation) was being ridiculed.

Teacher 3: *What do you mean?*

Since learners were free to air their views, one girl (Learner 5) interjected in response to learner 4's ascertion:

Learner 5: *But already they are men when they are born*
Learner 3: *My body is still clean, didn't you hear about the campaigns on radio and television*?

During these discussions, an emotional boy stood up and vehemently stressed the need for every man to be trained to be tough and not to be treated like women, thereby supporting an earlier claim by the other learner that those who undergo medical circumcision are weak as men. In fact, he was defending the way boys are treated in an initiation school in a bid to counter the earlier assertion that the initiation ceremonies were bent on cruelty.

From these results of the dialogical discourses in the classes, teachers' use of prompt and open-ended questions helped them to elicit learners' pre-instructional knowledge as the learners tried to answer each other's questions. Science teaching was linked to everyday real-life situations to which those scientific concepts were related. In this way, teachers managed to identify gaps which learners' social-cultural beliefs and practices could create between what they teach and what is learnt. At the same time such teaching approaches enabled the teachers to tackle challenges posed by the belief systems learners held, which may interfere in the learners' understanding of science concepts. Most importantly teachers managed to help learners distinguish scientific knowledge from their worldviews and to be able to deduce any connections. In this study argumentation and cooperative groups are referred to as inclusive teaching strategies because they stimulated debates and discussions among learners. Argumentation has been found to be an appropriate learning strategy teachers can employ as 'the goal of science must not only be the mastery of scientific concepts but also learning how to engage in scientific discourse' (Bricker & Bell, 2009). A clash of knowledge domains, the culture of science and the learners' worldviews, was evident. The teacher's patience allowed more vibrant exploration of the science concepts, despite the divergent ideas brought in by learners.

The role teachers assumed during classroom interactions

Because most learners were no longer in touch with their extended families due to urban migration, teachers adopted new roles as they incorporated learners' socio-cultural practices, experiences and beliefs, which Irvine (2003) referred to as parental/surrogate roles. Teachers acted as facilitators or guides as they did not interrupt discussions, but instead waited and used probing questions to provide focus to the discussions, nor did they readily provide the information for learners to answer the questions.

These class discussions encouraged learners to evaluate or validate their beliefs and practices against science knowledge and vice versa. The learners challenged each other's reasoning and in turn helped and supported each other in reaching group conclusions. Through these interactions, learning and development can take place. The teachers managed class discussions in such a way that this allowed tolerance for cultural diversity and divergent thinking among the learners. There were, however, insinuations of socio-cultural stereotypes in the responses made by some learners. In addition, more time were spent in classroom debates, discussions and at times comprised completion of learning areas within planned time.

The benefits drawn from such classroom interactions

In all the three teachers' classes, learner interactions in class were found to be valuable in fostering a sense of belonging or being valued. Consequently, most learners became active participants during the teaching and learning process. Class and group discussions enabled learners to express ideas and make connections between a real-life scenario and scientific concepts, thus enabling the teachers to elicit learners' pre-instructional knowledge, some of which, if ignored, could have created barriers to the understanding of new concepts. Analysis of interviews showed teachers acknowledging the importance of learner interactions in the science classroom due to integration of their socio-cultural background. The following are some of what the three teachers said about their classroom interactions:

> Teacher 1: *It helps me on how to structure my teaching with the learners in mind. Yes l could just easily follow the textbook but unfortunately learners will not come out in the open to share what they know and how they feel about the concept.*
> Teacher 2: *Learners presented issues about their beliefs that made me discuss certain science concepts regarding the topic that I had not planned for.*
> Teacher 3: *Talking to learners makes you realise how much they know which may even surprise you. I now believe in a way learners should lead the lesson and not the other way round.*

Classroom interactions (learner-learner and teacher-learner) formed important learning moments in that as learners discussed their questions and ideas, they also developed effective communication skills. The classroom discussions were very interactive and dialogic (Scott & Mortimer, 2003). In addition, this allowed the teachers to assess the depth of the learning process and also to identify potential misconceptions harboured by learners. From the lessons, it can be deduced that the teachers' task was mainly to provide scaffolding by giving direction and instructions, comments and feedback to the learners which made them acquire the intended concepts and skills.

Science concepts became more meaningful as they related to learners' daily lives and experiences. These classroom interactions created positive learning environments, which acted as a critical learner motivating tool, thereby making learners feel being part of the learning communities (Weinstein et al. 2006). In that way, learners also got more opportunities to model authentic scientific tasks which increased their scientific thinking (Abd-El Khalick & Lederman, 2000). This is in line with research which shows that learner-learner interactions increase both the understanding of key concepts (Smith et al., 2009) and problem-solving abilities (Hake, 1997).

CONCLUSIONS

The research findings show how learners' socio-cultural background influenced teachers to employ social constructivist teaching approaches that fully engaged learners in the science classrooms. Integration of socio-cultural practices, experiences and beliefs in science teaching increased learner participation in class. This could be because learners were involved in discussions of authentic life situations and also communicating their experiences related to the content under discussion. Science concepts became more meaningful as they related to learners' evryday life experiences.

Implications for future research

There are important questions that arise from the study which require further exploration if meaningful integration of learners' socio-cultural background is to be done in the science classroom. For instance: whose beliefs, practices and experiences should the teachers focus on considering the multicultural nature and diversity in the science classroom? Are the teachers familiar with the different learners' socio-cultural background? How do the teachers deal with their own beliefs, practices and experiences that conflict with those of the learners?

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Dissemination of the concept of biodiversity Conservation through the My Action Declaration in the case of Japanese students

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Abstract

In Japan, the concept of biodiversity conservation has not spread to the public. The author has developed an educational programme for university students to encourage the 'My Action Declaration' and to promote an understanding of biodiversity conservation. The programme was provided to undergraduate environmental sociology students using a photo submission SNS application. The overall result outcome of the programme indicates that photo sharing by SNS is an effective means of disseminating an understanding of biodiversity conservation among young people. Evaluating these outcomes, this paper shows that the students' understanding of biodiversity conservation improved. Indeed, most participants reported a better understanding of biodiversity. They also found that their ways of thinking had changed and that they were more conscious of their behaviour towards biodiversity conservation. Moreover, almost all students had favourable impressions of the programme. They were highly motivated to continue their effort and wanted to recommend biodiversity conservation to others. Another significant aspect of this programme is the ease of action; as we identified which action could be done without concern for time and place.

Keywords: Biodiversity Conservation, Japan, My Action Declaration, Undergraduate Students

INTRODUCTION

Biodiversity conservation is critical for maintaining a sustainable global environment. Various scientific, academic, and policy measures have been investigated since the concept of biodiversity was first proposed (e.g. British Ecological Society, 2018; International Union for Conservation of Nature, 2017). In the field of science education research, biodiversity conservation has been discussed as a framework for fostering scientific literacy, providing students with necessary knowledge and values regarding 'how to live sustainably' from both scientific and non-scientific perspectives (e.g. Lindemann-Matthies et al., 2011). However, this concept has not spread to the Japanese public (Cabinet Office Japan, 2014). Therefore, to promote a concrete understanding of biodiversity conservation in the mainstream, Japan's Ministry of the Environment and the Japan Committee for United Nations Decade on Biodiversity (UNDB-J) proposed the 'My Action Declaration' in 2012 (United Nations Decade of Biodiversity & Japan Committee for UNDB, 2015). This Declaration comprises five actions, which should be followed by individuals: namely, Eat, Feel, Show, Conserve, and Select (Table 1). These indicators are intended to instill a conscious behavior and appreciation of biodiversity conservation in each person. Following the announcement of the My Action Declaration, primary industries—that is, the agriculture, forestry, and fishery industries—published their approach to the plan (e.g. ZEN-NOH, n.d.; JForest, n.d.; JF Zengyoren, n.d.). However, while both municipalities and individuals have held several public events for these five indicators, few have evaluated the purpose of these endeavors or their impact on participants. As such, discussion of how the My Action Declaration indicators promote the understanding of biodiversity conservation and how the target participants view this activity is required.

Table 1. The Five Actions of the 'My Action Declaration' developed by Japan's Ministry of the Environment

Act 1	Eat	I enjoy locally produced seasonal food.
Act 2	Feel	I go out into nature by visiting such places as zoos and botanical gardens to experience the natural environment through engaging the senses.
Act 3	Show	I express my wonderment of nature in any way I can, for example through photos, paintings, or writing.
Act 4	Conserve	I participate in conservation activities to ensure harmony between nature, human beings, and cultures.
Act 5	Select	I buy green products.

RESEARCH PURPOSE

How can we promote biodiversity conservation awareness among the public? I developed an educational programme for undergraduate students to encourage the aforementioned actions (Eat, Feel, Show, Conserve, and Select). In a previous paper, entitled 'Students' concept of relevance of biodiversity conservation and everyday action' (Miyake et al., 2017), I introduced biodiversity conservation oriented photographs which students found in daily life, exploring why they interpreted the photographs as biodiversity conservation. This study explores the effectiveness of this educational programme and the 'My Action Declaration' initiative using on the basis of the following two research questions:

1) Has the students' understanding of biodiversity conservation improved?
2) How do the students evaluate the programme?

RESEARCH DESIGN

The My Action Declaration educational programme was provided to 40 students undertaking an environmental sociology course. An original photo submission Social Networking Service (SNS) application was utilized in the programme (Figure 1). The designed My Action Declaration programme proceeded along the following four stages. First, the students had four 90-minute lectures related to biodiversity issues, including an explanation of the five My Action Declaration indicators. After the lectures, they were asked to find biodiversity-oriented objects in their daily lives and to take photographs. Second, the students took a maximum of five photographs every week and uploaded them to a SNS album in which they could share their photographs. Students scored each photograph, with one to five points awarded to each of the five indicators (Act1: Eat, Act2: Feel, Act3: Show, Act4: Conserve, and Act5: Select). The activity of scoring their photographs was intended to make students more conscious of the five indicators, as well as why they chose the object as representative of biodiversity conservation, thereby encouraging them to think individually about what biodiversity

conservation entails. In the third stage, the students continued stages 1 and 2 for a period of three weeks. The programme was conducted from October to November 2017.
Fourth, a questionnaire about biodiversity conservation and an evaluation of the activity were conducted following the programme. The questionnaire comprised two types of multiple-choice questions: in questions 1–4, students answered with Yes', 'No', or 'Neither', and provided a reason; for questions 5 and 6, students had to select one corresponding action number and give a reason.

Q1. I think that my understanding of biodiversity conservation has progressed.
Q2. I think that my way of thinking has changed.
Q3. I will continue with action declaration.
Q4. I will recommend my action declaration to someone else.
Q5. Which action was the easiest?
Q6. Which action was the most difficult?

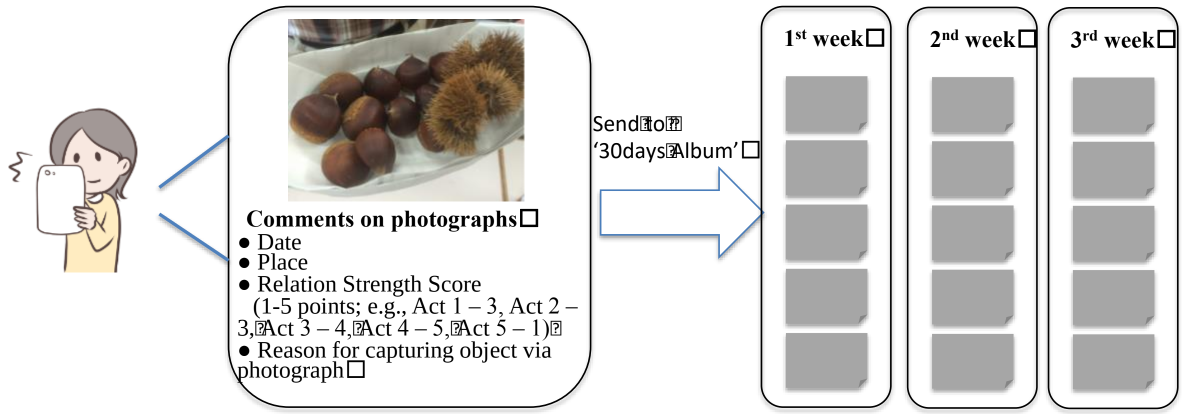

Figure 1. The outline of the 'My Action Declaration' programme

RESULTS

Over the course of the three-week programme, a total of 303 photographs were uploaded to the SNS album, along with students' comments justifying their understanding of biodiversity conservation.

Score distribution of each action indicator

The distribution of each action indicator and its relevance score is shown in Table 2. According to the distribution of the score, Act 1 and Act 5 acquired the scores of both 1 and 5. This means that students' impressions of these actions ranged in both extremes of low and high relevance to biodiversity conservation. Act 2 also obtained distributions at both intense scores of 1 and 5. In contrast, Act 3 has the largest distribution in the central score of 3. This may mean 'I do not know' or 'I cannot determine the relevance to biodiversity conservation'. In Act 4, the score distribution gradually decreases from low to high. This may indicate that the action of conservation is very difficult to identify or implement in daily life. We need further encouragement for the conservation action in the future.

Table 2. Score distribution of each action

Relevance	Score	Act 1 (Eat)	Act 2 (Feel)	Act 3 (Show)	Act 4 (Conserve)	Act 5 (Select)
low	1	194	92	23	87	135
	2	7	45	61	88	30
	3	10	57	90	55	30
	4	13	44	66	36	26
high	5	79	65	63	37	82

The results of the questionnaires

The results of the post-programme questionnaire are provided in Tables 3 and 4. Table 3 shows that the participants believed that their understanding of biodiversity conservation had progressed and that their way of thinking had changed. Thus, the programme requiring students to submit photographs to the SNS album promoted awareness of biodiversity conservation. Q3 and Q4 also indicate that the students wish to continue the activity in the future, as well as recommend it to other people. The programme was evaluated favourably in terms of continuity and popularity.

Table 3. Results of Q1–Q4

	Yes (%)	No (%)	Neither (%)
Q1	38 (95.0)	0 (0)	2 (5.0)
Q2	37 (92.5)	0 (0)	3 (7.5)
Q3	37 (92.5)	0 (0)	3 (7.5)
Q4	31 (77.5)	0 (0)	9 (22.5)

Table 4 shows the results of Q5 and Q6, which asked about the easiest and most difficult action, and show a clear differentiation. The easiest action was ‘Act 1 Eat’, while the most difficult action was ‘Act 4 Conserve’. There are several examples which illustrate this. Representative reasons for why Act 1 was deemed the easiest include the following:

‘Eating is the most familiar and it is an essential action every day’.
‘Eating is a kind of routine issue of every day’.
‘It was autumn, there were many seasonal items to find easily’.
‘It was easy to find the seasonal food’.
‘Eating happens three times in a day, it is easy to act’.
‘Since eating is inevitable in everyday life, touching seasonal things can be familiar’.

In contrast, representative reasons for why Act 4 was deemed difficult include the following:

‘It was difficult to understand whether what I was doing really conserved the environment’.

> *'It was hard to find what should be taken in the photograph and I felt it difficult to interpret the words'.*
> *'It is difficult to find opportunities to participate in the environmental conservation event'.*
> *'Environmental conservation is often done consciously rather than casually'.*
> *'Conservation is like an exaggerated issue to participate in something such as afforestation and garbage picking'.*
> *'It is difficult to do concrete action of environmental conservation, so we cannot do it easily'.*

DISCUSSION AND CONCLUSION

This study sought answers to two research questions. The first question queried whether the students' understanding of biodiversity conservation improved. For this question, the results indicate the affirmative since most participants reported a better understanding of biodiversity. The participant students also found that their ways of thinking had changed and that they were more conscious of their behaviour towards biodiversity conservation. The second question asked how the students evaluated the programme. The results suggest that almost all students had favourable impressions of the programme, that they were highly motivated to continue their efforts, and that they wanted to recommend biodiversity conservation to others. Overall, the educational programme, which used the five action indicators of the My Action Declaration, was evaluated as an effective activity for students.

However, the following two problems were also identified. First, there are some difficult behavioural indicators to address with regard to SNS photo submission. This is particularly true of the 'Act 4: Conserve' indicator, which students found a noticeably difficult action despite understanding its importance. This may be due to the short study period of three weeks. Indeed, the students seem to have decided that the action of conservation cannot be executed in such a short period of time because it is necessary to plan relevant events. Consequently, it may be necessary to discuss what kind of conservation activities can be tackled in a short period of time and what type of things symbolize environmental conservation before commencing the programme. Such preparatory exercise in advance of the programme may avoid this difficulty.

The second problem identified over the course of the programme is that simple and clear actions tend to be selected easily. Eating is the easiest of the five actions to identify because it is indispensable to daily life, as I noted earlier. A significant aspect of this was the ease of action. Indeed, it was discovered that students tended to be familiar with this particular action, which is not contingent upon time and place. Since these behaviour indicators were originally created by the Ministry of the Environment, easy actions were selected for a wide range of people from children to adults. When limiting the target to university students, however, it is also important to select planned actions rather than simple actions that occur on a daily basis. Thus, it may be necessary to explore other action indicators—that is, actions which require intention and planning—rather than only simple and obvious ones, like eating.
In fact, it is necessary to focus on daily life in order to understand how people's decision-making abilities are based on scientific literacy and develop these abilities accordingly (Cobern, 2000). It is also important to explore ways of fostering scientific literacy according to generations.

The My Action Declaration programme evaluated in this study indicates that photo sharing via SNS is an effective means of cultivating an understanding of biodiversity conservation among young people. I hope to continue developing and evaluating such educational programs to improve biodiversity awareness for future generations.

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Teachers and the historical approach in science education: a view from the everyday curriculum' perspective

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Abstract

Although there is a substantial consensus about the benefits of bringing together history, philosophy and sociology of science (HPSS) and science education at basic education, recent research shed light on the challenges of implementing pedagogical strategies supported by HPSS in everyday life of schools. Also, the educational research points out that there is some detachment between teachers practices and curriculum theorization, that is, teachers seem to have naïve visions of schools as arenas of political struggle. From the answers to a semi-structured interview carried out with four teachers from different realities in Brazil, we discussed the strategies carried out by them to implement HPSS in science classes and, also, their conceptions of curriculum, proposing some reflections on the relationship between these two analytical poles. Our results reinforce some previous studies' findings and suggest the importance of the discussion of Curricular Theory in teacher training so the teachers could be more prepared to face the challenges of implementing HPSS and other innovations at sciences classes. Furthermore, from our theoretical framework, we rose some possibilities for Science Education Research in everyday life of schools.

Keywords: Curriculum; Everyday Curriculum Theory; History and Philosophy of Science; Science Education

INTRODUCTION

History, Philosophy and Sociology of Science (HPSS) in Science teaching is a long-standing tradition inside science education community. It can be testified by institutionalization process that yielded the creation, in 1987, of IHPST (International History, Philosophy and Science Teaching Group) among other institutions dedicated to this research area, and, in 1992, the Science & Education journal, which aims to publish research using HPSS in science and mathematics teaching. From this community, we have reached some consensus about the benefits of bringing together HPSS and Science Education. For instance, some scholars (Guerra, Braga and Reis, 2013; Milne, 2011) argue that it allows the exploration of the processes of science's construction, and the relationship between the scientific enterprise and the cultural context of each time and space. Among other advantages, it can be found in the literature the defence of the HPSS as a good way to understanding science as a human enterprise and also for contributing to the movement of humanization of science education (Matthews, 1990). Also, it is said that when approaching cases or controversies of science, it would be better to study "closed" cases, that is, historical ones, instead of the so-called Socio-scientific issues, if the aim is to understand how sciences are constructed (Allchin, 2011).

Although the benefits of the HPSS approach to science and mathematics education are widely recognized, many studies also bring the difficulties of implementing such strategies in the classrooms. Some of them shed light on the teachers' role in this process as well as their challenges. Briefly speaking, some of these obstacles concerns the subject culture, that is, the way each disciplinary community generally teach their subjects; attitudes, beliefs and skills, that constitute the imagery of each teacher about the sciences, the schools, the students and the education at large, or what is their role inside these educational systems (Hottecke and Silva, 2011). Besides this, there are the environments outside the classroom, that we will emphasize in this study. Every school and every routine of work carry within many contingencies to what teachers can or cannot do (Oliveira, 2013), and generally, the teachers are not prepared to deal with this schools' reality, what can block the possibilities of innovation, or in doing something that goes in different ways comparing to the subject culture.

Recent research shed light on the challenges of implementing pedagogical strategies supported by HPSS in everyday life of schools. In particular, some studies investigate about the everyday life in the schools trying to answer why teachers with the proper formation on HPSS for Science Education do not develop often this approach in their classes, even recognizing the importance of it (Vital and Guerra, 2017). About this, Vital and Guerra (2017) bring some results that claim the necessity of including in physics teacher training courses, for instance, discussions about the everyday work in schools. For the authors, "the recognizing of disputes and symbolic violence that exist in school quotidian can lead to more active participation and a more enlightened view about the ideological sense of schooling routines" (p. 19).

In this study, aligned with the results of Vital and Guerra (2017), with previous studies concerning the challenges of History of Science implementation in elementary education, we aim to extend these results in the light of Curricular Theory, in particular, the everyday curriculum' perspective (Oliveira, 2013). To achieve this proposal, we develop an empirical study, in which we interviewed four science teachers, who had taken their master degree in HPSS and science teaching in four different Brazilian universities. From the answers to these interviews, we analyzed the strategies carried out by teachers to implement HPSS in science classes and their conceptions of curriculum, drawing some considerations on this.

CURRICULUM THEORIZATION AND SCIENCE EDUCATION: BRIDGING TWO TRADITIONS

Vital and Guerra (2017) from an empirical study developed in Brazil, in which they interviewed and followed the routine of some teachers that were trained to use the historical approach in their classes, suggest that the difficulties of the routine at the schools make the teachers drop the idea of innovating in their classrooms. So, from these difficulties, the teachers abandon using historical, sociological and philosophical approaches in their classes. Drawing from their theoretical framework, based on discourse theory, the main result is that the teachers didn't mention in their discourses any formulation about the school quotidian as a place of ideological dispute in which they could act somehow to implement the innovations that they recognize as good ones. This conclusion seems to connect to other ideas from curriculum theory and reach a research arena in which studies in science education generally do not bear because it looks closer to general pedagogy than science education. The provocation we offer here is trying to blur the lines between these two traditions.

Curriculum, reconceptualization and everyday curriculum' perspective

Many studies in education warn about the increasing role of accountability and control over the educational policies around the world. Miller (2014) brings some considerations about the audit culture we live in and the role of curriculum theorizing in this scenario. Based in Taubman's and Britzman's studies, she argues that many reasons let teachers vulnerable to this audit culture, sometimes driving them to contribute to processes that mean increased external surveillance over their practices and loss of their own power. For her, a better understanding about what are the curriculum theories, could help teachers' awareness about different aspects of educational experiences and, then, the teachers could avoid this "traps of establishment", if we could put in this way.

Another aspect which is emphasized by Miller (2014) is that the curriculum studies have changed profoundly over the last decades, especially with the process called reconceptualization during the 70's. If before this time, curriculum was understood generally under a Tylerian perspective as something to be designed, implemented and assessed, or only as a set of contents to be taught, after the reconceptualization, with critical and post-critical approaches, some new perceptions about what curriculum is have rose and transformed the curriculum studies (Lopes and Macedo, 2011). The curriculum is not understood anymore as a set of contents or abilities that must be taught in school, but something "alive," more a process than a thing, as suggested by Pinar's currere conception.

Nevertheless, we hypothesize that in the mainstream imagery, the curriculum is understood by science teachers as a set of contents and not something constructed, in dispute, open to debate and dependent of teachers' performances of curricular documents in daily practice. That is, an understanding close to the pre-reconceptualization times.

Everyday curriculum' perspective

Besides this, there are some Brazilian curricular theorists, as Inês Oliveira (2013), Carlos Ferraço (2013), Nilda Alves (2011), Maria Luiza Sussekind (2014) and others that bringing the notion of everyday curriculum, encouraging us to direct our research to the exploration of the daily life, the routine of teachers, students and other actors at the schools and other spaces of education. That is, investigating in/from/with school routines (Ferraço, 2013). If this idea is not entirely new (we can remember, for example, of the concept of "lived curriculum" (Lopes and Macedo, 2011) or the own traditions of science education research, in which it is common to explore real situations at the classrooms), these theorists add some complexities to this general proposition.

First of all, educational policies are understood as *practicalpolicies* as a way to express that each quotidian practice embeds a political choice and so, perform some educational policy that is not necessarily the one expressed in the official curricular documents (Oliveira, 2013). The words "practical" and "policies" are written together because to these theorists, it is a way to run from dichotomies and the Cartesian dualism that prevent us from understanding complexities that are outside these dichotomies. Understanding policies as *practicalpolicies* mean that is impossible to break apart them from each other, so, every practice is necessarily political. As a consequence, science education is eminently political in all its dimensions. Each teacher, with his/her everyday curricular choices, is understood as a *political praticioner* and the pedagogical practices that can be noticed in the daily life in schools are the *expressivepracticalpolicies* (Oliveira, 2013), that is, *practicalpolicies* that are expressed through actions, discourse and other ways. These neologisms try to grasp the complexities of everyday work at schools and rise as a new vocabulary to understand them (Süssekind, 2014).

Another central concept to them is to understand the *political praticioners* as subjects in which dwell knowledge, wants and powers. Or, in their expression, each subject is/build a network of knowledge, wants and powers (Ferraço, 2013). If we would look at Vital and Guerra (2017) research from the point of view of this curricular language, for instance, we can say that they inquired the practices of teachers who were known as subjects of knowledge concerning the implementation of historical approaches in science education, since they were all Masters in History of Science for science education. But in their quotidian, they were in environments that constrained them to implement HPSS strategies as they did the years before and/or during their master's research. This is to say that their power and wants (varying for each case) did not enable them to implement these approaches in their classrooms. To investigate these constraints without overlooking the theoretical dimension embedded in them is to get closer to the everyday curriculum' approach.

METHODOLOGICAL PATHS

In the complete study, we focused less on the knowledge of the teachers to implement historical approaches in the classroom and more on the conditions in which they perform these innovations. This paper was constructed from a piece of a more extended interview that addressed many aspects of professional life and everyday work of these teachers, from which we extracted some answers to investigate their conception of curriculum. We believe that if recognizing the disputes and symbolical violence in the dynamics of school everyday life can lead to a more active participation and a more enlightened view about the ideological sense of school routines (Vital and Guerra, 2017), a good first step to identify teachers' opinions about this issue is to understand their conceptualization on curriculum.

So, it was carried out semi-structured interviews (Erickson, 2012) with 4 teachers of different educational realities in Brazil. Brazilian's huge territory is permeated by cultural diversity, and this is not different for educational environments. The educational structure is mainly decentralized and is composed by 186,100 schools, from which 21,5% are private schools, and the remaining are free public schools. From the total of schools, 0,4% are under federal administration, 16,5% are administered by states and 61,7% by city governments. The structural conditions of schools and teacher's payment can be dramatically different even inside each of these administrations since they are not centralized. Apart from federal and very few private schools, teacher's profession is not well recognized nor well paid, in general. It is common for a teacher work in more than one school to increase his wage, for example. That is the reason why we have chosen to interview these 4 teachers from different realities and that work under different administrations.

The interviews were carried out and recorded through Skype, a digital application that allowed interview the subjects remotely. The moments in which the teachers answered the questions on how they define curriculum and about how they have developed the historical-philosophical approach in their quotidian were transcribed. The researchers also watched the whole interviews seeking to the moments in which the teachers expressed something else about their concept of curriculum or any complementary information about their routine as teachers that could be important to our analysis. We analyzed the answers through a qualitative approach (Erickson, 2012). Following ethical prescriptions of qualitative research, the teachers were informed about all the aspects of research and authorizing the use of data in publications.

Aspects of the interviewed subjects
The 4 teachers were masters in Science Teaching with appointments and dissertation in History of Science for Science Education in Brazilian graduate programs that are traditional in this research area. They graduated by 4 different universities under the supervision of 4 different scholars. All of the advisories develop research in HPSS approach to science teaching. All of the interviewed subjects teach at urban settings. The first one (T1) is a man who teaches chemistry and physics (but with background only in chemistry) at two small cities in Brazil, one of them at São Paulo state and the other at Minas Gerais State, with a distance of about 100km between them. The other three teachers are women, one (T2) teaches biology and general sciences at a big suburb of Rio de Janeiro, the second (T3) teaches physics at a tiny town at Brazilian northeast, and the last one (T4) teaches physics at the 4th biggest city in Brazil, Salvador. All of them were chosen to this research because of their use of science history in the classroom and because all of them had similar trajectories at the graduate course, that is, developed research in HPSS to science teaching.

RESULTS

The main results were organized into two tables with excerpts of the interview. In the first table we present teachers' conceptualizations on curriculum; in the second table, are given their answers about prior formation on curriculum discussions; finally, in the third part, we present other conclusions drawn from the rest of interview and considerations about the results as a whole.

Table 1: Responses on the conceptualization of curriculum

Code	Excerpts of answers
T1.1	"[...] Today I guess I would define curriculum as a set of concepts that I seek to explore in the classroom [...]"
T2.1	"I understand that we have several curricula, right? I guess that there is a more formal curriculum [...] then we have to account for them […] sometimes in my classes they (students) ask to learn about something […] a curriculum, it is constructed as well […]"
T3.1	"[…] the curriculum is not something that is "ready and finished", it is being constructed, being modified, right?, especially according to the "public" I will meet {…]"
T4.1	"[…] I think about curriculum as a set of… err… don't know… a set of concepts and contents, of knowledge structures, in our case of physics, that we need to approach in the classroom […]"

The first remarkable result is that all of the teachers manifest in their discourse notions about curriculum that are closer to a pre-reconceptualization understanding than the critical and post-critical assumptions of curriculum. Then, they don't seem to understand the curricular decisions as something in dispute or shaped by the power of institutions, of the different actors in this process and themselves as well. Of course, there are important quasi-exceptions to this result, in which the teacher recognizes the responsivity of curricular decisions to the different classes, realities and students' interests (as in T2.1 and T3.1). In this case, we can infer an approximation with the "currere" concept, by Pinar (Lopes and Macedo, 2011). But, in a general way, the answers are still very close to pre-reconceptualization concepts. This seems to be justifiable if we analyze their answers when asked about when they learned about curriculum theories (Table 2).

Table 2: Responses on prior formation about curriculum conceptualization

Code	Excerpts of answers
T1.2	"Right! I remember from this concept (curriculum) from the undergrad course"
T2.2	"I studied a little about curriculum, during the undergrad course, I guess […] I remember when I was doing an internship at a school we discussed curriculum… about the very history of the discipline."
T3.2	"very fast, very superficial during the undergrad course […] but the discussion about curriculum that I have had and it was more profound is in a post-graduate course I'm taking now […]"

From the same interview, we extracted other conclusions from the analysis of their responses. These conclusions concern the adoption of strategies relating to HPSS implementation. We did not bring the excerpts of the interviews because these aspects are mentioned in different moments of the interview and are very long to this short communication.

The teachers T1 and T2 mention that they usually try to establish work partnerships with colleagues, but it doesn't have yielded much success recently. T2 says that some colleagues help her when she has to use more time than expected to finish their activities with students.

The teachers T1 and T3 (especially) mention that in private schools they have less freedom to innovate and because of that, generally, they use to give up using history of science in their classes. These teachers do not recognize the school and the curriculum as a space of dispute. It is important to point out that in Brazil there are many private schools. In the Brazilian public schools, teachers have a stable position so, they cannot be fired; otherwise, in Brazilian private schools, they can be fired without strong reasons, which means that teachers take this into account. So, for them, it is necessary that in the list of contents prescribed by the school or in the schools' recommendation there is some clear consideration that it is allowed to use the HPSS approach. Without this recommendation, they consider that this approach is not part of the school's expectations.

T1 and T2 mention infrastructure of the schools as something negative and T3 and T4 mention as something positive. These two last are from Federal schools.

T1 and T4 talk in their answers about the necessity of teaching for the big scale exams, we have in Brazil, which shape some curricular decisions (or the adherence to the national parameters).

Taking into account this analysis, teachers considered they gave up the IHPSS approach because there was something out of their control in the schools where they work. Their discourses suggest that for these teachers the curriculum is not constituted as a disputed field, and they are not a *politicalpraticioner* (Ferraço, 2013). That is, the political dimension is out of their decisions, or, in another way, we can infer that instead of seeking to strategies of implementation that overcome the contingencies of each situation, understanding that curriculum is something more than only contents, but can be manifested in each aspect of pedagogical practices, they follow the school recommendations. This is not to blame teachers about the fact they drop the HPSS approach when facing difficulties at schools but is to say that maybe their formation did not nurture them to create different networks of knowledge/wants/powers (Oliveira, 2013) that allow them to run from curricular normativity excesses.

Hence, in general, our data meet the results by Vital and Guerra (2017) about the hostile scenarios of HPSS implementation and the necessity of specific training of the teachers to face these problems. Our results suggest that though these teachers were graduate in History of Science and Science Education, they have a simple conceptualization about the curriculum and their possibilities. When we confronted this result with these teachers' formation, we verified that all of them did not study curriculum properly in their undergraduate and graduate course. So, we argue that the results of our study suggest that the teacher formation should be done in via a proper discussion about Curriculum Theories, promoting discussions about the curriculum and their possibilities, especially connecting these discussions with real situations in the classroom, to avoid exclusively theoretical discussions on curriculum. That is why we propose that everyday curriculum theory can be the glue to unite theory and practice in teacher training since this proposal break with the idea that curriculum policies are determined in ministries' offices and to teachers remain only the option to implement (or not) these policies (Oliveira, 2013).

FINAL REMARKS

The study discussed here aimed to bring some considerations about the challenges concerning innovations in school, especially towards HPSS approach. From account that the problem of this innovation is not the lack of teacher knowledge about HPSS, we interviewed four science teachers, who had taken their master degree in HPSS and science teaching in four different Brazilian universities. The results of these interviews suggest that these teachers barely did not discuss Curricular Theory during undergraduate and graduate courses. The teachers' speeches also indicate that they developed their Master degree in HPSS and science teaching without problematizing the political perspective of their practice. These teachers seem not to consider the curriculum as a political field of dispute. They seem to hope that they could find a school without conflict, in which they could implement the HPSS approach.

As Miller (2014) states, know more about curriculum theories and their possibilities could be an important antidote for this education's audit culture we live in, empowering teachers to tension more the contexts in which they act. It's essential to profound the research of/in/with teachers' routines, investigating not only the knowledge of teachers but also their wishes and powers inside the schools. How they construct partnerships, how their tentatives of innovation are blocked by external curricular guidelines and how they invent exits to this scenario, that is, how they perform their role as *politicalpraticioner*. Further research that seeks to analyze the actual situations of HPSS implementation avoiding contexts "generically described" or "disregarded" can make more effective the historical approach in Science Education.

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The effect of an inquiry-based pedagogy on the self-efficacy of grade 10 physical sciences learners in South Africa

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Abstract

This study investigated the effect of an inquiry-based pedagogy on the self-efficacy of grade 10 physical sciences learners at five schools located in a socio-economically disadvantaged community in South Africa. The research involved a quantitative survey of learners by means of a questionnaire developed by Vedder-Weiss and Fortus (2010). Self-efficacy is a key construct that relates to achievement, and highly efficacious students tend to expect high grades in examinations and tests. A quasi-experimental design was adopted in order to compare pre-post-intervention self-efficacy data between-within the experiment and control groups of learners. The experimental group experienced inquiry-based learning, while the control group were taught science in a traditional teacher-centred approach. The experiment group showed a significant increase in self-efficacy pre-post-intervention, however, the control group experienced a decline in self-efficacy during the same period. Between the experiment and control groups, there was no significant difference in self-efficacy pre-intervention, however, a significant difference existed post-intervention. From these results, it can be concluded that inquiry-based learning does support increased science self-efficacy in learners.

Keywords: inquiry-based learning; sefl-efficacy; school science

INTRODUCTION

The socio-economic transformation policies of the South African democratic government place a strong emphasis on human resources in the fields of science and technology (Taylor, 2007). However, despite major investment in uplifting the infrastructure of schools, and in-service professional development to upskill teachers, learners especially at township schools continue to perform poorly in mathematics and science. In South Africa, the term ‘township’ usually refers to under-developed urban areas that were historically created for ‘non-whites’ during the apartheid era. According to Naidoo and Lewin (1998), ‘‘the apartheid policies inflicted on the African student a curriculum which many be perceived as largely irrelevant to their needs, difficult to the point of impossible given the learning context, and taught by a large number of unqualified science teachers in schools with few or no laboratories and science equipment’’ (p.730). Previous research by the author (Mupira & Ramnarain, 2018) suggests that learners at township schools are poorly motivated and have low confidence in their ability. In addition, teachers at township schools display a strong teacher-centred pedagogical orientation when teaching science, where learner autonomy is stifled. This research sought to establish the effect on an inquiry-based pedagogy on the self-efficacy of grade 10 physical sciences learners at township schools. Scientific inquiry is a means to motivate students in the learning of science. Evidence of this is shown in studies where students doing inquiry had developed an improved attitude towards science. Harlen, Black, and Johnson (1981) reporting on a study involving 11-year-olds found that they showed a high level of interest and enthusiasm when doing inquiry. A similar finding was made by Piburn and Baker (as cited in Chin & Kayalvizhi, 2002) and Osborne (2010) who found that doing inquiry provided opportunities to work with other students and this was highly motivating. Given these findings, this research sought to investigate the impact of inquiry-based learning experienced by grade 10 physical sciences learners at five historically disadvantaged schools in schools on the motivational construct of self-efficacy. Understanding the self-efficacy of learners is especially pertinent to South Africa given the poor achievement in science (Holborn, 2013). Self-efficacy consistently displays a positive relationship with academic performance (e.g. Nicolidau and Philippou, 2004; Chowdhury and Shahabuddin, 2007; Jungert and Rosander, 2010; Ramnarain & Ramaila, 2018).

Accordingly, the following research questions were investigated:
1. What is the self-efficacy of Grade 10 physical sciences learners at township schools?
2. What is the effect of an inquiry-based pedagogy on the self-efficacy of grade 10 physical sciences learners?

SELF-EFFICACY AND INQUIRY-BASED LEARNING

Self-efficacy refers to "...people's judgements of their capabilities to organise and execute courses of action required to attain designated types of performances." (Bandura, 1986, p. 391). Self-efficacy is used to accurately predict subject selection, academic achievement and vocational choices for all learners (Schunk, 1991) and understanding it becomes pertinent to South Africa given the poor achievement in physical sciences (Holborn, 2013). At the heart of self-efficacy is the theoretical position that maintains that individuals are self-regulating and will monitor and regulate their behaviour (Bandura, 1982). It is a part of an individual's belief system and is influenced by prior experiences, successes, and failures (Jones & Leagon, 2014; Uzuntiryaki, 2008). For instance, if students successfully complete a given task, they will feel confident and will be more willing to try the next task. This can be ascribed to their perception of their ability that increases with positive experiences.

Bandura (1986, 1997) postulates that there are four sources of self-efficacy. According to him, a student's sense of self-efficacy emanates from mastery experiences, vicarious experiences, social persuasion as well as emotional and psychological states. The most significant of the four was mastery experiences because they "provide the most authentic evidence of whether one can master whatever it takes to succeed" (Bandura, 1997, p. 80). There is a correspondence between the learning outcomes of a mastery climate, namely developing the best solution to a problem and perseverance in the face of obstacles, and the deep learning and perseverance associated with inquiry-based learning (Ames, 1992; Epstein, 1988).

Inquiry learning affords learners direct experience of scientific knowledge, processes, skills, experience with failure and peer interaction in addition to fostering in them scientific dispositions of "...curiosity, creativity, originality, perseverance..." (Hugerat & Kortam, 2014, p. 449). Scientific inquiry has been advocated as a common curriculum goal in school science education in South Africa, and also throughout the world. Curriculum documents advocate that teachers use strategies that involve children "in asking scientifically valid questions, setting up investigations, collecting and analyzing data, and coming to some conclusion based on the data collected" (Crawford, 2014, p. 515). Anderson (2007) describes inquiry learning as synonymous with constructivist learning where students "construct meaning for themselves, such meanings are dependent upon prior constructions, the understandings, the understandings are context dependent, and they are socially constructed" (p. 821).

RESEARCH DESIGN AND METHODOLOGY

A quasi-experimental design was adopted in investigating the effect of an inquiry pedagogy (5E-inquiry-based learning) on the self-efficacy of grade 10 physical sciences learners. The 5E learning cycle model (Bybee et al., 2006) lists five inquiry phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation. During the engage phase, the teacher assesses learners' prior knowledge. During the second phase, explore, the teacher facilitates learners actively working together with other learners in a hands-on, minds-on activity. The explain phase begins when a teacher starts questioning learners and encouraging them to explain their ideas about the concepts based upon the evidences of their activity. The elaborate phase is where learners are asked to demonstrate capacity to apply the learnt skills and knowledge to real-life situations. In the evaluation phase, a summative evaluation is created to test for the stated objectives in the inquiry lesson.

Sixty-six learners from three township schools were randomly designated as the experimental group, and 49 learners from two township schools were randomly chosen as the control group. The learners in the experimental group participated in 6 weeks (30 hours) of 5E inquiry lessons. Over the same period, the control group received traditional instruction. Both groups were taught the same topics over this period. Data on the self-efficacy of learners were collected by means of a questionnaire developed by Vedder-Weiss and Fortus (2010). The learners responded to items on self-efficacy by selecting an appropriate option on a 5-point Likert scale ranging from 1 (not true at all) to 5 (very true). An example of an item was "I can do even the hardest work in this class if I try."

RESULTS

The results of the analysis revealed no significant difference in self-efficacy for experiment and control groups during the pre-intervention period (Mann-Whitney $Z= -.685$, $p= 0.494$). The experiment group showed a significant increase in self-efficacy pre-post-intervention (Wilcoxon signed ranks $Z=-2.646$, $p=0.008$) with a low effect size ($r=0.175$). The median self-efficacy score for the intervention group increased from pre-intervention ($Md= 4.375$) to post-intervention ($Md= 4.500$). The control group showed a decline in self-efficacy pre-post-intervention (Wilcoxon signed ranks $Z=-2.797$, $p= 0.005$) with a small effect size ($r= 0.283$).

DISCUSSION AND CONCLUSION

We conclude that 5E-inquiry influences the self-efficacy of learners. This conclusion confirmed the claim by Bandura (1997) that mastery learning such inquiry-based learning foster the development of self-efficacy. In particular, the study confirmed recent findings on the effect of different inquiry strategies in fostering the development of Chemistry self-efficacy. For example, Qureshi, Vishnumolakala, and Southam (2016), and Sen and Erdogan (2016) claim that applying an inquiry strategy in teaching chemistry promoted the development of learners' chemistry self-efficacy.

The results suggest that an inquiry-based approach could be a viable alternative to the traditional teacher-directed approach that is commonplace in South African township schools (Ramnarain, 2016) which do not offer learners autonomy for mastery learning. The results suggest that an inquiry-based pedagogy can foster self-efficacy development which is a reliable predictor of school and post school achievement (Bandura, 1986; Britner & Pajares, 2006; Schunk, 1991). Therefore, we recommend professional support of teachers in applying inquiry in the teaching physical sciences. Despite the strong curriculum emphasis for the adoption of an inquiry-based pedagogy, South African teachers show a lack of confidence in anacting this approach. This can be ascribed to their lack of competency in inquiry-based learning that can only be addressed to professional development efforts where teachers themselves are cast in the role of inquirers.

Future studies may examine how learner characteristics such as age, gender, race or ethnicity shape learner' self-efficacy. In addition, research could also explore the stability of the developed self-efficacy over an extended period of time.

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Do Activities Represent the "Inquiry-Based" Approaches in Turkish Biology Textbooks?: Reflections of Educational Reform Movement In a Developing Country

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Abstract

The purpose of this study was to determine how inquiry-based approaches represented in the Turkish biology textbooks. Four biology textbooks for 9-12 grades approved by the Ministry of National Education of Turkey were the sample of this study. Inquiry-based Tasks Analysis Inventory (ITAI) developed by Yang and Liu (2016) was used for analysis. Eighty-one activities were analyzed and findings showed that textbooks do a poor job of preparing students for understanding what scientific inquiry is. Scientific inquiry is an essential fragment of scientific literacy and despite being emphasised as a goal in the national curriculum, Turkish biology textbooks do not reflect this objective in the activities.

Keywords: Biology Textbooks; Educational Reform; Inquiry-based Teaching

INTRODUCTION

Scientifically literate individuals are indispensable components of democratic societies. In the structure of democratic societies, it is expected that each person who are the dynamic part of the society will actively participate in many national decisions (Hurd, 1998). Individuals need to have some cognitive (e.g., selecting, organizing, and utilizing science knowledge) and metacognitive (e.g., reflection, scientific reasoning) skills in order to participate in that kind of responsible decision-making processes (Zeidler, Berkowitz & Bennett, 2014; Zimmerman, 2000). Given the importance of generating scientifically literate citizens, current science education reform documents (see; AAAS, 1993; NRC, 1996) emphasize the integration of inquiry-based approaches that improve those aforementioned skills to the school science curriculum as an essential way of achieving scientific literacy. Teachers have a key role on moving the philosophy of the curriculum to the classroom and prepare learning environments that meet the contemporary pedagogical approaches. Therefore, textbooks (biology textbooks in this case) are also crucial because research showed that more than 90% of science teachers design 90% of their courses on the basis of textbooks (Yager, 1996). As Park (2005) stated textbooks greatly influence teachers' choices of concepts as well as how they are taught. As a matter of fact, although this idea seems innocent, it may reduce the teachers' interaction with the national curriculum. When something like this happens, unqualified textbooks may hinder the success of the educational systems of the countries in educational reform movement.

Turkey is a developing country with the 80 million population and geographically located between Europe and Middle-East. In other words, Turkey is a cultural and social bridge between eastern and western world. Since many different cultures live together in Turkey, it is clear that a more inclusive understanding of education should be adopted. Therefore, effects and reflections of the educational reform movement may vary from other countries around the world. Like other governments around the world, the Turkish government is aware of the importance of preparing its citizens for the challenges of the new century (Irez, 2009). Thus, the national curriculum has been updated according to the current educational approaches in the world since the 2000s. The curriculum for secondary school science courses (biology, physics and chemistry), was updated in 2007 and 2013. Because, it is very important to determine the non-working aspects of these curriculums in countries own contexts (Ayas, 1995) and to make interventions according to research in the field. Current studies underscore that one of the most effective approaches to achieving scientific literacy is the inquiry-based teaching approach (Lederman, Antink & Bartos, 2014). As stated below, inquiry-based approach was also considered as main concept of the Turkish high school biology curriculum by curriculum developers.

> The success of the biology curriculum depends on the preparation of learning environments that provide meaningful contexts for learning where students can set his or her own learning goals and work with other students as well as independent study. Therefore, it is necessary for teachers to diversify teaching approaches, in the sense that the individual needs of students, their knowledge, skills and learning styles are different from each other ... in general, the structure and content of biology curriculum is based on research and inquiry-based approaches…(MOE, 2013, p.VI)

Investigations have shown that scientific literacy is the main concept of the Turkish biology curriculum which developed in 2013 and in this context it has been prepared in accordance with inquiry-based approaches (Karatay, Timur & Timur, 2013). The aim of this study was to determine whether the textbooks developed after the curriculum change, as the first step of the educational reform, were suitable for this change. In order to analyze the traces of the inquiry-based approaches, it is often not possible to obtain sufficient information in the text. Thus, analyzing the activities in the textbooks will give more accurate results. “How do activities in the currently approved high school biology textbooks match the inquiry-based approaches which were the main objective of the national curriculum in Turkey?” was a research question of this study.

DESIGN/PROCEDURE

Content analysis research design which is associated with qualitative oriented approaches were used in this study as a methodological framework. In Turkey, all courses have separate curriculum and they all prepared by a team of researchers and teachers together in that specific field. High school biology curriculum is one of these and the curriculum developers stated the purpose of the curriculum as “The biology curriculum has been evaluated as a process in which inquiry and research are essential… [learners] can interact with other students, teachers and the environment…can transfer knowledge to the novel situations” (MEB, 2013, p.VI). Parallel to this purpose of the curriculum, the necessity of the presence of new teaching methods in the content and the design of the book (Ogan-Bekiroğlu, 2007) was the argument of this study. The content of the Turkish biology textbooks consists of theoretical lectures and activities supporting these lectures. Four biology textbooks for 9-12 grades approved by the Ministry of

National Education of Turkey were the sample of this study (Table 1). Inquiry-based Tasks Analysis Inventory (ITAI) developed by Yang and Liu (2016) was used for analysis. ITAI involved three main dimensions (1-construction of understandings about scientific concepts (CUASC), 2-expected skills (ES), 3-understandings about scientific inquiry (UASI)) with 22 sub dimensions. Eighty-one activities (39 for 9th grade, 10 for 10th grade, 21 for 11th grade and 11 for 12th grade) were analyzed by the author and another researcher. In case of low inter-rater agreement, a meeting was set up to compare and discuss the disagreements and made sure that final agreement was 100% for all activities. Analysis involved percentages and frequencies to reveal the most emphasized scientific inquiry (SI) aspects separately and the quality of the textbooks in case of the integration of all aspects.

Table 1. Textbooks reviewed in the study.

Author(s)	Date /Edition	Grade	Publisher	Number of activities/unit	Number of activities
Commission	2016/3	9	MEB	17/1, 14/2, 8/3	39
O. Ebinc	2016/3	10	PALME	6/1, 3/2, 1/3	10
Commission	2016/1	11	MEB	10/1, 11/2, 0/3	21
Z. Arslan, E. Unver	2016/1	12	IPEKYOLU	1/1, 10/2, 0/3, 0,4	11

FINDINGS

The findings from the analysis of the 9th grade biology textbook is summarized in table 2. The last column on the right-hand side shows the total numbers and percentages of the themes appearances in the activities. These percentages can be interpreted by the readers as to what extent textbook authors consider the theme in their activities. Furthermore, the last row on the bottom shows the how well activities fit into SI themes. By looking at these numbers, readers can understand the compliance of each activity with the SI. Examinations of the activities regarding the consistency with curricular knowledge objectives in the 9th grade textbook showed that the vast majority of the activities were prepared in accordance with the curriculum. The curriculum includes a list of concepts that teachers and also textbook authors should focus on. Analysis indicated that textbook authors designed activities by considering these concepts in all 39 activities (100%). On the other hand, it was found that 66.7% (26/39) of the activities were related to the “core idea” of that particular topic. Analysis of the activities regarding to the opportunities for students to use inquiry process skills was made under twelve items. As can be seen from the table, observing (53.8%) and inferring (59.0%) were the most considered skills by the textbook authors. In contrast, “formulating hypotheses” and “formulating models” skills were the least emphasized ones and each of these skills observed in only one of the 39 activities (2.6%). Analysis on students’ understandings about SI showed that textbook authors considered the importance of explanations that generated from data and prior knowledge (27/39, 69.2%). Parallel to this finding, 56.4% of the activities encouraged students to generate conclusions based on the data they collected.

Table 2. Scientific Inquiry aspects reflected by the 9th grade biology textbook

Grade		**9**																																							
UNIT		**1**																	**2**														**3**								**Over all score for themes**
Dimensions	**Sub-Dimensions**	Act. 1	Act. 2	Act. 3	Act. 4	Act. 5	Act. 6	Act. 7	Act. 8	Act. 9	Act. 10	Act. 11	Act. 12	Act. 13	Act. 14	Act. 15	Act. 16	Act. 17	Act. 1	Act. 2	Act. 3	Act. 4	Act. 5	Act. 6	Act. 7	Act. 8	Act. 9	Act. 10	Act. 11	Act. 12	Act. 13	Act. 14	Act. 1	Act. 2	Act. 3	Act. 4	Act. 5	Act. 6	Act. 7	Act. 8	
CUASC	Lesson Objectives	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	**(39/39) 100**
	Core Ideas	•	•	•	•	•	•	•	•	•	•		•	•	•	•		•	•				•	•	•	•							•	•		•	•		•	•	**(26/39) 66,7**
	Observing			•				•	•	•	•		•	•	•	•		•	•	•	•	•			•		•	•		•		•		•						•	**(21/39) 53,8**
	Inferring	•	•	•		•	•	•	•	•	•		•	•			•	•								•				•	•		•	•	•	•	•		•	•	**(23/39) 59,0**
	Measuring			•												•		•	•													•									**(5/39) 12,8**
	Communicating	•		•		•															•					•			•	•				•	•	•	•		•	•	**(13/39) 33,3**
	Classifying						•					•								•			•	•																	**(5/39) 12,8**
ES	Predicting	•	•	•		•	•	•											•									•		•	•	•				•	•	•	•	**(15/39) 38,5**
	Contr. Var.			•																												•		•							**(3/39) 7,7**
	Defining Operationally	•																	•													•							•		**(4/39) 10,3**
	Formulating Hypotheses			•																																					**(1/39) 2,6**
	Interpreting Data	•		•					•	•	•		•	•		•	•	•								•						•				•				•	**(14/39) 35,9**
	Asking Questions	•						•											•																				•		**(4/39) 10,3**
	Formulating Models																																						•		**(1/39) 2,6**
	Begin with a Question	•						•											•																				•		**(4/39) 10,3**
	Multiple Methods																		•																				•		**(2/39) 5,1**
	Guided by the question asked	•																	•																						**(2/39) 5,1**
	Same procedure-same result?	•																	•											•			•			•			•		**(6/39) 15,4**
UASI	Procedure inf. Results?																		•		•									•										•		**(4/39) 10,3**
	Conclusion data conformity	•		•				•	•	•	•		•	•	•	•	•	•	•							•				•		•	•	•	•	•			•	•	**(22/39) 56,4**
	Data differs from evidence			•														•																							**(2/39) 5,1**
	Data and prior knowledge-based explanations	•		•	•	•	•		•	•	•		•	•	•	•	•	•	•	•	•					•				•	•	•	•	•	•	•			•	•	**(27/39) 69,2**

Overall score for each activity	(13/22) 59.1	(4/22) 18.2	(13/22) 59.1	(3/22) 13.6	(6/22) 27.3	(6/22) 27.3	(8/22) 36.4	(7/22) 31.8	(7/22) 31.8	(7/22) 31.8	(2/22) 9.1	(7/22) 31.8	(7/22) 31.8	(5/22) 22.7	(7/22) 31.8	(5/22) 22.7	(9/22) 40.9	(14/22) 63.6	(4/22) 18.2	(5/22) 22.7	(2/22) 9.1	(3/22) 13.6	(3/22) 13.6	(3/22) 13.6	(7/22) 31.8	(2/22) 9.1	(2/22) 9.1	(3/22) 13.6	(8/22) 36.4	(4/22) 18.2	(9/22) 40.9	(7/22) 31.8	(8/22) 36.4	(5/22) 22.7	(8/22) 36.4	(5/22) 22.7	(2/22) 9.1	(14/22) 63.6	(9/22) 40.9

Contrary, 5.1% of the designed activities only have potential to help students to understand that there is no single set of methods followed in the inquiry process (multiple methods, 2/39) and student's spontaneous questions might change the direction of the procedure (5.1%). Also, again only two of the activities (5.1%) were eligible to support students to grasp the difference between scientific data and scientific evidence.

Table 3. Scientific Inquiry aspects reflected by the 10th grade biology textbook.

	Grade	**10**										
	UNIT	**1**						**2**			**3**	**Overall score for themes**
Dimensions	**Sub-Dimensions**	Act. 1	Act. 2	Act. 3	Act. 4	Act. 5	Act. 6	Act. 1	Act. 2	Act. 3	Act. 1	
CUASC	Lesson Objectives	•	•	•	•	•		•	•	•	•	**(9/10) 90,0**
	Core Ideas	•	•	•		•		•	•	•	•	**(8/10) 80,0**
	Observing	•	•	•			•	•			•	**(6/10) 60,0**
	Inferring	•	•	•	•	•	•	•	•	•	•	**(10/10) 100**
	Measuring		•	•			•					**(3/10) 30,0**
	Communicating					•						**(1/10) 10,0**
	Classifying								•			**(1/10) 10,0**
	Predicting	•	•	•				•	•	•	•	**(7/10) 70,0**
ES	Contr. Var.											**(0/10) 000**
	Defining Operationally											**(0/10) 000**
	Formulating Hypotheses											**(0/10) 000**
	Interpreting Data		•	•			•	•	•			**(5/10) 50,0**
	Asking Questions											**(0/10) 000**
	Formulating Models								•			**(1/10) 10,0**
UASI	Begin with a Question											**(0/10) 000**

Multiple Methods											(0/10) 000
Guided by the question asked											(0/10) 000
Same procedure-same result?					•		•	•			(3/10) 30,0
Procedure inf. Results?											(0/10) 000
Conclusion data conformity		•	•				•	•			(4/10) 40,0
Data differs from evidence		•	•				•	•			(4/10) 40,0
Data and prior knowledge-based explanations	•	•	•		•	•	•	•			(7/10) 70,0
Overall score for each activity	(6/22) 27,3	(10/22) 45,5	(10/22) 45,5	(2/22) 9,1	(6/22) 27,3	(5/22) 22,7	(10/22) 45,5	(11/22) 50,0	(4/22) 18,2	(5/22) 22,7	

The “quality” of inquiry-based tasks in the 9th grade biology textbook showed in figure 1. Overall scores for each activity showed that only 4 activities had the score more than 50%. These scores were 63.6% for two of the activities and 59.1% for the others. In the textbook, 5 activities showed the lowest quality rate, emphasizing only 2 of 22 SI themes (9.1%). One of these themes was common for all activities which is about the conformity to curriculum and the others were "observing" for 3 activities, "predicting" for one and "classifying" for the other activity.

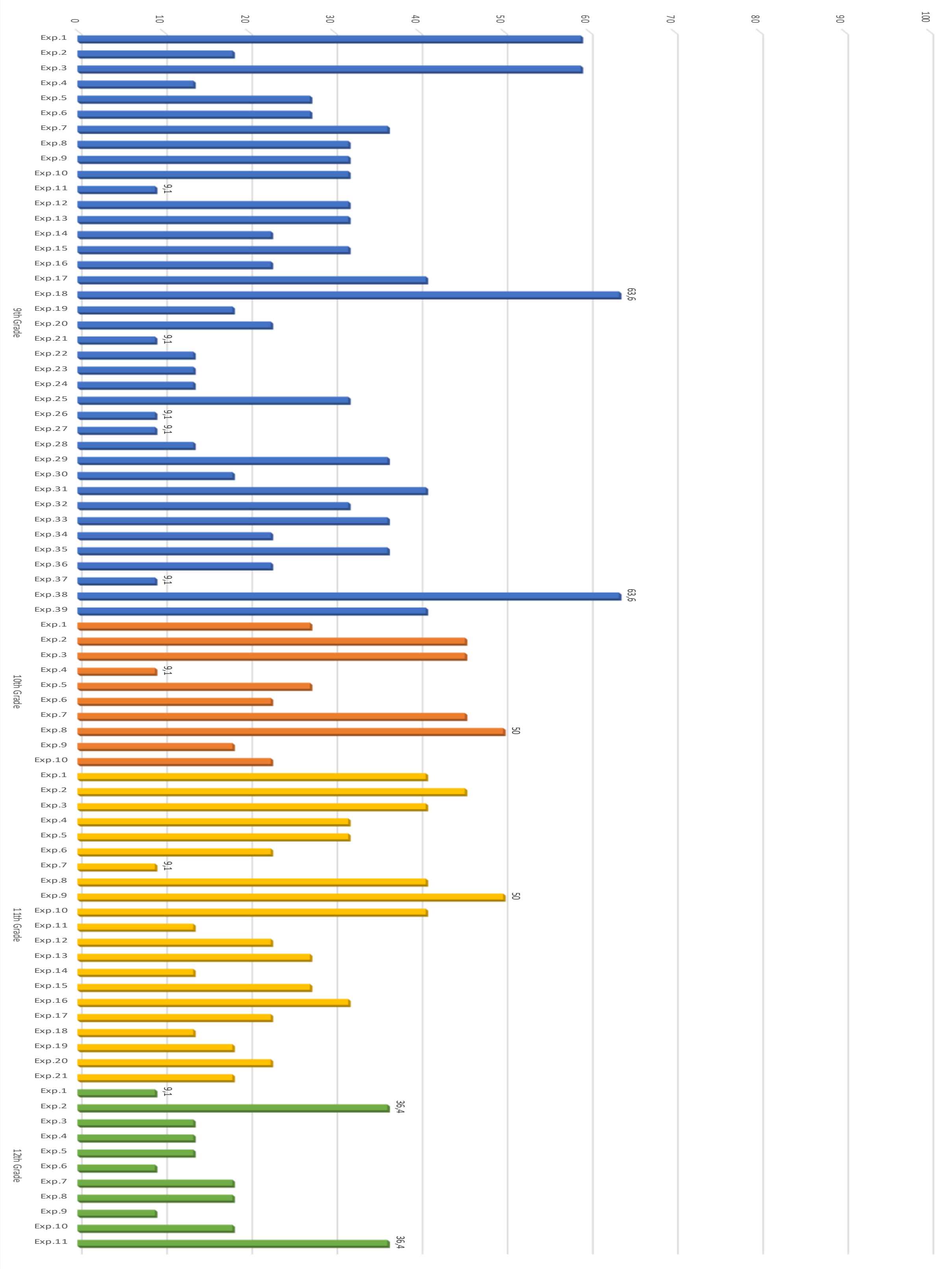

Figure 2. Percentages of SI aspects demonstrated in each activity for 9-12 biology textbooks.

The 10th grade biology course was structured under the three units in the national curriculum. These units were "reproduction", "general principles of heredity" and "our world". It was seen from the analyses that 9 out of 10 activities were compatible with the curriculum (Table 3). Also, eight of the activities were reflect the core ideas of the subjects (80%).
The most emphasized skills by the textbook author was "inferring" (100%) and "predicting" (70%). Contrary, "control variable", "defining operationally", "formulating hypothesis" and "asking questions" skills were never mentioned in the activities (0/10).

Table 4. Scientific Inquiry aspects reflected by the 11th grade biology textbook.

	Grade	11																						
	UNIT	1										2											3	Overall score for themes
Dimensions	Sub-Dimensions	Act. 1	Act. 2	Act. 3	Act. 4	Act. 5	Act. 6	Act. 7	Act. 8	Act. 9	Act. 10	Act. 1	Act. 2	Act. 3	Act. 4	Act. 5	Act. 6	Act. 7	Act. 8	Act. 9	Act. 10	Act. 11	No Act.	
CUASC	Lesson Objectives	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		(21/21) 100
	Core Ideas	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●		●	●	●	●		(19/21) 90,5
	Observing	●	●		●	●			●	●	●		●	●		●	●	●				●		(13/21) 61,9
	Inferring	●	●	●	●	●	●		●	●	●		●		●	●		●	●		●			(15/21) 71,4
	Measuring		●							●														(2/21) 9,5
	Communicating			●			●		●	●	●			●			●	●		●				(9/21) 42,9
	Classifying							●				●												(2/21) 9,50
	Predicting	●	●	●	●		●						●			●		●		●		●		(10/21) 47,6
ES	Contr. Var.	●							●	●	●						●							(5/21) 23,8
	Defining Operationally																							(0/21) 000
	Formulating Hypotheses																							(0/21) 000
	Interpreting Data	●	●	●		●			●	●	●						●				●			(9/21) 42,9
	Asking Questions																							(0/21) 000
	Formulating Models																							(0/21) 000
	Begin with a Question																							(0/21) 000
	Multiple Methods																							(0/21) 000
	Guided by the question asked																							(0/21) 000
	Same procedure-same result?													●										(1/21) 4,8
UASI	Procedure inf. Results?													●										(1/21) 4,8
	Conclusion data conformity	●	●	●	●	●			●	●	●													(8/21) 38,1
	Data differs from evidence		●	●						●														(3/21) 14,3
	Data and prior knowledge-based explanations	●	●	●	●	●			●	●	●					●	●				●			(11/21) 52,4

Overall score for each activity	(9/22) 40,9	(10/22) 45,5	(9/22) 40,9	(7/22) 31,8	(7/22) 31,8	(5/22) 22,7	(2/22) 9,1	(9/22) 40,9	(11/22) 50,0	(9/22) 40,9	(3/22) 13,6	(5/22) 22,7	(6/22) 27,3	(3/22) 13,6	(6/22) 27,3	(7/22) 31,8	(5/22) 22,7	(3/22) 13,6	(4/22) 18,2	(5/22) 22,7	(4/22) 18,2

Additionally, "communicating", "classifying" and "formulating models" skills were only mentioned once in three of ten activities. It was also determined that there was no reference to four themes in UASI dimension (begin with a question, multiple methods, guided by the question asked and procedure influence results). As in the 9th grade textbook, the most emphasized theme was the consideration of explanations that generated from data and prior knowledge (70%). Findings regarding the SI quality for 10th grade textbook showed that none of the activities were able to exceed 50% success (Figure 1). Three of the activities contained 10 of the 22 aspects (45.5%). Finally, one of the activities had only 2 (9.1%) aspects which were compatibility with the curriculum and inferring.

Table 5. Scientific Inquiry aspects reflected by the 12th grade biology textbook.

	Grade	**12**													
	UNIT	**1**	**2**										**3**	**4**	**Overall score for themes**
Dimensions	**Sub-Dimensions**	Exp. 1	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Exp. 6	Exp. 7	Exp. 8	Exp. 9	Exp. 10	NoExp	NoExp	
CUASC	Lesson Objectives	●	●	●	●	●	●	●	●	●	●	●			**(11/11) 100**
	Core Ideas		●		●	●		●	●		●	●			**(7/11) 63,6**
	Observing	●	●	●	●	●	●	●	●	●	●	●			**(11/11) 100**
	Inferring		●	●					●			●			**(4/11) 36,4**
	Measuring		●									●			**(2/11) 18,2**
	Communicating		●					●			●				**(3/11) 27,3**
	Classifying														**(0/11) 000**
	Predicting														**(0/11) 000**
ES	Contr. Var.											●			**(1/11) 9,1**
	Defining Operationally														**(0/11) 000**
	Formulating Hypotheses														**(0/11) 000**
	Interpreting Data		●									●			**(2/11) 18,2**
	Asking Questions														**(0/11) 000**
	Formulating Models														**(0/11) 000**
	Begin with a Question														**(0/11) 000**
	Multiple Methods														**(0/11) 000**
	Guided by the question asked														**(0/11) 000**
UASI	Same procedure-same result?														**(0/11) 000**
	Procedure inf. Results?														**(0/11) 000**
	Conclusion data conformity														**(0/11) 000**

Data differs from evidence												**(0/11) 000**
Data and prior knowledge-based explanations		•									•	**(2/11) 18,2**
Overall score for each activity	**(2/22) 9,1**	**(8/22) 36,4**	**(3/22) 13,6**	**(3/22) 13,6**	**(3/22) 13,6**	**(2/22) 9,1**	**(4/22) 18,2**	**(4/22) 18,2**	**(2/22) 9,1**	**(4/22) 18,2**	**(8/22) 36,4**	

There were three units named “energy in living things” with 10 activities, “human physiology” with 11 activities and “behaviour” with no activities in 11th grade biology textbook. All 21 activities in this textbook were compatible with the curriculum objectives and 19 of the activities were developed in accordance with key ideas in the curriculum (Table 4). While “inferring” was the most considered skill (71.4%), defining operationally, formulating hypothesis, asking questions and formulating models were the disregarded ones in ES dimension. The other highlighted skills in the activities were observing (61.9%), predicting (47.6%) and interpreting data (42.9%). In UASI dimension, “data and prior knowledge-based explanations” aspect was the most considered aspect (52.4%) and again there were no mention about three aspects (begin with a question, multiple methods and guided by the question asked).

As seen in figure 1, findings regarding the SI quality for 11th grade textbook were very similar to 10th grade textbook and only one of the activities had 50% of aspects. One of the activities included 10 of 22 sub-dimensions (45.5%), while four of them included 9 sub-dimensions (40.9%) and got the best score on this class level. Analysis also showed that almost half of the activities (10 of 21) had less than 25% of the sub-dimensions.

The last textbook of this study (12th grade biology) contained four units titled “from gene to protein” with 1 activity, “plant biology” with 10 activities and “community and population ecology” and “evolution” with no activities. Authors of the textbook prepared activities compatible with the curriculum (11/11, 100%). Seven of the activities (63.6%) were also well-suited with the core ideas of the curriculum (Table 5). While “observing” was the most considered aspect (100%) in ES dimension, there were no clue about classifying, predicting, defining operationally, formulating hypotheses, asking questions and formulating models aspects (0%). When it comes to UASI, only 2 of the 11 activities were underline the importance of the data and prior knowledge based explanations and rest of the aspects were not be detected. Quality of the 12th grade textbook in case of SI was the lowest one. Only two of the activities met the 36.4% of the aspects.

CONCLUSIONS

Findings indicates that textbooks were not eligible for preparing students for understanding what scientific inquiry is. Scientific inquiry is an essential fragment of scientific literacy and despite being emphasised as a goal in the national curriculum, Turkish biology textbooks do not reflect this objective in the activities. In Turkey, textbooks must be approved by a commission (at least 8 people and must contain teachers, field and visual experts) who are selected randomly among the volunteer teachers and educational scientists by Ministry of

National Education (Ders Kitaplari Yönetmeligi, 2012, Item 18/1). Therefore, the members of the commission must have informed understandings about all SI aspects. As can be seen in previous section, most emphasized aspects were inferring, observing and predicting. Obviously, textbook writers develop activities considering predict-observe-explain (POE) method mostly. As Liew and Treagust (1995) stated, POE strategy provides opportunities for students to use their prior knowledge to generate new explanations. Student centered POE method is also expected to allow students to; generate their own hypothesis (only 0,7% of activities in this study), ask their questions (only 2,6%), let them design their own procedures (3,8%), and help them to understand the nature of SI in various ways. However, findings of the current study showed that most of the aspects were ignored by the textbook writers. Apparently, members of the commission either had naïve understandings about SI or ignored the importance of all aspects of SI. Another explanation may be the "teaching to test" oriented textbook writers and textbook evaluators because of the high stake exam at the end of the high school which is only criteria to get in university in Turkish educational system. Therefore, it is no surprise that textbooks only consider how students predict the right choice of the questions by interpreting the evidence given in the questions. As seen in figure 1, the quantity and the quality of activities are decreasing from 9th grade to 12th grade because of the preparations of the content knowledge oriented university enterance exams.

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Sign language and science on a TV show for deaf children

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Abstract

Based on the theoretical concept of modes of address, the following study focuses on understanding the aesthetic, pedagogical and ideological strategies in the episode "Ants", produced by TV INES. The TV show is designed for children aged 3 to 8 years old, aims at drawing Deaf children spectators, by allowing them access to a media product in their language and approaching the children's world, always taking science into account. It could be found the show uses a ludic-symbolic representation of children, giving them the leading role, with competence to solve problems, to take initiatives, and to be creative. Founded on this conception of the spectator, the program introduces the Anthill theme to present the environment of the ants: where they live, what their names and sign names are and the roles of each one within this environment with an ecological relationship approach. The TV show allows Deaf children to have early access to sign language in a non-formal learning environment and, on the other hand, for hearing children, there is the possibility of getting to know another language. At the end of the show, a quiz invites the child to participate and to systematize the content intended by the producers.

Keywords: children's TV show, deafness, science, modes of address

INTRODUCTION

Children's TV shows have always found in Natural Sciences a fertile field for narratives that introduce especially children of Early Childhood Education to their surrounding environment. Among others, animals, the woods and their mysteries, the creation and transformation of materials are common themes and characters that attract children's attention. Based on the work of Bettelheim (2015), Fuenzalida (2015) states that children's programs may, as in fairy tales, lead the child to experience "unconscious existential fears through fictional ludic symbols" (p.18) because children remain animistic until their puberty, i.e. they do not separate objects and living beings in their vision. According to Bettelheim (2015), "a child relies on what fairy tales say because the worldview presented to them is in accordance with their own" (p. 67)". According to Silva (2002), "children's minds have to move characters, drama, heroes, and all the simple and popular experiences that will contribute to the higher forms of expression and communication" (p.53).

The technological advance or the so-called "Technological Age" has contributed significantly to the transformation in the way children relate to the world. Early contact with technology seems very familiar to them and the former interest in storybooks, tags, hopscotchs, among other playground games, can also be found in gadgets that can be easily accessed by children, anytime, anywhere.

According to Paiva and Costa (2015), the time exposure of children and young people to these gadgets might have consequences for their physical, mental and social health. However, for the deaf community, the possibility of using gadgets - which not only allow them to visualize images, but also the image in movement - has promoted the design of materials in sign language, either their own or other producers' materials.

Deaf children, according to Goldfield (2001), acquire language differently from the hearing child and this difference relates both to quantitative and qualitative aspects. Mostly born in hearing families, deaf children miss the conversations in their surroundings as well as do not receive stimulation from their parents, such as storytelling or watching TV shows together. This absence of stimulation in crucial periods of any child's development will be reflected on the linguistic, cognitive and emotional repertoire of deaf children.

In 2015, TV INES, a web TV created by the National Institute of Education for the Deaf (INES) of Brazil, in association with Roquette Pinto Educational Communication Association, designed an app for Android and IOS devices and for digital TV, and created the first deaf children TV show: Tito's Chest. This program was conceived to bring to a specific group of the population, deaf children, the possibility of being inserted in the media storytelling universe mostly missed by them since the products available are largely in Portuguese.

Modes of address and children's TV shows

Constructing an affective, sociocultural and cognitive conception about its viewer is a way to be followed by producers to construct the modes of address, according to Ellsworth (2001). Modes of address is a concept that stems from cinema studies and indicates the inevitability of addressing to specifically someone any communication, text or action. The concept seeks to understand where the relationships between a filmic text and the experience with its spectators are established. For the movie/series message to reach the idealized audience, Ellsworth (2001) considers that the questions "who does the movie think you are?" and "who does the movie want you to be?" drive the construction of the modes of address of an audiovisual material. The first question is based on the producers' assumption about the identity and characteristics of the audience. The second on the political and ideological spectrum of this very audience. From then on, from the belief of who the viewers are, and where they might watch the movie/series, the producer will build up the characters (leading and supporting roles), their conflicts and dilemmas, narrative, set and costume design, cinematography, sounds and camera positioning, always assuming the audience understands the movie/series the way it has been idealized. However, this relationship is not so direct. Firstly, because most of the times the producers are not so close to the audience; secondly, because the audience might not be who the producers believe they are, and thirdly, because the viewer is active at the time of the reception, he/she can interpret the movie in various ways (Ellsworth, 2001).

For Hartley (2002), modes of address are used by TV shows as a textual strategy with the aim of conveying the dominant ideology to the public in a naturalized way. This is undoubtedly the rule on broadcasting commercial networks. However, according to Sampaio and Cavalcante (2012), public TV network must steer their audience toward another place based on shows committed to culture and citizenship formation. As a public TV network, TV INES is aimed at an audience mostly not included as a target audience by other broadcasters. The development of a TV show for deaf children implies to reflect upon who this audience is, what their needs and desires are and how it is possible to communicate to them.

In this way, based on the mode of address concept, this study intends to describe and analyze some of the aesthetic, pedagogical, and ideological strategies used in the production of the episode "Ants", one of the five of "Tito's Chest" series. Therefore, the concept of modes may allow us to understand the journey traveled by the production of "Tito's Chest" for the construction of the discursive field that sought to contemplate deaf child as a spectator in the chosen episode of this study.

METHODOLOGY

Tito's Chest was the first children's TV series produced entirely by TV INES. Its first season had five episodes, and premiered as a homage for deaf children on October 12, 2017, Brazilian National Child's Day. According to the production team, the program targets children aged from 3 to 8 years old.

Seeking to know the modes of address strategies created by the producers of "Tito's Chest" to attract deaf children to Science subjects, we chose the episode "Ants" to do a filmic analysis. This analysis implies to deconstruct the episode into its parts and then rebuild it, trying to understand how the producers and the episode serve as a springboard to a place for the child/deaf viewer to learn from Science. Furthermore, we searched for the presence of the most contemporary trends in children's TV show production in this episode, according to Fuenzalida indications (2015).

RESULTS

Episode analysis

The TV show's opening credits dynamically present scenes of adventures carried out by the two characters (Tito and Bel) and are accompanied by an entertaining soundtrack. The opening sequence ends with the name of the program made in the Brazilian Sign Language (BSL) by Tito (Figure.1). This ending already gives clues to the viewer that the program is somehow related to the universe of deafness.

Figure 1: The show's opening credits.

In the episode “Ants” there is a mystery to be unraveled. Who stole Tito's cookie? In order to unveil it, Tito and Bel go on a foray through an anthill from the portal in the chest. In the first scene, Tito is shown on the floor reading a storybook. His room is colorful, has typical elements of a boy's room, such as a ball, a plane, drawings, and some stuffed animals. On the wall, there is also Tito’s name in the Brazilian Sign Language (Libras/BSL) alphabet, which we may consider as a way of addressing the Deaf viewer (Figure 2).

Figure 2: Tito and his room

The mystery of the episode comes right after the second scene when Tito, talking to himself in BSL, says that he is hungry and looks for a cookie in his jar on the shelf and only finds some crumbs left. In this scene, it becomes clear to the viewer that a deaf child is starring the program, an important element for the identification of deaf children with the character of the story besides being one of the contemporary elements in the production of children's shows - a child in the role of a child (Figure 3).

Figure 3: Where's my cookie?

Suspecting Bel has eaten the cookies, Tito goes to the chest to inquire her. When he opens it, some fairy dust comes out from the inside, visually demonstrating this is not just any chest. These visual aids are essential for any child, but especially for the deaf child, as it shows it is a special chest (Figure 4).

Figure 4 - The magic that comes from the chest.

Bel shows up and Tito asks about the cookie, she denies she has stolen it and blames the ants. As Tito cannot believe her, Bel invites him to get to know an anthill and so they cross the portal and disappear in the chest. Here, some features of the anthill start being introduced.

When they arrive at the anthill, they soon see the worker ants carrying cake crumbs and Bel soon tries to explain to Tito they are also responsible for digging tunnels and cleaning the anthill. Then, in order to reinforce the name of the ants, a card with the name "worker ant", the image of the ant and Bel making the sign of "worker ant" in BSL are shown in the video. By presenting the word in Portuguese, its correspondent image and sign in BSL, it cleary characterizes the Bilingual proposal of the show (Figure 5).

Figure 5 - Bilingual proposal.

The walk through the anthill goes on and, suddenly, Bel sees what she called a soldier ant wearing a soldier helmet and a spear in one of its legs. Tito is amazed by the size of the ant and tells Bel he is afraid. She reassures him they are soldier ants and their job is to protect the anthill. Tito is frightened of walking into the anthill any further. Bel, however, comforts him by claiming she knows all about ants. She ends up putting a toy antenna on Tito's head, who finds it amusing. Once again, a card with the word soldier ant, its image, name in Portuguese, written and oral, and Bel making its correspondent sign are shown.

The children keep on going in the anthill and now they go through a deep tunnel dug by the ants and arrive in the room of the Queen Ant. Tito is amazed by the size of the room and Bel soon guides him to bow to the queen. A similar card with name, sign in BSL and image is shown once more. Tito is amazed by the size of the ant and Bel explains she is the mother of all ants and commands everything in the anthill. In the room, we can see both the soldier ant guarding the Queen and other ants that certainly play a role in the anthill. Bel then tells Tito the queen is calling her and Tito is astonished to learn Bel knows the Queen Ant. Later, sitting on the Queen ant's lap, Bel calls for Tito's help to get her out of there because the Queen does not want to release her because of her smell. And Tito asks her friend about what smell she is talking about. Very awkwardly Bel says it is the smell of chocolate. Tito then finally discovers who had really eaten his cookies. Bel once again asks Tito to help her and he lets her to get on with the Queen Ant, and leaves the room laughing at the situation where his friend got in. In the final scene, Tito faces the camera and recaps some information about the episode: he asks about the sign concerning the Queen Ant. After showing the correct answer to his question, Tito says goodbye to Bel and laughs at the trouble in which his friend got into. He leaves Bel crying in the lap of the Queen Ant.

CONCLUSIONS

The analysis of the episode shows it displays several elements that characterize the latest trends in children's TV series production. Deaf children take the lead role and use the Brazilian Sign Language, which allows identification with the show's target audience. Taking segmentation into account, children aged from 3 to 8 years old, language adequacy, children's development and content have been carefully and intentionally developed by the producers. Interactivity with children by allowing them to explore their playfulness is another element present in the episode in question and this happens when the characters look directly at the camera and through the quiz at the end of each show.

With a playful-symbolic layout, the 2D environment of the cartoon contains strategies that involve aspects of playfulness, imagination, and interaction with the viewer. The narrative, the visual changes lead the viewer/child to experience, along with the characters, feelings like fear and surprise. According to Fuenzalida (2015), programs for children aged 3 to 6 years old have evolved into a proposal where the child is asked to participate, whether to solve challenges, to think, to gather clues, among others. The question posed at the beginning of each program allows the child to be aware of what might happen in the story and might go raising hypotheses about who ate the cookie. The content expressed in the anthill program presents a kind of harmonious ecological relationship, i.e. each ant has a role, which shows the social organization of the ants and the idea of species. It points out that the natural habitat of the ants is in tunnels and underground galleries built by the worker ants. Further to that, children might acquire basic vocabulary on the subject, either in Brazilian Sign Language or in Portuguese. Children are introduced to the subject without the pretense of further deepening on the environmental issue, in fact, this stage is for deaf children, the period of acquisition of a language either in Brazilian Sign Language or Portuguese and the period of contact with the representations that are part of their universe. The narration format allows deaf children to build their own scripts, and, thus, it stimulates their attention, the temporal sequence of the story, the cognitive elements. Unmasking Bel's lie, and somehow leaving his friend in danger, the fear of a strange place and of the animals he met are experiences that Tito went through in this episode that may help, in a playful way, a deaf child to experience and also to empathize with these feelings. A 2D cartoon program built with several different modes of address that might help the audience to identify themselves with the program. Deaf children's early access to sign language is also a way to enable them to acquire the culture that the language carries. And for hearing children lies the possibility of getting in touch with another language. The quiz at the end of the program aims to trigger functions such as memory, attention, association between meaning and signifier, calling children to respond to Tito's question.

According to Fuenzalida (2011), "a television education different from curricular schooling, carried out in a ludic audiovisual language of affection, can help to strengthen the capacities of empowerment and resilience indispensable for overcoming social diversity" (2011, p.18).

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UFES Chemistry Undergraduate Students' Social Representations on "Experimentation"

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Abstract

This paper presents the results of a study on the meaning of the term "Experimentation" for chemistry undergraduate students. The theoretical-methodological perspective of Social Representation Theory (SRT) underlies the study design, in the Central Core Theory (CC) approach. In this perspective, the CC of the Social Representation (SR) guides the meaning and the organization of the SR, while its peripheral system reflects the individual experiences and enables the adaptation of the SR to the more immediate social context. A free-association questionnaire, comprising four questions relative to the inductor term "experimentation", was answered in 2017 by 59 initial teacher education students in chemistry at the Federal University of Espírito Santo (UFES), located in the city of Alegre, ES, Brazil. The results show that the CC terms of the SR on experimentation, for this group of future teachers, are "experiment", "knowledge", "discovery", and "research". The meaning of these terms refers to laboratory activities and knowledge development, both scientific activity processes. Additionally, for a subgroup, the terms "contextualization" and "experiment" are represented as a teaching-learning process, which points to a new meaning for the object.

Keywords: Central Core Theory; Experimentation; Social Representation Theory.

INTRODUCTION

The term "experimentation" is polysemous (Mori and Curvelo, 2017) and usually has two meanings in chemistry teaching: on the one hand, it is an element of scientific research, on the other, it means practical laboratory activity in the teaching process (Duit and Tesch, 2010). Such polysemy is seen in the way students represent that term, enabling different conceptions of scientific work (Gyllenpalm and Wickman, 2011) and chemistry teaching (Vogel, 2016).

Today, it is understood that one of the aims of science teaching is to provide individuals with ways of interpreting natural phenomena that deviate from common sense. It is, therefore, necessary for students to apprehend the educational dimension of scientific knowledge. In the specific case of chemistry, it means that students should understand the articulation between the different domains of chemical knowledge – macro/submicro/representational – and be able to express their interpretation of phenomena by using this language.
In this context, multiple surveys have been conducted with the aim of inventorying students and teachers' representations of science (Kosminsky and Giordan, 2002; Melo, Tenório and Acciolli, 2010; Goldschmit, Goldschmit and Loretto, 2014). The results show a reductionist representation of science that brings to mind idealistic and empiricist views of the scientific

work and method, regardless of age range and education level. This type of representation has been observed in elementary school students, high school students, undergraduates, and science teachers, pointing to the permanence of these conceptions throughout the educational process. For all participants, the experimental character is predominant and linked to the idea of laboratory work, which is seen as synonymous with a predetermined sequence of steps to carry out experiments to obtain truths or prove theories.

In this context, this paper presents the results of a study on the social representation of "experimentation" by undergraduate students of an initial teacher education undergraduate course in chemistry at the Federal University of Espírito Santo, Brazil, aiming to contribute to the reflection on the educational process developed in this course.

THEORETICAL ASSUMPTIONS

Social Representation Theory

Social Representation Theory (SRT) was proposed by Serge Moscovici in his doctoral thesis entitled "*La psychanalyse: son image et son publique*", defended in France in 1961 (Moscovici, 2008). Social representations (SR) play a fundamental role in the practice and dynamics of social relations, as they enable communication within a social group to be relatively non-problematic due to the considerable degree of consensus existing among the group members with respect to the object of representation.

The development of SR entails reciprocal interaction between individual and group, in which a continuous exchange of ideas and values takes place through language and consensual signs that make communication clear and precise among the members of the group. SR constitutes the basis for the signification of objects external to the subject.
SR show two seemingly contradictory characteristics: they are concomitantly stable and changeable, consensual and marked by the individuality of their components. The structural approach to SRT, named Central Core Theory (Abric, 2001), proposes that the components of the SR structure are two articulated systems: the central core and the peripheral system, which play different roles in the SR.

The central system is marked by collective memory and by the group's system of norms, reflecting socio-historical and valuative conditions. It constitutes the common and collectively shared basis for the SR, thus reflecting its homogeneity. The central system is relatively insensitive to the immediate social and material context, ensuring the continuity and permanence of the representation. Its functions are to generate meaning, determine the global organization of all the other terms, and provide stability, ensuring the permanence of the representation. The Central Core (CC) is comprised of one or more terms that occupy a privileged position in the representational structure. These terms must be identified and their relation to the other terms of the SR must be determined in order to unveil the SR of an object (Sá, 2002).

The peripheral system presents greater sensitivity to the social and immediate context, which ensures representation flexibility to the various social contexts, favoring the updating and contextualization of terms. Through successive changes in external circumstances and social practices, the terms constituting the peripheral system can be modified and eventually become part of the CC, thus altering the representation. Therefore, the peripheral system protects the terms of the central system from the immediate contingencies experienced by individuals and, consequently, from the modification of the social representation of a certain object.

Allocation of terms in the Central Core of a Social Representation

In the structural approach (Abric, 2001), the symbolic value of an SR term is inferred from its salience and associative character (Table 1), both of which reflect the term's symbolic significance for the group. These qualitative properties are expressed in quantitative properties: connectivity, frequency, and hierarchy of the terms evoked by the group concerning an inductor term.

Table 1 - Properties of the CC terms

	Properties	Characteristics of the CC properties[a]
Qualitative	**Symbolic Value**	Expresses the importance of an SR's term to the group. It is an SR-related qualitative property, indicating the unnegotiability of the term, the significance of the word for the social object, which can be manifested in the hierarchy chosen for the term and in its frequency.
	Associative Character	Polysemous capacity of the central terms. It is related to the ability of association of these terms with other SR terms.
	Salience	Consequence of the symbolic value of the term to the representation. The response evocation rank and the frequency of a specific term reflects its salience in a free word association task proposed to a social group.
Quantitative	**Connectivity**	Associated with the symbolic value, it expresses the relation between terms, highlighting the process of co-occurrence of subjects evocations within the same social group.
	Average Order of Evocation	Related to the symbolic value. It is expressed by the hierarchy and frequency with which a term is evoked, and expresses the order of a specific term in relation to the set of terms evoked.

a. Abric (2001); Sá (2002); Wachelke (2009); Vogel (2016)

Salient terms are those evoked with higher frequency and high hierarchical level by the members of a group when referring to a particular social object. Those two variables determine the average order of evocation (AOE).

The associative character, i.e. the term's capacity to organize other terms of a representation, is expressed by its connectivity since the CC terms coordinate the other words of a representation. By associating the term salience with the term connectivity, it is possible to identify the elements of the peripheral system and the CC of an SR using the prototypical analysis proposed by Vergès (see Figure 1).

METHODOLOGY

The data were collected with the aid of a free-association questionnaire comprising four questions with the stimulus word "experimentation". The first two questions are to determine the frequency and hierarchy of the terms evoked by the subjects. The last two ones reduce the subjectivity in the evocations´ categorization on the content analysis which attributes meaning to the CC terms of the SR. Another nine questions referred to the social group characterization.

After the data collection, the evoked terms were submitted to the EVOCATION 2005 (Vergès, Junique, Barry, Scano and Zeliger, 2003) and IRAMUTEQ (Ratinaud and Dejean, 2008) software. EVOCATION 2005 leads to the parameters used in the SR prototypical analysis of the collected information. It calculates the AOE, which is the ratio of the product of the term evocation hierarchy (*h*) by the number of distinct terms (*n*) and their evocation frequency (*f*) (Equation 1). In the Vergès four-quadrant presentation (Figure 1), the data are distributed according to the cut-off values calculated for the X (AOE average; Equation 3) and Y (median evocation frequencies; Equation 2) coordinates.

$$\mathrm{A} \qquad {}_i\sum_{j=1}^{k} n_j/f_i \qquad (where\ i\ ;\ j\ \in N) \qquad \text{(Equation 1)}$$

$$\hat{f} = MED(f_i) \qquad (i \in N) \qquad \text{(Equation 2)}$$

$$\mathrm{AAOE} = \sum_{i=1}^{n} \frac{\mathrm{AOE}_i}{m_i} \qquad (i \in N) \qquad \text{(Equation 3)}$$

frequency (***f***); median frequency (***f*****med**); term evocation hierarchy (***h***); number of terms (***n***); Average Evocation Order (AEO); Average Average Evocation Order (AAEO); Schaffer, 2007; Vogel, 2016

The IRAMUTEQ program performs a statistical calculation of co-occurrence values of the terms evoked by the group concerning the social object in question, relating word frequency (f) and co-occurrence, and generating a graph called maximum similitude tree (Bouriche, 2005; Figure 2), which makes it possible to identify the SR term connectivity.

Lastly, to assign meaning to the SR terms, the subjects' explanations for the evoked terms were subjected to a content analysis, inspired by Bardin propositions (1996), leading to the categories presented at Table 3.

RESULTS

The survey was responded by 59 students of an initial chemistry teacher education undergraduate course from the Federal University of Espírito Santo, in the city of Alegre, ES, Brazil. Over a half of the students (31; 52.5%) are in the first year; 5 are in the second; 10 in the third; and 13 are in the fourth year of the course. Over a half of these students (32; 54.2%) take part in projects of Initiation on Teaching or Undergraduate Research. They are young, between 18 and 30 years old, mostly female (61%), and recently graduated from public high schools (81%). The initial teacher education course is their first higher education course (89%), and they need to engage in a remunerated activity (47%) to pay for their expenses, as great part of them are not settled in the city of Alegre until they engage at this undergraduate course.

Symbolic value and associative character of terms according to salience and connectivity

The EVOCATION 2005 software analysis show that the survey subjects produced 347 out of 354 possible terms (6 terms multiplied by 59 subjects), of which 157 terms were different. Posterior to the data input, a term homogenization regarding plural/singular, female/male, and verb inflection was carried out, resulting in 146 different terms. The software provided an AAOE value of 3.47. The minimum frequency value (f) was set to 4, which corresponds to roughly a half of the total evoked terms (53.3%; 186 terms). For the calculation of the median evocation frequency (fmed), the value 7 (36.9%; 128 terms) was set for the group of high-frequency terms.

In the Vergès quadrant, terms are organized according to frequency and AOE values. Terms with frequencies (f) higher than or equal to the median frequency (fmed = 7) and with AOE values lower than or equal to the AAOE (3.5) are placed in the left-hand top quadrant (Figure 1) and probably are the CC terms: *knowledge*, *discovery*, *research*, *experiment*, *learning*, *contextualization*, *curiosity*, *study*, and *practice* (Figure 1). These terms reflect the group homogeneity. They are related to collective memory and are consensual and stable.
In the right-hand top quadrant are placed the first periphery terms, with frequencies (f) higher than or equal to the median frequency (f_{med}) and AOE values higher than the AAOE: *laboratory* (f = 19; AOE = 4.6) and *test* (f = 6; AOE = 4.1).

Terms with frequencies lower than the median frequency (f_{med}) and AOE values higher than the AAOE are placed in the second periphery, right-hand bottom quadrant, such as, for instance, the terms *results* (f = 6; AOE = 4.8) and *reaction* (f = 4; AOE = 4.7). The salience of these terms is not expressive, indicating that their symbolic value for the group´s representation is not noteworthy.

f

Central Core

Term	*f*	AOE
Knowledge	16	2,5
Discovery	16	2,7
Research	16	3,5
Experiment	14	3,2
Learning	9	2,0
Contextualization	9	2,6
Curiosity	7	2,4
Study	7	2,4
Practice	7	3,4

$f_{med} \geq 7$ | AOE $\leq$ 3,5

First Periphery

Term	*f*	AOE
Laboratory	19	4,6
Test	6	4,1

$f_{med} \geq 7$ | AOE > 3,5

AOE

Contrast Zone

$f_{med} < 7$ | AOE $\leq$ 3,5

Term	*f*	AOE
Science	6	2,6
Analysis	6	3,5
Investigation	5	2,2
Teaching	5	3,2
Content	4	3,5
Hypothesis	4	3,5

Second Periphery

$f_{med} < 7$ | AOE > 3,5

Term	*f*	AOE
Results	6	4,8
Experience	5	4,0
Chemistry	4	3,7
Observation	4	4,0
Novelty	4	4,2
Reaction	4	4,7

***AOE** – Average Order of Evocation; ****AAEO** – Average Average Evocation Order

Figure 1 - Chemistry students' SR terms concerning the object "experimentation"

In the left-hand bottom quadrant are allocated the contrast zone terms, with frequencies lower than the median frequency (f_{med}) and AOE values lower than the AAOE. Such terms are, for instance, Science ($f = 6$; AOE = 2.6) and Hypothesis ($f = 4$; AOE = 3.5). These terms indicate the existence of a subgroup that assigns great value to terms different from those expressed by the majority.

With the aid of the IRAMUTEQ software, we set the term frequency cut-off value as equal to that of the salience analysis (4), and obtained a graph – the maximum similitude tree – composed of vertexes and lines linking the terms in pairs, in order to show their connectivity, which reflects the associative character of the terms. A higher frequency (f) is manifested by the higher value of the vertex, and is represented by a greater area. Edges (Ar), in turn, link two terms, and the number above them shows their co-occurrence value, i.e. how many times two terms have been jointly mentioned. By combining these two types of analysis (prototypical and similitude), it is possible to identify the terms with higher salience and connectivity, and infer that they have the highest symbolic value for the representation of an object by this social group. By analyzing Figure 2, the terms with higher connectivity can be identified through the greater number of connections (edges), each of them indicating multiple co-occurrences. The terms with higher associative character and salience are listed in Table 2.

Table 2 - Central core terms for "experimentation"

Evocation	**salience**		**associative character**	
	frequency	**AOE**[a]	**Edge**	**Connectivity (Σco)**
Discovery	16	2.7	8	24
Knowledge	16	2.5	4	13
Laboratory	19	4.6	4	18
Research	16	3.5	4	18

a. Average Order of Evocation of the word evoked.

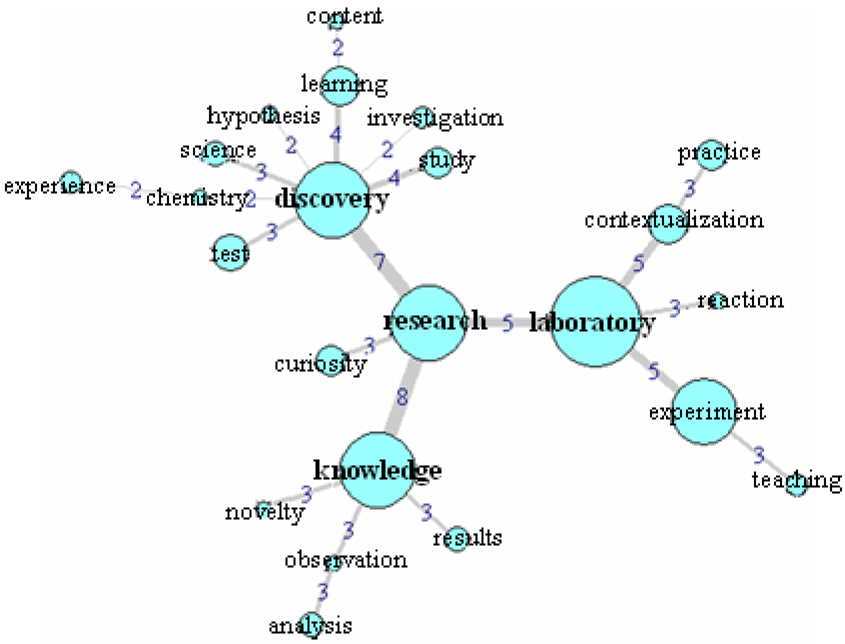

Figure 2 - Maximum similitude tree of chemistry students' most representative terms concerning the object "experimentation'.

The term *Research* deserves attention because it connects the other high connectivity terms in the graph shown in Figure 2. It is the organizing term of the maximum similitude tree. The term *Laboratory*, although initially placed in the first periphery (Figure 1), shows high frequency, substantial number of edges (Ar) and important co-occurrence summation (Σ co), i.e. high connectivity, all of them characteristic of a CC term. Similar approaches are found in the literature (Pecora and Sá, 2008). On the other hand, the term *Experiment*, albeit salient (f = 14; AOE = 3.2), it has low connectivity (edges = 2; Σ co = 8) and, like other terms in the left-hand top quadrant, does not belong to the SR CC (see Figure 1; *Learning*, *Contextualization*, *Curiosity*, *Study* and *Practice*).

Aiming for a more complete study on the CC composition of this SR, another look was taken at the data, and the terms were categorized, which enables us to understand the meaning assigned by the group to the CC terms of the SR on "experimentation".

Categorical Content Analysis

In the content analysis of the evoked terms, the students' justifications for their evocations related to the inductor term "experimentation" are read, resulting in units of meaning that are grouped in categories. This leads to the creation of two categories, which orient the meaning of the CC terms of this SR (*research*, *laboratory*, *knowledge*, and *discovery*; Table 2). The relation between terms and categories of meaning is represented in Table 3 and Figure 3.

Table 3 - Analytical categories for the CC terms of initial chemistry teacher education students´ SR on "experimentation".

Categories	Definition of categories
Laboratory activities	Procedural aspects of an experiment's study and execution.
Knowledge Development	Knowledge or product development for the subject or the humankind.

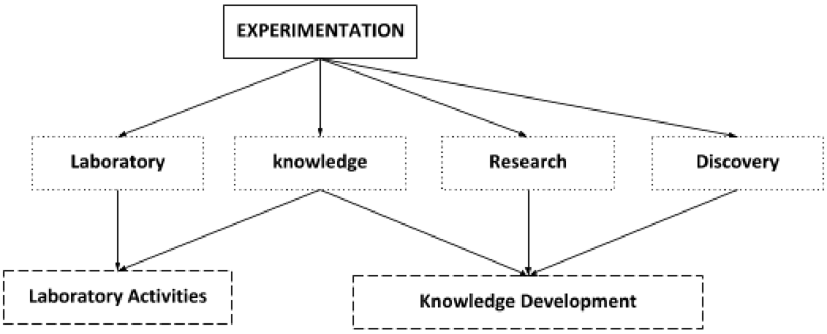

Figure 3 - Relational scheme of **CC** terms of an **SR** on "experimentation" in categories.

The main emergent category for the term laboratory is *Laboratory Activities* (see Figure 3). This result show that these students view the laboratory as a physical space adequate for carrying out experiments, an essential component of the scientific investigation, especially in chemistry, for its proper structure regarding equipment, glassware, reagents and safety materials. A study focused on physics undergraduates (Goldschimit, Goldschimit, and Loreto, 2014) and science teachers (Silva and Cunha, 2012) arrive to similar results, showing that science is indissociable from experimentation in these subjects view.

The *Laboratory Activities* category is also important to understand the meaning of *knowledge*, which, in this category, means the support necessary to perform tasks, referring to the need for chained steps.

The term *knowledge* also has meanings in the *Knowledge Development* category, expressing that the result of experimental activities can assume two perspectives: construction of own learning and development of a product relevant to society (such as theoretical models and technologies).

The knowledge mentioned by the students presents a strong conceptual character: theoretical knowledge is necessary for the execution of experimental procedures. Little is said about the abilities needed to develop investigative activities, and even less about the attitudes required for the research process.

The meaning of the term *Research* is mainly comprised of the *Knowledge Development* category and refers to a methodical investigation process composed of a definite series of steps whose aim is to achieve a result.

The subjects' discourse content analyses show that their representation concerning research includes aspects of a corroboratory and practical character that suggest their empiric-positivistic conceptions of science. These students also understand that an experiment play the role of validate experimental results.

Therefore, *Discovery*, whose corresponding category is *Knowledge Development*, has the meaning of a material product with practical applications in society. The experiment is the instrument with which research is carried out, and discovery results of the scientific process.

In short, the subjects express a simplistic, empirical and utilitarian view of the scientific process. Simplistic because they consider experimentation to be the central aspect of scientific work, ignoring other processes involved, such as non-experimental sciences, and the exchange of information among scientists. Their understanding of scientific development implies experimentation and related actions and permits to infer the empirical character of their representation concerning science. The association of scientific work to a higher goal, namely, the development of technologies to be later used in society reveals their utilitarianism.

On the other hand, the terms *experiment* and *contextualization*, although are not CC elements of this SR, have a relatively high frequency, AOE and connectivity when compared to additional terms of this SR. They signify *experimentation* as a viable activity for the teaching-learning process, that is to say, they assign a new possible meaning to that inductor term, similar to that observed for initial physics teacher education students (Melo, Tenório and Accioli, 2010). In this sense, our results, by showing a more positivistic understanding of "experimentation", also point to the absence of perception of other aspects concerning the nature of science in these students' discourse.

These findings have also been identified in a state-of-the-art study about teacher performance in laboratory activities (Duit and Tesch, 2010) which shows that it seems "in general, that the practice of science instruction is still significantly focused on teaching and learning science concepts and principles and neglects the competencies providing insight into scientific inquiry and views of the nature of science" (p. 25).

CONCLUSIONS

This study has found that this group of chemistry initial teacher education students has an SR on "experimentation" whose CC terms are *laboratory*, *knowledge*, *research*, and *discovery*. Data show that the meaning of these terms is related to *Laboratory Activities* and *Knowledge Development*. The term knowledge is considered by the subjects both as a necessary component for the development of investigative processes carried out in the laboratory and as the result of these processes. This term has been identified as a pivoting term for the categories, although the *Laboratory Activities* category also includes the term laboratory, viewed as a physical space adequate for carrying out investigative activities. *Knowledge Development* category includes the terms *research* and *discovery*, viewed as a methodical investigation process intending to the acquisition of new knowledge or the development of products with practical application in society. The understanding of the term "experimentation", therefore, is of a scientific activity in a positivistic panorama, with emphasis on simplistic, empirical and utilitarian conceptions of the scientific process.

Data shows that the terms *experiment* and *contextualization* have symbolic value for the students concluding their undergraduate studies, most of whom take part in projects of Initiation to Teaching. These terms represent a teaching-learning process, which indicates the existence of a new meaning for the social object "experimentation" and, consequently, a SR that have been enlarged during the course.

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XVIII IOSTE SYMPOSIUM

Future educational challenges from a science and technology perspectives.

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Challenges of teachers' roles in learning paradigm shifts

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Abstract

This study observes how science and technology education lecturers at the National Defence University, Finland (NDU), cope with learning paradigm shifts in their university and the simultaneous development of their roles as teachers and leaders. Blended learning arrangements, group work, and report-type homework, as well as the use of a learning material portal (LMP), were major elements in the implementation of a student-centric teaching approach. As a part of this shift, the role of the teacher also began to change. This study investigates the challenges these changes represent with regards to the role of the teacher. To maintain proper coordination and high-quality tasks, a view of the teacher's role that involved versatile leadership is emphasized and discussed. Student evaluations for teaching questionnaires in NDU's learning material portal were used for data collection. Our research revealed that students appreciated self-regulated learning and found well-guided team work to be a motivational task. The teacher's role as a versatile leader was found to be effective, especially in new kinds of learning arrangements, such as blended environments.

Keywords: Leadership in education; multitasking teacher; student feedback

INTRODUCTION

Around the world, education and learning paradigms are under increasing pressure to meet the demands of a new knowledge and information-intensive society. Most curricula planners and instructors agree on the urgent need for innovation in the education system. The structural paradigm shift in education started with the transition of the traditional teacher-centered practice towards more student-centered practices. This paradigm shift has redefined the university as an institution that exists to produce learning and research. Such a paradigm shift challenges the relationship between teachers and students—a situation that is not only desirable but necessary (Barr & Tagg, 1995).

Previously, the learner was a passive recipient of knowledge conveyed by the teacher. Now, however, the learner has become an active recipient who chooses what they want and who may influence the ways in which existing knowledge is distributed to others. Classroom teachers are no longer the only means of acquiring knowledge. Moreover, course books are no longer the only media used in learning. With LMPs, even the average learner is moving from a physical classroom to a virtual classroom. This virtual classroom is more flexible in terms of space and time. Guri-Rosenblit (2004) points out that, historically and practically, information technology-based and later portal-based education methods have their roots in the demand for effective tools for distance education. Changes in educational information and communication technology (ICT) structures mean that learners are assumed to utilize applications or sets of applications. Today, massive online open courses (MOOCs) offer a full set of choices for student-led, self-directed learning. These MOOCs have been deployed with virtual teams in order to collaborate on problem-based learning tasks (PBLs) without the presence of instructors. However, according to relatively new studies, to achieve learning aims in virtual

group work, additional support is still required to prepare participants to work in a virtual environment (Verstegen, Daily-Hebert, Fonteijn, Clareabout and Spruijt, 2018).
In face-to-face situations, specific guidance, ad hoc discussions, and the answering of student questions come naturally and easily; as such, some parts of courses are often held in the classroom. The reading of course material, homework, or specified teamwork can be done outside of the classroom, according to the student's own schedule. This, in brief, is the generic concept of blended learning. Researchers studying the blended learning paradigm have claimed that student satisfaction is a baseline requirement for successful implementation. Moreover, in quality of teaching measurements, student satisfaction was seen as one of the leading factors (Ramsden, 1991).

When transitioning from present educational contents and/or skill-specific education to something new, there is an accompanying need for an updated definition of the expected learning outcomes of the training itself. In other words, there needs to be clarification of what the students should be able to accomplish at the end of their training. According to Schreurs and Dumbraveanu (2014), the responsibility of educators is to create learning environments that support learning activities conducive to realizing the intended learning outcomes, ensuring that the learners become active creators of knowledge or even co-responsible for knowledge creation. It is not only students that need diverse new skills. Teachers, too, need new skills and attitudes. This means that teachers ought to see themselves as multitasking leaders and tutoring consultants. Challenges and changes in learning environments require that teachers see themselves as performing versatile roles.

Rapid changes in applied knowledge, skills, and communication technologies require learning to be a lifelong process. As such, education systems have to be modified not only to prepare the workforce but also to help existing workers stay competent in their professions. In modern society, the major concern of the individual is to survive as an independent agent. This belief is a necessary condition for the survival of individualism in schooling as well in professional life. Even though an officer's profession involves a deep responsibility towards the community, this responsibility is not limited to their work as a professional.

Research questions and methods

To develop a tool for better learning outcomes, we evaluated teacher roles in NDU's education system. Teacher roles varied in two course combinations. In another case, teachers worked in the background while visiting experts were afforded greater teaching space (case more blended arrangements). In earlier courses (Table 1), teachers took a more prominent role as leaders of their courses. Effects were analysed through student evaluations of instruction (SET) data. The questions in the SET data are generic and concerned education environment design where the emphasis was on the teacher's role and its meaning.

This study considered two research questions:

1. Which types of leadership elements are useful features for teachers at NDU, especially in new kinds of learning environments, such as blended arrangements?
2. Can SETs be used as a sub tool for estimating leadership success in NDU, and can SETs help to make corrective steps for the future?

EDUCATIONAL ENVIRONMENT IN NDU

Environment

NDU is a training institution responsible for educating the future leaders of Finland's armed forces. Master's level studies at NDU require prior educational qualifications and a commitment to a military profession. Studies in the military sciences commence at the undergraduate level. Undergraduate science, technology, engineering, and mathematics (STEM) related courses are relatively short and intense. Lectures and customized exercises are preferred for learning or re-learning basic knowledge in these disciplines. Deep, motivating, and pragmatic learning experiences, such as miniature laboratories and work and life related field experimentation, provide students with concrete learning experiences (Rissanen & Saastamoinen, 2017). Master's level studies consist of advanced studies and a thesis. In addition, students study minor subjects, including language and communication studies.

Learning goals

The learning goals for graduate students in technology may be divided into four related goals. The first two learning goals are 1) use of scientific knowledge and 2) an understanding of how technology makes use of scientific results. Also needed are 3) advanced abilities to manage practical exercises and weapons related research within a working environment and 4) the ability to strengthen one's personal learning capabilities to ensure lifelong learning.

Informal learning

Compared to classical, formal learning, informal learning has become a significant aspect of the learning experience. In the applied sciences, formal education no longer comprises the majority of learning. Learning now occurs in a variety of different ways—through private knowledge acquisition, course related networks, and the completion of work-related tasks. Sometimes learning and work-related activities are not fully separate. In NDU, they are both deeply linked as a part of the military profession.

Need for new type of learning material

At higher educational levels, the wide variety of student interests and levels of understanding and capability cannot always be accommodated when preparing learning materials. Relative levels of understanding need to be estimated and, if possible, tested. In light of these estimations, all components of the educational system may be trimmed to become more learner centred. But as such, simple, generic educational packages may still be less useful to less motivated learners. This is because these packages are designed with neutrality and generality mind, and so are targeted to learners with average levels of knowledge and average skill development goals.

LEADERSHIP IN EDUCATION

Teacher as a leader

The literature on educational leadership focuses mainly on managers of educational systems. The administrators are part of a hierarchical system where teachers inhabit the lowest level. From the substance and professional development viewpoint, educators are recognizing the need for teachers to become other types of leaders while remaining in their schools and classrooms (e.g., Howe & Stubbs, 2003).

According to a more radical view of future education leadership, teachers create a space in which young people can speak back regarding what they consider to be important and valuable about their learning (Smyth, 2006). Furthermore, Smyth summarizes those principles around which such a view of leadership might be constructed:

- giving students significant ownership of their learning in other than tokenistic ways
- supporting teachers and schools in giving up some control and handing it over to students
- promoting flexible pedagogy that understands the complexity of students' lives
- fostering an environment in which people are treated with respect
- endorsing forms of reporting and assessment that are authentic to learning
- cultivating an atmosphere of care built around relationships

Leadership in NDU's science education

Senior teachers are often considered to be consultants, especially in blended learning arrangements. Even when in training for professional leadership, students are advised by retired officers as part of a mentoring model. For academic disciplines, this is not resource efficient; it is also hard to support with any type of LMP. To develop a suitable leadership model for STEM courses, teachers at NDU have begun practising reflective evaluations. At NDU, these factors have been compared with observations from SETs and with communications with students.

The generated profile was compared to leadership literature (Jing & Avery, 2008). As a result, the following list consists of both discipline specific as well as citizenship related items that describe teacher leadership more comprehensively in the NDU context. At NDU, the teacher-as-leader involves the following roles:

- Instructor: instructors must be constantly developing pedagogical skills and subject knowledge
- Learning coordinator: an important role, especially in blended learning systems
- Supporter: supporters make efforts to accommodate different type of learners
- Visionary: visionaries have the ability to utilize and create new technologies and environments
- Inspirer: inspirers foster creativity with intelligent questions and engaging discussions; they are there to inspire students
- Link to administration: knowing and supporting students with organisation related tacit practises

Person in seniority: someone who is able to encourage students to discuss less discipline specific worries, such as those related to study or to life in general. Teachers must develop their skills and attitudes in all these areas to be competent leaders and teachers.

FEEDBACK FROM STUDENTS

Data collection

Standard local SET questionnaires in Moodle were used for data collection, data comparisons, and data storage. Observations focused on common course impressions. Personal estimates of learning results, motivational aspects, and free text impressions were analysed. The questionnaires involved a five step Likert scale. When the quantitative data from the questionnaires was combined with the qualitative data—such as data gathered using open-ended questions, participant observations, and interviews—the questionnaires' validity improved and our results became more accurate.

Table 1. Summing Students' Evaluations from 8 Master Level Courses

Standard Questions set	
I achieved the goals set for the course.	4.3
I was an active learner.	3.8
The learning atmosphere supported my learning.	4.5
The instructors mastered the facts.	4.6
My overall grade for teachers	4.3
The course provided me with new knowledge; it was not just a repetition.	4.5
The assessments supported my learning.	4.1
The LMP was utilised well.	4.3
The course's demands and credit units fit each other.	4.0
My overall grade for the course as a whole, on a scale of one to five.	4.4
N (voluntary responses)	78

When studying variations from course to course, the reasons for major differences were given in answers to open ended questions.

In the 2016 academic year, two new courses replaced older versions. In these new courses, the idea was to reduce contact lectures and to utilize self-guided studies and self-aligned project groups. According to the SET records, an average 1.5-unit drop was detected when compared to earlier generalized feedback (see Table 1, summary of previous courses). Discussions and open-ended questions revealed issues in leadership from the instruction side as well as the need for support during exercises. Furthermore, limiting natural group formation meant that students did not find out what elements were discipline specific and which were supposed to be learned for general professional purposes—for example, the ability to operate in strange environments.

Analyses

Scores for student satisfaction were greater in courses where the teacher's role was more prominent. Lower scores were given for courses where instruction was principally conducted by visiting experts from outside the department and where the head teacher's role was focused more on background assistance (a blended instruction type with a self-learning emphasis). Furthermore, it was noticed that, in these courses involving outside experts, students were less aware of their own duties and that, from the students' viewpoint, the structure of the course was less clear.

The SETs provide necessary information for instructors regarding how to streamline teaching protocols. However, SETs provide only a limited number of tools for significant educational improvements. The key role is still played by skilled professional instructors. According to the data, it appears that students appreciated strong teacher leadership and good coordination. The challenge is to create blended environments that make use of versatile leadership styles in terms of teaching practice. To develop leadership in teaching requires more than just empirical evidence drawn from learning results and student desires and evaluations. True leadership in STEM involves developing creative responses to continuous challenges.

DISCUSSION

Some argue that strong leadership perspectives place too much responsibility on teachers and not enough on students. Teachers occasionally respond: “Don't students have responsibilities in this process? Shouldn't students display initiative and personal accountability?” Indeed, teachers and students do share responsibility for learning. However, even with valiant teaching efforts, we cannot guarantee that all students will learn everything to a high standard. In genuine leadership, it is understood that students have their responsibilities and teachers make efforts to support students in their challenges. The appropriate assessment of teaching and learning through student feedback helps teachers to evaluate their teaching orientations and pedagogical methods (e.g., Guskey 2003).

Findings as recommendations for the educational environment:

- Utilize blended environments in education with careful lesson plans and evaluation
- Know your students
- Curriculum is not enough for planning
- Work on motivation and be aware and interested in students’ voices
- Be aware of long-term learning aims
- Follow resource use and measure how many resources you allocate to each course
- Give constant feedback to students
- Utilize instructional teams when feasible (e.g., in exercises)
- Modernize your attitude towards leadership

CONCLUSIONS

This study investigated courses consisting of relatively small groups. Typically, group-based tasks are given when in-person lectures are limited. Guidance and clearly articulated goals for groups are needed to ensure success in group-based learning (Hammar Chiriac, 2014). While blended learning continues to be regarded by most students as less effective, it can nonetheless generate satisfactory results if enough time is given over to planning and there is clarity with regards to duty sharing. Students at NDU still preferred face-to-face courses even though they were satisfied with their grades and performance in blended learning courses. This study did not find that stronger leadership in the teacher’s role was the better choice. It did, however, reveal that strong but versatile leadership in blended learning environments is actually effective due to coordinative reasons.

Student evaluations—including measurements of satisfaction regarding applied teaching—are important because they can impact motivation and thus enhance student success and completion rates. Measurements of satisfaction are also valuable to institutions because they can be used to evaluate courses and programs and—to a certain degree—to predict student attrition rates.

The standard local SET questionnaire utilizing Moodle was not created for this study. However, additional measures made it a valuable quantitative tool. It is important to listen students' voices, but when creative steps are taken such signals are not enough. Good student feedback does not mean that all is fine. Teachers with multitasking leadership roles will be required in the future when blended learning environments occupy more instructional space. For coordination and quality reasons, the teacher's role in such learning arrangements will be in need of constant self-evaluation.

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Inquiry-based Teaching and Science Achievement: Some findings from PISA 2015

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Abstract

For a long time, laboratory work, inquiry-based learning and experimental activities have been a topic of study and debate amongst science educators and researchers. However, there are unsettled points, such as the concrete goals of this kind of activity in school setting. Furthermore, sometimes there is a mismatch between teachers' and students' intentions and expectations with enquiry or laboratory work. Although the teacher planning targets an epistemic shift, often the laboratory work ends up reinforcing naive conceptions on science enquiry. In this study, we investigate the impact of inquiry-based teaching (IBT) on student achievement in PISA compared to teacher-directed instruction. The literature indicates a negative impact of IBT on student achievement in previous PISA tests, leading us to wonder if the very same relation is valid for Latin American countries? Besides the PISA country rankings and the strongly normative OECD orientations, PISA survey might provide some interesting insights on teachers' practices and how it affects students' learning and motivation. Furthermore, result shows that teacher support and guidance is a relevant factor for academic achievement in Latin American countries. Finally, there is a negative correlation between laboratory work and performance in paper (or computer) type test.

Keywords: Enquiry-based teaching, Laboratory work PISA

INTRODUCTION

It is possible to say that the experimental activities, especially inquiry-based, are the cornerstone of school science education today. Its relevance is reflected in many different levels, from educational policies and curriculum design to everyday teaching. For a long time, it has been a topic of study and debate among science educators and researchers (Furtak, 2006; Furtak, Seidel, Iverson, & Briggs, 2012; Lazonder & Harmsen, 2016; Trumper, 2003). However, the meanings and practices developed around this topic might vary drastically depending on the context and material conditions (Abd-El-Khalick et al., 2004). Even though it is not easy to find consensus around what compose an effective inquiry-based teaching, some core issues appear recursively in the literature. Only to mention two: what might be the general features of an effective inquiry-based teaching and what is the role of teachers' guidance in this process?

Regarding inquiry-based teaching goals, on the one hand, Trumper (2003, p. 647) points that "Science teachers have the responsibility of helping students to understand the nature of scientific inquiry". It implies that scientific inquiry is the object (and content) of science teaching. Abd-El-Khalick *et. al.* (2004) underline that it might appear in school practice sometimes as *means* – instructional approach – and other times as *ends* – learning outcome. It indicates the versatility in which laboratory, experimental activities and inquiry are grounded. On the other hand, according to Abd-El-Khalick *et. al. (2004, p. 416) "*a good number of science educators who engage such discourse assume that we know what 'authentic' scientific inquiry actually is." In their perspective, "the scientific endeavor is looking more like a mosaic of disciplines with a host of ontological, epistemological, and methodological commitments, than a unified and homogeneous entity" (idem). Furthermore, in many cases there is a mismatch between teachers' and students' intentions and expectations with inquiry or laboratory work. Although the teacher planning targets an epistemic shift, often the laboratory work might end up reinforcing naive conceptions on science inquiry. The study of Wilkinson and Ward (1997) compares the perception of cohorts of students with their teacher's perception on laboratory work in six schools in Australia. According to the study, most teachers believed they conducted laboratory work on a regular basis and the laboratory work they were conducting were useful for daily life. However, students' perceptions go in a very different direction, they report a different and somehow divergent perspective on laboratory activities.

In a recent debate on inquiry-based teaching effectiveness, Kirschner at al. (2006) affirm that not "only is unguided instruction normally less effective; there is also evidence that it may have negative results when students acquire misconceptions or incomplete or disorganized knowledge." They also underline that "It is regrettable that current constructivist views have become ideological and often epistemologically opposed to the presentation and explanation of knowledge." According to them, the open ended activities (such as inquiry, problem-based learning, discovery) implies a cognitive load since students generally are novice regarding the content. Mainly low performance students are impacted as they might find hard to navigate through high complex tasks. Although aspects of this discussions is corroborated by the literature, Kirschner at al. (2006) position overlooked the nuances between different approaches such as inquiry-based teaching, problem based-learning and learning by discovery (Hmelo-Silver, Duncan, & Chinn, 2007).

The role and amount of guidance, its compatibilities with teacher-led approaches as well as the impact in student learning, remain an object of scrutiny today. Since there are inherent challenges in quantitative researches on the topic, is undoubtedly a difficult task to propose comparable features for such a variable practice. Although some advances in this field is acknowledged, the assessment, especially for quantitative purposes – such as large-scale comparisons – have not reached consensus. Furthermore, as underlined by Teig et al. (2018), the measurements available concentrated attention in the frequency of use instead of quality and school level instead of the classroom. The last criticism is particularly true for Programme for International Student Assessment (PISA) database which uses school level in its sample design.

The present study

In this study, we investigate the impact of inquiry-based teaching on student achievement in PISA compared to teacher-directed instruction. The literature has indicated a negative impact of inquiry-based teaching on student achievement in previous PISA tests. We might formulate the question: is this relation still valid in the last PISA for Latin American countries?

METHODOLOGY

In order to exam the impact of Teacher-directed science instruction (TDTEACH) and Inquiry-based science teaching and learning practices (IBTEACH) in student achievement we run a multilevel analysis based on the PISA 2015 survey. PISA 2015 have assessed roughly 72 different countries and economies. In this study, we work with a selected database of the 10

Latin American countries that took part in the assessment. Besides the index of economic, social and cultural status (ESCS) all three indices used in the model come from students answer sheet about the frequency that each practice happens in the classroom (OECD, 2009). Although all the predictors considered in the model are from the students' level, the use of multilevel model will enable to properly calculate the error (Agresti & Finlay, 1986).

The item parameters for Inquiry-based science teaching and learning practices (IBTEACH) was developed with the answer for: When learning <school science> topics at school, how often do the following activities occur?

The text should be formatted according to the below:

- Students are given opportunities to explain their ideas.
- Students spend time in the laboratory doing practical experiments.
- Students are required to argue about science questions.
- Students are asked to draw conclusions from an experiment they have conducted.
- The teacher explains how a <school science> idea can be applied to a number of different phenomena (e.g. the movement of objects, substances with similar properties).
- Students are allowed to design their own experiments.
- There is a class debate about investigations.
- The teacher clearly explains the relevance of <broad science> concepts to our lives.

The item parameters for Teacher support in a science classes (TEACHSUP) was developed with the answer for: How often do these things happen in your <school science> lessons?

- The teacher shows an interest in every student's learning.
- The teacher gives extra help when students need it.
- The teacher helps students with their learning.
- The teacher continues teaching until the students understand.
- The teacher gives students an opportunity to express opinions.

The item parameters for Teacher-directed science instruction (TDTEACH) was developed with the answer for: How often do these things happen in your lessons for this <school science> course?

- The teacher explains scientific ideas.
- A whole class discussion takes place with the teacher.
- The teacher discusses our questions.
- The teacher demonstrates an idea.

All the parameters for the confirmatory factor analysis run by OECD are available in the technical report for 2015 (OECD, 2017).

RESULTS

Table 1. Descriptive data of the indices used in the multilevel model.

Country	ESCS		TEACHSUP		TDTEACH		IBTEACH	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Brazil	400.68	89.15	-0.96	1.12	0.38	0.77	-0.15	0.82
Chile	446.96	86.02	-0.49	1.08	0.31	0.86	-0.04	0.85
Colombia	415.73	80.37	-0.99	1.11	0.29	0.88	-0.02	0.87
Costa Rica	419.61	70.02	-0.80	1.14	0.45	0.87	-0.21	0.87
Dominican Republic	331.64	72.47	-0.90	1.04	0.61	0.80	0.13	0.90
Mexico	415.71	71.41	-1.22	1.21	0.48	0.85	0.08	0.89
Peru	396.68	76.70	-1.08	1.20	0.35	0.81	-0.02	0.85
Argentina	475.19	85.76	0.01	1.15	0.20	0.88	-0.04	0.83
Trinidad and Tobago	424.59	93.80	-0.23	0.92	0.09	0.97	0.07	0.94
Uruguay	435.36	86.54	-0.78	1.09	0.25	0.86	-0.28	0.77

Table 2. Multilevel regression model by country.

	Estimate	Std. Error	t value
Argentina			
Intercept	472.29	2.40	196.73
ESCS	21.61	2.62	8.26
TEACHSUP	-5.15	3.24	-1.59
TDTEACH	12.69	2.71	4.69
IBTEACH	-4.67	3.00	-1.55
Brazil			
Intercept	420.41	1.60	262.33
ESCS	11.53	1.25	9.23
TEACHSUP	0.58	1.16	0.50
TDTEACH	7.89	0.92	8.58
IBTEACH	-12.85	1.10	-11.71
Chile			
Intercept	462.11	1.01	458.40
ESCS	13.97	1.48	9.42
TEACHSUP	0.54	1.59	0.34
TDTEACH	10.16	1.35	7.52
IBTEACH	-14.46	1.51	-9.59
Colombia			
Intercept	434.37	1.24	349.20

ESCS	11.42	1.04	11.02
TEACHSUP	-0.53	1.47	-0.36
TDTEACH	13.54	1.24	10.93
IBTEACH	-9.38	1.33	-7.04
Costa Rica			
Intercept	433.35	1.32	327.91
ESCS	12.85	1.08	11.93
TEACHSUP	1.39	1.56	0.89
TDTEACH	5.98	1.28	4.67
IBTEACH	-8.64	1.42	-6.09
Dominican Republic			
Intercept	350.70	2.36	148.75
ESCS	10.88	1.51	7.19
TEACHSUP	0.68	1.64	0.42
TDTEACH	8.01	1.20	6.68
IBTEACH	-9.72	1.54	-6.29
Mexico			
Intercept	430.98	1.63	264.00
ESCS	8.82	1.00	8.78
TEACHSUP	-0.71	1.25	-0.57
TDTEACH	9.12	1.04	8.74
IBTEACH	-8.97	1.14	-7.88
Peru			
Intercept	424.34	1.91	221.65
ESCS	15.55	1.18	13.13
TEACHSUP	-0.53	1.18	-0.45
TDTEACH	5.69	1.27	4.47
IBTEACH	-10.93	1.19	-9.16
Trinidad and Tobago			
Intercept	422.07	1.40	300.69
ESCS	7.20	1.57	4.59
TEACHSUP	2.35	1.39	1.69
TDTEACH	4.79	1.32	3.63
IBTEACH	-4.41	1.52	-2.89
Uruguay			
Intercept	422.07	1.58	292.21
ESCS	17.63	1.25	14.05
TEACHSUP	-2.91	1.38	-2.11

TDTEACH	11.70	1.40	8.34
IBTEACH	-9.40	1.32	-7.10

In the context of Latin American countries which correspond to the bottom part of PISA rankings, i.e., it is usually an achievement below the OECD average, the teacher-directed approach shows a positive impact. The impact runs from 1.39 in Costa Rica to 13.54 in Colombia. On the other hand, in all cases, the IBTEACH is a predictor for student achievement. Nonetheless, for all Latin American countries, the IBTEACH impacts negatively in student achievement in Science.

CONCLUSION

Besides the PISA country rankings and the strongly normative Oecd orientations (Sjøberg, 2015), PISA survey might provide some interesting insights on teachers' practices and how it affects students' learning and motivation. Particularly, in the results regarding laboratory work and inquiry-based teaching there are some evidences that this type of activities teachers develop impact positively the students' motivation, in the literature (Cairns & Areepattamannil, 2017; Chi, Liu, Wang, & Han, 2018) and teachers' general perceptions. However, before going any further in outlying and concluding, we should critically examine how laboratory and inquiry skills have been assessed in standardized tests (including Pisa). In further studies, a multilevel analysis might be useful to detect school as well as country effects.

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XVIII IOSTE SYMPOSIUM

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Didactic games and knowledge acquisition in Sciences: a case report

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Abstract

Didactic games are pedagogical tools that combine playful aspects with situations that require students' logical reasoning, initiative, imagination, attention and curiosity. This study aimed at: a) analyzing if knowledge worked in Sciences through the use of didactic games became more meaningful for Brazilian students at the Basic School level (6th to 9th grades); b) studying the interferences that the use of didactic games can cause in the interpersonal relationships of the students of the same group and of these with the teacher who applied them. Five didactic games were applied to students in two different schools. Themes included ecological ideas, anatomical and physiological skills, and chemical principles. Questionnaires answered by students after game application were applied to evaluate their learning in both short and long terms. The percentage of assertive answers made it possible to affirm that the goal of the games was reached, since the students demonstrated to understand the relation between the concepts studied during the theoretical classes and the rules presented in the games. Another positive point is the intense interaction of students during the application of the games and how they were interested in knowing the theoretical concepts about the subjects.

Keywords: Basic Education; Didactic games; Sciences; Teaching and learning.

INTRODUCTION

One of the greatest challenges teachers may face is to finish their classes with the feeling that students have learned in a pleasant and effective way, and that the results of such learning will be carried throughout schooling years and perhaps thereafter (Antunes, 2017). Such challenge can be minimized when various and diversified pedagogical strategies that aim at enhancing students' interests in what is being studied are applied, whilst at the same time actively inserting them in the teaching and learning process (Antunes, 1998; Campos et al., 2003; Gomes & Friedrich, 2001).

Teaching Sciences is a great challenge, especially when students seem not to be familiar with the importance of scientific knowledge in their daily life (Zabala, 1998). Moreover, educational games can be a powerful tool to allow students to learn naturally and dynamically, as well as to offer them possibilities of greater social involvement and the build-up of ethical concepts of solidarity, common rules, group work, and mutual respect (Kishimoto, 1996; Nicoletti & Filho, 2004).

By allying playful and cognitive aspects, games are an important strategy for teaching and learning abstract and complex concepts, favoring internal motivation, reasoning, and student interaction among themselves and with teachers (Fortuna, 2003). However, teachers should clearly know the objectives and expectations of the games to be applied. Thus, it is worth mentioning that even a well-crafted didactic game may not be correctly used by students (and, therefore, goals may not be achieved): it is important that teachers accompany students throughout the process of game use, assisting them in their doubts and mediating possible conflicts. The present communication aimed at reporting a case study with two Brazilian schools regarding the use of five didactic games in Science education.

MATERIAL AND METHODS

Science-teaching didactic games were applied to 6th to 9th grade students (Basic Education level) in two different schools (Sao Roque and Mairinque Municipalities, Sao Paulo State, Brazil), in 2017.

Five games were chosen: a) 'Prey-Predator', which works with food chains (Figure 1); b) 'Natural Selection', which focuses on evolution (Figure 2); c) 'War of the Biomes', which works with global biomes (Figure 3); d) 'Skeletal System', which emphasizes anatomical and physiological aspects of the human skeleton (Figure 4); and, e) 'Ionic-Covalent Bonds', which focuses on chemical bonds (Figure 5). They were adapted from preexisting games, commonly used in Brazil to deal with scientific matters (Macedo et al., 2000). In all figures, students' faces have been covered to keep anonymity.

Figure 1. Badges of the game 'Prey-Predator' (left). Top down, left to right: "Small fish", "Zooplankton", "Phytoplankton", "Big fish", "Pelican", and "Fungus". Students wore these badges to represent trophic levels in a food chain and play the game (right).

Figure 2. Caps of several colors obtained from soft drink plastic bottles and used during the game 'Natural Selection' (left). These lids were deliberately spread over various surfaces (e.g. grass, asphalt, colored benches etc.) so that students had to pick them in a predetermined period, thus simulating predators looking for their prey (the soda caps, image on the right).

Figure 3. Board (up left) and cards (up right) of the game 'War of the Biomes'. Students should associate correctly animals and plants of the world biomes as cards were shown during the game (down).

Figure 4. Flags used in the game 'Skeletal System' (left). Teams (yellow and blue) had to place the flags correctly on the parts of a resin skeleton (right). Here, "clavicle" (yellow) and "sternum" (blue) are visible.

Figure 5. Cover and card (left) of the game 'Ion-Covalent Bonds'. Students playing the game (right).

Students answered open-question questionnaires after the application of games, in two distinct phases: a) short term, i.e. right after game playing (within a week), and, b) long term, i.e. six to eight months after game playing. Both situations took place during normal standard curricular periods, i.e. in a 50-minute class. The average number of students per class at the Sao Roque School was 27, whereas at the Mairinque School it was 31. Questionnaire answers were analyzed and categorized into different criteria, including correct answers, partially correct answers, and misplaced or incoherent answers.

RESULTS

There were no significant differences between the short- and long-term answers obtained with questionnaires (Table 1). Three categories were considered: a) Correct answers include those with direct concept learning, such as “Lettuce is a producer in a terrestrial food chain”; b) partially correct answers engulf those with semi-correct concepts, such as “Bears and penguins are found in the Arctic Biome” (only bears, in this case; penguins are found in the South); and, c) incoherent answers are those with conceptual mistakes, such as “The liver is the only source of red cells in our bodies” (in this case, the red medulla of certain bones are responsible for producing erythrocytes).

Table 1. Condensed information of questionnaires regarding the three categories: correct (I), partially correct (II), and incoherent answers (III), both in short- and long-term assessment (A = Prey-Predator; B = Natural Selection; C = War of the Biomes; D = Skeletal System; E = Ion-Covalent Bonds). The Arabic numbers refer to the subtotals of answers.

	A			B			C			D			E		
Short term	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
	25	07	04	32	11	08	28	11	03	29	09	03	31	17	07
	A			B			C			D			E		
Long term	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
	22	05	06	28	08	06	26	09	04	22	07	02	29	17	09

CONCLUSIONS

By analyzing the questionnaires, it is possible to affirm that the five games applied positively contributed to the students' learning, both in short and long terms. It is also important to consider the intense interaction of the students during the games, and how they deal with the teacher who applies them. Students begin to yearn for the application of the games and participate more actively in the theoretical classes, both for the expectation that some new concept will be worked on in a competitive game, and for having observed during the games already applied concepts that were not appropriate in classes, thus feeling the need to resume them to clarify doubts.

In general, didactic games promote such pleasant moments between one class and another that, regardless of the results of learning assessment, are worth replicating, whenever possible. The high percentage of answers for the questionnaire “Prey-Predator” evidences its importance to students in terms of significance to the point that they remembered rules and theoretical aspects of the game 16 months after its initial application. The same can be said of the game “Natural Selection”, with which we obtained positive results even in the long term.

The games "War of the Biomes" and "Skeleton System" were memory-like strategies. The first contributed more positively to know animals' characteristic of each biome, and not their location. Satisfactory answers were obtained, in the short term, with the game "Skeleton System". As we expected, right answers for bone location were few in the long term, even amongst students who remembered the game and its phases.

We see that it is comprehensible that students might forget concepts and nomenclature. However, the fact that they carried out a different activity about a specific topic and remember it may be a trigger for the teacher to resume its contents whenever necessary. Positive results were obtained both in the short and long terms with the game "Ionic-Covalent Bonds". In the long term, the result had the interference of a review on ionic and covalent bonds by the Chemistry teacher (second semester, 2017). The application period of short-term questionnaires was standardized only to "War of the Biomes", "Skeleton System" and "Ionic-Covalent Bonds". Thus, the application of such questionnaire to "Prey-Predator" and "Natural Selection" games might have negatively influenced students' answers, as they did it two days after (comparing the two schools).

It is important to mention the intense interaction during game application, not only amongst students, but also between the teacher and students. Students started to long for game application and participated more actively during theoretical classes, not only because of a 'new' concept to be potentially used in a competition game, but also due to their observation of concepts applied during the games, which had not been learnt during theoretical classes. In an overview, we say that besides the positive results concerning learning, didactic games may promote pleasurable moments between classes and we consider that their application should be done whenever possible.

This investigation fully aligns with the XVIIII IOSTE Symposium as to suggest current and to-apply approaches to teach and learn Sciences.

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XVIII IOSTE SYMPOSIUM
Future educational challenges from a science and technology perspectives.
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The Legacy of IOSTE– and two Competing Visions for Science and Technology Education

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Abstract

Established in 1978, IOSTE has a proud history of 40 years. It was born during the cold war as a forum for dialogue across political and cultural borders, based on shared values. In this sense, IOSTE differs from many other organizations for Science and Technology education. The current global challenges are many. These are addressed by UN-organizations by initiatives for the promotion of human development and basic human rights, access to free education and care for the environment. Major UN initiatives address climate change and sustainable development, eradication of poverty and the promotion of gender and ethnic equity. These concerns and values are in harmony with the values underpinning IOSTE. But there are other global trends that push in other, possibly conflicting directions. International Large-scale Assessments (ILSAs) of students' achievement increasingly dominate educational debates and policies. Although these studies have differing agendas, they often result in a global race to climb on the rankings. Schools are under pressure to become efficient producers of Human Capital for the competetive global market. The effects on educational policy and life in schools is often standardization of curricula, more testing, commercialization and privatization of schools, degradation of the teaching profession and test-based accountability of teachers and their schools. The need to produce a global, "fair test", implies that items have to be context-free, contrary to what most educators recommend, at least for the compulsory school level. The current most influential international test, PISA, does not address the major global concerns facing mankind that the UN has put on the agenda. Strikingly, PISA-scores correlate negatively with teaching methods that are recommended by science educators, like all aspects of Inquiry-Based Science Education. The purpose of this position paper is to raise concerns about the role and future of IOSTE in the light of its legacy and these conflicting global visions for education.

Keywords: Education for sustainable development, Education Policy, IOSTE, PISA, OECD, Globalization

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INTRODUCTION: THE LEGACY OF IOSTE

IOSTE was established in 1978, during the cold war, to promote dialogue across cultural and political borders. Since then, 18 international IOSTE symposia have been arranged, covering all continents.

Today, there are several national, regional and international associations for Science and Technology (S&T) education and research, like NARST, ESERA; ASERA. They have professional journals, promote common interests and host regular conferences, often with attendance of thousands participants. They have become important arenas for career promotions and for presenting and sharing research. In this professional landscape, IOSTE is unique in several ways.

In contrast to the other associations and organizations, IOSTE has clear value commitments and is meant to embrace not only researchers, but to "*gather researchers, policy makers, teachers and others who are concerned about how S&T can contribute to the goals as stated in IOSTE's Mission Statement*", (http://www.ioste.org/).

The mission statement, paragraph 1 in the IOSTE constitution, spells out the details, here are some key phrases:

> **S&T education** for citizenship …for informed, critical, and active participation in democracy … cultural and human values of S&T …promote equity … just and sustainable development … fight against poverty, discrimination and injustice … promote peaceful and ethical use of S&T … encourage cultural diversity and international understanding … (http://www.ioste.org/about-ioste/)

The concern in this position paper is to keep this legacy in mind, in a situation where schools and educators are facing conflicting and confusing signals about the role and purpose of education. Let us start with what seems to be serious concerns for the future, as seen from global perspective.

GLOBAL CHALLENGES: THE FUTURE OF THE PLANET

The world as a whole is facing a series of serious challenges for its future development. A short, not prioritized and not comprehensive list:

- Growing inequalities *between* and *within* countries: economic inequality and unequal access to education, health care and other public services.
- Growing intolerance of "others", based on ethnicity, culture, religion, gender and sexual orientation.
- Increasing geopolitical tensions: an emerging arms race and a new Cold War?
- Global warming and Climate change: a global challenge, but hitting poor countries and poor families the hardest.
- Sustainable development, depletion of resources, pollution of water, oceans and air.
- Decreasing biodiversity at a local and global scale.
- New technologies as new possibilities, but also as challenges and threats.
- Attacks on democracy and the credibility and objectivity of science: "alternative facts" and "fake news".

Important UN-initiatives like the Millennium Development Goals (http://www.un.org/millenniumgoals/) from 2001 strengthened and elaborated on the concerns about the global challenges, also highlighting initiatives in the education sector. This UN work has from 2016 been followed up with the 17 Sustainable Development Goals (http://www.un.org/sustainabledevelopment/). These goals are endorsed by all UN member states, and are clear messages to its political leaders. Education for Sustainable Development (ESD) has become an agreed global education priority.

The concerns of the UN-system (including UNESCO, UNEP, UNDP and UNICEF) also resonate well with priorities in the international S&T education communities: ESD is a key concern, likewise context-based teaching, relevant and meaningful curricula and Inquiry-Based Science Education (IBSE). These ideas are expressed by science educators (Osborne and Dillon (eds), 2008), and also by international unions of scientists (ICSU, 2011). Similar ideas are also expressed in policy-documents of the EU (2007), and have become important in priorities for research and development in the education sector, like the current Horizon 2020.

So far – most stakeholders raise similar concerns and endorse initiatives going in the same direction, well in line with the values expressed in the IOSTE mission statement. But other current influences push in a very different direction.

THE POWER OF INTERNATIONAL LARGE-SCALE ASSESSMENTS

Ideas and ideals about education have always traveled across continents and between countries, informing and inspiring each other. More systematic comparative studies of students' achievement and the characteristics of different education systems started some sixty years ago with the establishment of IEA (International Association for Evaluation of Educational Achievement). The most commonly known is TIMSS (Trends In Science and Mathematics Study), which has roots back to the early 1970s. TIMSS has been held every fourth year testing science and mathematics since 1995 and is used, as the name indicates, to monitoring trends in students achievement over time. TIMSS has played a role in educational debates in many countries over the years.

The emergence and influence of of PISA

Although international studies of educational achievement have been around since the early 1970s, it was not until the OECD (Organization for Economic Cooperation and Development) launched its PISA project in 2000 that the studies started to make war-like headlines in the media and to influence educational policy. In contrast to the descriptive and analytical approach in the IEA studies, PISA is deliberately normative, with a purpose to influence and change policies (Addey et al., 2017).

The influence of PISA is well documented in an OECD-report on the policy impact of PISA that builds on a broad analysis and reviews of educational reforms and development. The abstract states that

> PISA has been adopted as an almost global standard, and is now used in over 65 countries and economies. [….] PISA has become accepted as a reliable instrument for benchmarking student performance worldwide, and PISA results have had an influence on policy reform in the majority of participating countries/economies. (Breakspear, 2012).

Similarly, Andreas Schleicher, the director of PISA and also of the Directorate of Education and Skills in OECD, in a well visited TED-talk starts his presentation by stating that *"PISA is really a story of how international comparisons have globalized the field of education that we usually treat as an affair of domestic policy."* (Schleicher, 2013).

The PISA-test is explicitly *not* related to the curricula in any country. And, since it is a global test, items cannot be related to any local, national or regional context. The underlying concern for the PISA testing is to prepare the students for "success" in the global economy. The PISA score is supposed to be a predictor of the future economy competitiveness the nation. This is also how results are presented by the OECD and understood world-wide. Hence the enormous publicity given to PISA.

PISA is constructed and intended for the 35 industrialized and wealthy OECD countries, but has later been joined by a similar number of other countries and "economies". The intentions of PISA are, of course, related to the overall aims of the OECD and its commitment to a competitive global free market economy. When PISA is presented, its importance is stated by claiming that participation *"make up nine tenths of the world economy."* (OECD, 2010, p 3). This is a telling way of counting pupils; it indicates that the focus of the PISA-project is the economy.

The influence of PISA manifests itself in different ways in different countries, often closely linked to national policy issues. But most of the countries use PISA to legitimize neoliberal policies and New Public Management, standardization of curricula, more testing, rankings of schools and school districts, accountability systems and merit-based salaries. The above mentioned UN initiatives like the present "Sustainable Development Goals" and ESD are not even mentioned in the PISA Assessment Framework (OECD, 2016a).

Seen from the OECD, PISA has been a remarkable success. By providing rankings, data and indicators based on its data, the OECD sets the scene for discussions about quality of schooling and entire school systems. And in most countries, politicians and policy-makers follow suit (Breakspear, 2012).

The most profound influence of PISA is epistemological, by implicitly redefining and restricting the very meaning and purpose of schooling, by reducing schools to be producers of Human Resources in the service of the national competitiveness in the global economy.

Expanding and extending PISA

Given the political success of PISA, it is easy to understand that the OECD is also broadening its scope and influence on the education sector with other "PISA-like" studies, ranging from kindergarten to adult life, from the national level down to the school level, and from highly developed OECD countries to developing countries (Sellar and Lingard, 2014). A brief indication of the expansion follows:

Starting Strong, also called **"Baby PISA"** is one of several OECD-programs to address preschool/kindergarten level. The population include 5-year old children. Four early learning domains will be measured: Emerging literacy skills, Emerging numeracy skills, Self-regulation and Social and emotional skills. Many countries have decided not to be part of this study. The first data collection is in the autumn 2018. (OECD, 2017a).

PISA-based Test for Schools is a "PISA-like" test that may be used to test how well a school or school district compares with each other or with the PISA-winners. It may thereby bring the power of influence closer to school districts, local authorities and even particular schools and their teachers. The product is commercially available in the USA, UK and Spain and is likely to expand (OECD, 2018b).

PIAAC, Survey of Adult Skills (often called "PISA for adults") is measuring skills and competencies of the adult work-force (16-65 years), on a scale similar to the PISA scale for "PISA-like" competences. The survey measures adults' proficiency in key information-processing skills - literacy, numeracy and problem solving in technology-rich environments - and gathers information and data on how adults use their skills at home, at work and in the wider community. In each country, a representative sample of about 5 000 are interviewed in face-to-face settings. Some 40 countries took part in the first testing round, and data are published and available in many formats, see for instance (OECD, 2016d).

PISA for Development is a version of PISA that is meant to be used by low- and middle income countries. It will do this using "*enhanced PISA survey instruments that are more relevant for the contexts found in middle- and low-income countries but which produce scores that are on the same scales as the main PISA assessment.*". In this project, the OECD also defines supposedly globally valid competencies that are needed for young people in all developing countries. Results are likely to be used as benchmarks for development assistance from the World Bank and other donors. PISA for Development publishes regular policy briefs with progress reports and findings. (OECD, 2018a).

Education at a glance: OECD Indicators. This is an annual book that brings indicators and statistics from the above and other sources, and is widely used by policymakers and researchers world-wide. It is presented as "the authoritative source for information on the state of education around the world" and is published in English, German and French. It contains data from various sources, where the OECD's own data constitutes the core (OECD, 2017b).

As we can see from the above, the OECD has over the last decades emerged as probably the prime source for high quality data, statistics and indicators to describe and understand what is going on in education world-wide. Given the authority of the OECD and the defining power of numbers and statistics, one may say that this may to also be seen as the power to define the purpose of education and set the political agenda.

PUZZLING AND PROBLEMATIC PISA RESULTS

If taken seriously, which we should, since policymakers do, PISA-results raise many paradoxes for education, and S&T education in particular.

Money spent on education has no influence?

Already from the first PISA round, the OECD produced graphs that showed small or negligible correlations between a country's PISA scores and its spending on education (OECD, 2001). This, of course, was immediately noted and used by politicians world-wide.

More concretely, it is particularly interesting to note that for the five Nordic countries, the relationship between public spending and PISA scores is actually strongly negative. Finland, for instance, is highest in PISA score, but lowest in spending. These relationships have been used in political debates in various ways: Finnish teachers encountered difficulties when asking for higher salaries, more funding or other changes, since they already are on top of the rank. Norway, on the other hand, had been much lower on the PISA ranking, but with higher public spending on schools. Based on PISA, Norwegian politicians argued that it has been "proved" that more spending would not increase the quality of schools.

PISA findings on cost and funding, like the above, are frequently used in influential OECD publications, like the annual Education at a Glance. They conclude that "averaged across

OECD countries, there is potential for reducing inputs by 30.7 % while maintaining outputs constant." (OECD, 2007, p16).

PISA science scores correlate negatively with interests and attitudes

PISA scores are often presented as league rankings between countries, with the winners on top and the losers at the bottom. But PISA also has many questions about attitudinal aspects of how young people relate to science. This was an important element in the PISA 2006 study, when science for the first time was the core subject. The definition of science literacy actually included “willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen.” (OECD, 2006).

The possibly most surprising finding is that many countries with the highest mean PISA science score were at the bottom of the list of students’ interest in science (Bybee & McRae, 2011). Finland and Japan are prime examples: they are at the top on PISA science score, and at the very bottom on constructs like “interest in science”, “future-oriented motivation to learn science” as well as on “future science job”, i.e. inclination to see themselves as scientists in future studies and careers. In fact, the PISA science score correlates negatively with Future science orientation (r = -0.83) and with Future science job (r = -0.53) (Kjærnsli and Lie, 2011). It should be noted that the above negative relationships are found when *countries* are the units of analysis. When individual students within each country are the units, some of the correlations are positive. This unjust statistical inference from differences between groups to individual differences is actually labeled “ecological fallacy”.

Such findings are most disturbing. If the students in PISA top ranking countries leave compulsory school with strong negative orientations towards science, one needs to step back and think about the reasons for this as well as the possible consequences. Care should be taken not to interpret correlation with cause and effect, but one should at least think twice before using these countries as educational models and ideals to be copied.

In an analysis of the PISA 2015-data Zhao (2017) points out that students in the so-called PISA-winners in East-Asia (e.g. Japan, Korea, Hong Kong, Singapore) seem to suffer from what he calls "side-effects" of the struggle to get good marks and tests-scores. He presents the PISA-data that show that students in these countries get high scores, but have very low self-confidence and self-efficacy related to science and mathematics. He points out that

> There is a significant negative correlation between students’ self-efficacy in science and their scores in the subject across education systems in the 2015 PISA results. Additionally, PISA scores have been found to have a significant negative correlation with entrepreneurial confidence and intentions." (Zhao, 2017)

One should also note that many of the winners in the PISA science score also have the largest gender differences in PISA score. Finland is a prime example. Finnish girls strongly outperform boys on all three PISA subjects. In reading literacy, the difference in means is about 50 % of a standard deviation. Again, such findings from PISA should call for some caution against trying to copy the “PISA winners”.

PISA science scores correlate negatively with the use of ICT

In a special OECD/PISA report on the use of computers in teaching and learning (OECD, 2015a), the highlighted conclusions are strikingly clear:

> **What the data tell us.** Resources invested in ICT for education are not linked to improved student achievement in reading, mathematics or science. […] Limited use of computers at school may be better than no use at all, but levels of computer use above the current OECD average are associated with significantly poorer results. (OECD, 2015, p 146)

In spite of these clear findings, many countries strongly promote more ICT in schools in order to climb on the PISA rankings. This is just one example of the selective readings of PISA results to justify reforms and initiatives.

PISA science scores correlate negatively with Inquiry-based teaching

The concept of science as inquiry has a long history and has in recent years been lifted as if it was a newcomer. IBSE (Inquiry-Based Science Education) is now an often-used acronym, and is the key recommendation in the influential EU-document "Science Education Now" (EU, 2007). The term IBSE has been adopted as the key concept in calls for EU-funding in the Horizon 2020-program. In PISA 2015, where science was for the second time the core subject, nine statements in the student questionnaire constitute an *Index of inquiry-based teaching*. Some of the statements are these:

> "Students spend time in the laboratory doing practical experiments";
> "Students are required to argue about science questions";
> "Students are asked to draw conclusions from an experiment they have conducted";
> "Students are allowed to design their own experiments" and
> "Students are asked to do an investigation to test ideas" (OECD 2016c, p 69).

Among the interesting findings is that in most of the "PISA-winners" (Japan, Korea, Taiwan, Shanghai, Finland) students report very little use of inquiry-based teaching. For the variation within the same country, the PISA finding is that *"in no education system do students who reported that they are frequently exposed to enquiry based instruction [….] score higher in science."* (OECD 2016c, p 36) But, although the relationship between inquiry based science education (IBSE) and PISA test score is negative, IBSE relates positively to interest in science, epistemic beliefs and motivation for science-oriented future careers:

> However, across OECD countries, more frequent enquiry-based teaching is positively related to students holding stronger epistemic beliefs and being more likely to expect to work in a science-related occupation when they are 30. (OECD 2016c, p 36)

One of the questions in the Inquiry Index may be of special interest. Experiments play a crucial role in science, and have always played an important role in science teaching at all levels. But when it comes to PISA, the report states that: *"activities related to experiments and laboratory work show the strongest negative relationship with science performance"* (PISA 2016c, p 71).

Key concepts and acronyms in current thinking in science education are well known: science in context, IBSE, hands on-science, active learning, NOS (nature of science), SSI (socio-scientific issues), argumentation, STS (Science, Technology and Society). There seems to be no evidence from PISA to back up such advice, PISA rather provides counter-evidence.

The conflict between the recommendations and priorities of scientists as well as science educators on the one hand, and PISA results on the other hand is most problematic. The provoking question has to asked: *Should we sacrifice Inquiry-Based Science Education to climb on the PISA rankings?* (Sjøberg, 2018).

CONCLUSION

This rather short position paper has just briefly described important tensions underlying our work as educators. There are obvious conflicts between the the educational signals that influence educational policies and priorities at the national and global level. On the one hand, the UN-system as well as organizations for science research and science education promote humanistic values, sustainable development, peace and solidarity. These are in line with the priorities and values that are expressed in the mission statement of IOSTE. On the other hand, the influence from the OECD, with PISA as a main instrument, promoting competition and "success", where the purpose of schooling is to produce the human capital that is needed for the global market.

The OECD is at present functioning as a de facto global ministry of education, promoting its own standardized curriculum and system of quality assessment. In this development, the OECD now operates in close contact with the world's largest commercial providers, in particular Pearson, the world's largest commercial provider of educational products and services. In the urge for national priorities to climb on the PISA-scores, one has to sacrifice practically everything that S&T educators recommend, be it context-based content, the stress on education for sustainable development and active teaching and learning methods like IBSE, in particular practical and experimental teaching.

The obvious conflict between the two described influences on education, and S&T education in particular, is seldom problematized. IOSTE has strong value commitments. This is what distinguishes IOSTE from the other S&T education organizations. If IOSTE wants to maintain and deserve a place among the many S&T education organizations, it has to strengthen its identity and address these fundamental conflicts of values and priorities.

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XVIII IOSTE SYMPOSIUM

Future educational challenges from a science and technology perspectives.

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Implementation of Industrial Oriented Project-Based Learning in Undergraduate Engineering Education at Karlstad University

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Abstract

The continuous falling of the birth rate in developed countries is resulting in a reduction in the number of students where most of them are going away from scientific fields. From the academic point of view, such issues represent a great challenge for universities to motivate and make clear the importance for them to contribute to the fourth industrial revolution of connected machines, reconfigurable systems, advanced robotics and seamless information flows. Therefore, in this paper, an industrial oriented project-based learning is proposed and implemented for the undergraduate course *Project Course in Electrical Engineering* (ELGB24) at Karlstad University. In particular, the proposed course syllabus for the course ELGB24 is described and some examples of the projects selected by the students in collaboration with our industrial partners. For each of the selected projects, a description of the work done as well as a summary of the most relevant results are given.

Keywords: PBL, Mechatronics, Vision.Based Navigation Control, Solar Photovotaltic System, STEM

INTRODUCTION

Developed countries hold very large shares in high technology industries (IEA, 2018). In particular, different countries have been actively contributing to the industrial development, mainly in the areas of smart industry, renewable energy, etc. However, a great challenge is presenting in developed countries due to the continuous falling of the birthrate. This situation may affect the industry by losing competitive power in the future due to the shortage of talented engineers. Moreover, the curricula of engineering programs at the universities is currently lacking of practical experience to motivate the creativity to design novel systems; resulting in the lack of opportunities to attract their interest in doing further studies.

From the academic point of view, the issues described above represent a great challenge for universities, which intend to introduce students to robot technology (RT). In fact, the main challenge in introducing the RT is in finding simple and efficient educational ways to show students the basic components of robots, as well as, their application for solving real-world problems.

In recent years, the proliferation of amateur robot contests (including elementary school children) supported by private companies and local governments (RoboCup, 2018; Rescue-Robot Contest, 2018; Robot-Sumo Tournament, 2018) have demonstrated an effective way of motivating students to get involved in the robotics field. Such kind of contests represents an opportunity for talented students to actually integrate an autonomous and/or semi-autonomous system by themselves to enhance their understanding of robot technology, cultivate their practical abilities and strive enthusiastically to achieve higher levels of accomplishment.

RESEARCH QUESTIONS

In recent years, the proliferation of amateur robot supported by private companies and local governments have demonstrated an effective way of motivating students. Even though several robot contests have been promoted by local governments; at the university level, there are still difficulties in introducing more effective educational methods. In particular, several universities have been implementing Project Based Learning (PBL) to introduce robotics to undergraduate students (e.g. Solis et. al, 2009, etc.) as well to graduate students (e.g. Solis, 2012, etc.). Project-based learning (PBL) is a model that organizes learning around projects. According to the definitions found in PBL handbooks for teachers, projects are complex tasks, based on challenging problems that involve students in design, problem solving and decision-making (Jones et. al, 1997, Thomas et al. 1999). This diversity of defining features coupled with the lack of a universally accepted model or theory of Project-Based Learning has resulted in a great variety of research and development activities.

For this purpose, several attempts to build educational robots have been made during the past few decades (Miller at al., 2008). In fact, the development of educational robots started in the early 1980s with the introduction of the Heathkit *Hero − 1* (Heat Company, 2018). Such kind of robot was designed to encourage students to learn how robots are built. However, no information on the theory or principles behind the assembly were given. More recently, several other companies in cooperation with universities and research centers, have been trying to introduce educational robots to the market. Some representative examples are as follows: K-Team (K-TEAM, 2018) introduces the *Hemisson*, which is a low-cost educational robot designed to provide an introduction to robot programming by using reduced computational power and few sensors. Another example is the *LEGO* R _ *Mindstorms RCX* which is a good tool for early and fast robot design by using the LEGO blocks (LEGO, 2018). In Japan, we can also find some examples such as: the *RDC-TEC34* kit designed to provide a general platform to enable students to built their own robots (Japan Robotech, 2018), *ROBOVIE−X* from Vstone designed as an education tool to introduce principles of mechanical manufacturing, assembly and operational programming of small−sized humanoid robot (Vstone, 2018), etc.

Even though several universities and companies have been building robotic platforms for educational purposes, we may observe that there is still no platform designed to intuitively introduce the RT from the fundamentals to their application to solve real world problems. In fact, most of the current educational platforms focus on providing the basic components to enable students to built their own designed Mechatronic systems. However; such kind of platforms are used to merely introduce basic control methods (i.e. Sequential Control), basic programming (i.e. Flow Chart Design, C language), and basic mechanism design.

Up to now, the implementation of industrial oriented PBL has been scarcely studied in the early stages at the universities. Therefore, in this research, the author has focused in exploring the possibilities to extend the concept of PBL outside of the academic environment. Based on the proposed approach, the students may not only learn the basic concepts of complex system but also may obtain an understanding of the real applications of the theorical concepts from a interdisciplinary approach within the different areas of STEM (Science, technology, engineering and math) education.

Thus, the aim of the present study is to examine the possibilities of active involment of the industry in project-based learning in relation to students' possibilities to apply their theoretical knowledge to solve real world problems. This study is focused on the following research questions:

1. What are the possibilities of students to experience real-world problems based on simplified systems?
2. How can students gain a broader perspective on research issues?

PROPOSED METHODOLOGY

The author considers the importance to increase the chances to facilitate the integration between the theoretical and practical knowledge with the support both from academia and industry. For this purpose, the author has proposed to include the *Project Course in Electrical Engineering*, ELGB24 (10 ECTS), as an obligatory course in the bachelor in science in Electrical Engineering at Karlstad University. Upon completion of the course ELGB24, the students should be able to:

- Describe the basics of sensors and actuators and of embedded intelligent systems,
- Describe the different methods used to steer electric servo systems,
- Give an account of the different methods used to measure mechanical quantities,
- Describe methods of steering and monitoring industrial processes,
- Design an embedded system and use modern design tools for real-time simulation.

The course comprises the following components:

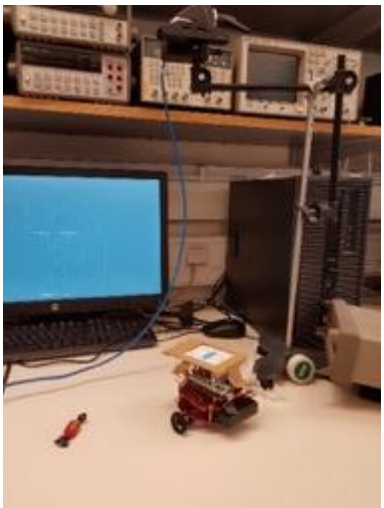
- actuators, proprioceptic/exteroceptic sensors and architectures for steering intelligent machine systems
- transducers for measuring temperature, pressure, deformation, acceleration and force and for measuring mechanical quantities
- modelling and simulation of mechanical systems
- sequence steering and programming user interface for human-maching interaction
- multi-tasking, hardware/software architectures and programming of embedded systems.

In the first four weeks of the course, the students follow lectures and exercises for using modern design tools (e.g. Matlab), in order to program a robot (e.g. LEGO® EV3). Within the third and four weeks, the students are required to find a suitable project in the industry in order to solve a specific problem and to submit a proposal to the course responsible for his approval. After its approval, the student can perform the project course either at the industry and/or at the university during the next coming seven weeks. In parallel, the students follow lectures (sensor technologies, automatic control, modeling and simulation, and embedded systems) and laboratory exercises (characterization of a solar photovoltaic cell and automatic control) at the University.

During the actual period of the course project, the students received supervision from both an external supervisor from industry and an internal supervisor from the university. At the end of the course project, the students were requested to give an oral presentation (within 10 minutes for project) to the rest of the students in the course as well as to the different external supervisors and interal supervisors. As part of the oral presentation, the students were asked to answer the questions from the attendees (within 5 minutes). Based on the comments/suggestions given by the attendees, the students prepared the final report in order to be assessed by the Examiner of the course.

RESULTS

In the autumn 2017, seven students followed the compulsory course on the third term of the bachelor program. Some examples of the projects selected by some of the students are as follows.

a) 

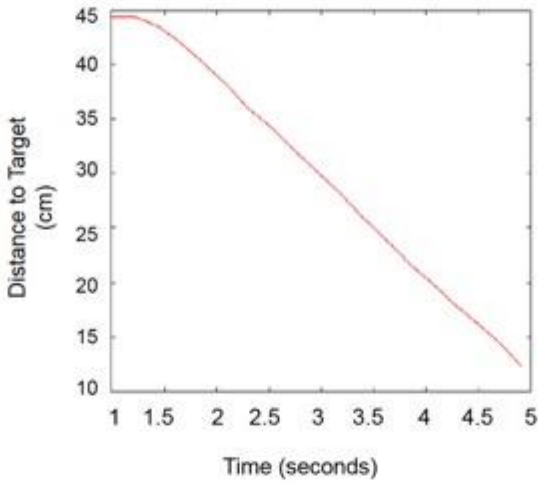
b) 

Figure 1. Examples of selected projects for the course ELGB24 in the autumn 2017 (Vision-based navigation control): a) Experimental setup b) Experimental results.

Development of a vision system for the control navigation of a robot by from images taken by a RGB-d camera: In this proposed project, Camanio Care AB develops a device for people to eat independently, targeted to those who for some reasons cannot eat themselves. In this project, the aim is to use a vision system to pick food placed on the table by using a homemade mobile robot implemented with Arduino (Figure 1a). For this purpose, the students find an alternative solution to enable a mobile robot for navigating to a given target (e.g. candy) using data retrieved from an RGB-D sensor. In particular, the students have implemented the following steps: calibration of the whole system in respect to the world coordinate reference, control the yaw angle of the robot towards the candy, calculate the distance between the robot and the goal and control the navigation of the mobile robot towards the candy (Figure 1b).

Study of the impact of snow in a solar photovoltaic cell: In this proposed project, Glava Energy Center develops, test and validate methods for applying pattern recognition to local energy systems and microgrids. In this project, the aim is to identify the point at the thickness of snow covering the PV solar module in the winter season affects considerably the production of electricity by using LEGO® EV3 and the LEGO® renewable energy add-on set (Figure 2a). For this purpose, the students find an alternative solution to analyze the effect of snow with different thickness (0, 5, 10 and 14mm) at different light intensities by logging the voltage output signal with the LEGO® Energy Meter. In particular, the student proposed the following algorithms: frequency analysis techniques based on the short fast Fourier transform (Figure 2b) and statistical analysis algorithms based on the two-way ANOVA.

As a result, from the course analysis based on the comments from the students, the course was in generally good. The students developed their practical experience in contact with the industry. Based on the selected course projects, the students could focus in one or several areas covered in the course. On the other hand, the external supervisor from the industry showed also great interest in the work presented by the student at the seminar and provided valuable advice in order to motivate to further work in the selected project (e.g. further develop their project course towards the thesis work, consider the possibility to carry out a summer job at the company, etc.).

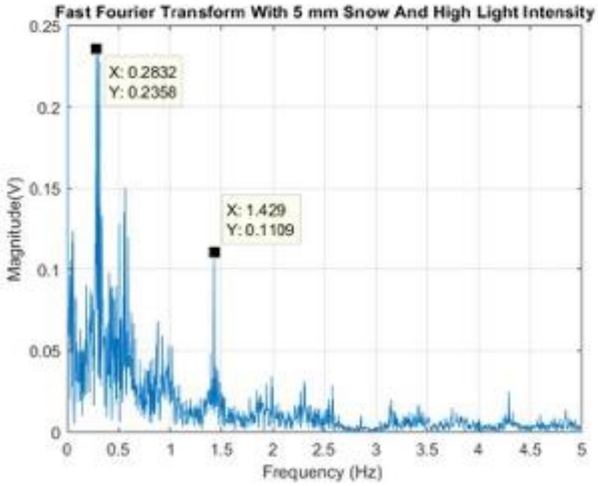
a)  b) 

Figure 2. Examples of selected projects for the course ELGB24 in the autumn 2017 (Study of the effect of snow on the PV solar cell): a) Experimental setup b) Experimental Results.

In addition, based on the examples of the course projects described above, the experimental results obtained in the course were further developed in order to submit a research paper (where the co-authors are student, the external and internal supervisors) to well-known international conference in the respective fields (Mechatronics and PV Systems respectively). As a result, from the course project on the development of a vision system for the control navigation of a robot by from images taken by a RGB-d camera, the paper was published and presented to the 16th Mechatronics Forum International Conference held in Glasgow, U.K. (Solis, Karlsson and Linborg, 2018). Based on this result, the student gained a broader perspective on research issues on vision-based navigation control. On the other hand, the result from the course project on the study of the impact of snow in a solar photovoltaic cell, the paper was published and presented at the 35th European PV Solar Energy Conference held in Brusels, Belgium (Solis, Hamanee and Nilsson, 2018). Based on this result, the student gained a broader perspective on research issues on PV systems.

CONCLUSIONS

In this research, an alternative method to implement the project-based learning has been proposed and implemented in the Project Course in Electrical Engineering (ELGB24) at Karlstad University. As a result, undergraduate students have selected industrial projects to solve specific problems. Based on the projects described in this paper, there is a potentiality for students to develop critical thinking, creativity, problem solving, communication, collaboration, global awareness, and social responsibility.

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An Analysis of the Coverage of Science News and the Use of Newspapers in the Science Classroom

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Abstract

The concern about how the media in particular newspapers portray science news is growing, since there is a belief that newspapers can play a pivotal role in educating the citizens. Newspapers can play a role in science education as it is regarded as medium that can heighten students' knowledge, enhance vocabulary skills and encourage a positive attitude towards learning. The aim of this study was to provide an overview of how online newspapers portray astronomy news in terms of framing and tone. The study is underpinned by framing theory, which suggests that presentation can influence the choices people make. A mixed method approach was employed since it combines both qualitative and quantitative methods to deal with different questions of the study. An instrument to collect data was not required, the data was available on the internet. I retrieved the newspapers from the internet and samples were drawn from two online newspapers, the Mail & Guardian and News24 from 1 January 2012 to 31 July 2015. The Nisbet framework and a modified story analysis form were used to analyse data. The quantitative results indicate that the coverage of astronomy news is limited based on the newspapers analysed.

Keywords: Astronomy Education, Framing Theory, Online newspaper.

INTRODUCTION

The 21st century is close to two-decades-old, however, there is already a growing concern that South African media needs to improve their science news coverage to conscientise citizens with scientific literacy i.e. their knowledge about science, the environment, and health isuues. This will assist in developing active citizens in a world that is dominated by complicated scientific and technological advance.

Reading is an essential practice in science education since it is a rarely used teaching and learning resources in the classroom, however, it is a basic skill learner need to acquire at an early age for ongoing learning. In recent years, teachers have been encouraged to incorporate newspaper articles in their teaching and learning (Bowling, Crostarosa & Swift, 2008). Learning through newspapers is considered as a form of informal science learning, this is an area of education that is not considered. There is a belief that using newspapers in the classroom is difficult when it comes to assessment (Wellington, 2007). A research conducted in the United Kingdom suggests that most science teachers often incorporate news reports in their classroom if they want to emphasise a concept that has been taught or associate an abstract concept to science in everyday life (Halkia & Mantzouridis, 2005; McClune & Jarman, 2010).

However, there is a need to use newspapers in science classroom often to encourage learners to take control of their learning and brings the element of using real-world examples. Real-world examples assist in conceptual understanding for learners since they have a magnetic attractiveness to most learners. Newspapers are regarded as a medium that can heighten students' knowledge, enhance students' vocabulary skills, conceptual understanding and encourage a positive attitude towards learning (Sanderson, 1999). Newspaper articles are often based on scientific knowledge, which the reader needs to know to make a critical analysis of the environment they are living in (Oliveras, Márquez & Sanmartí, 2011). Awujobi and Adeokun (2012) support the claim that, if teachers use newspapers with awareness in science class, they can play an essential role because newspapers act as a link between formal science education and informal science education. These are some of the reasons why a newspaper needs to be incorporated in the science classroom. However, it is important to understand it is not the responsibility of journalists or newspapers to impart scientific knowledge to society and to learners it is the responsibility of the educational system.

The educational system does not accept newspapers as a form of formal learning, since, it is demanding to assess the level of learning through newspapers and information in newspapers often disagrees with formal learning or school knowledge (Wellington, 1991). Science portrayed in newspapers is interpreted as factual and encompasses new and forthcoming breakthroughs that are not yet officially published (Turner, 2008). Teachers' do not know or understand how they can make use of newspaper articles in their teaching for learners' conceptual understanding. Again, the rigidness of the curriculum, teachers find it difficult to deviate and try other new teaching methods as they are rushing to cover the syllabus.

To access newspapers online is a very easy and they assist people to learn about science news, and discoveries since formal science education are only out in the open to a small number of South Africans. Most people read about science discoveries/news in newspapers, magazines, or digital communications such as social networks. In this study, I selected newspapers over other forms of media because in South Africa newspapers are still the form of communication most people can easily access (Van Rooyen, 2002). The Audit Bureau Circulations of South Africa released a statement on the 19 February 2015 that hard copy newspaper readership is declining in South Africa and around the world. However, they are still among the favoured forms of media. Accessing online newspapers is simple since most people in Africa access internet through their cell phones as it is less expensive than other forms of media.

The aims of the study are to provide an overview of how online newspapers portray astronomy news in terms of framing and tone. In the study, "tone" is used to analyse and reflect on the mood of the article, whether the journalist reports about the positive or negative news.

i. How much coverage does astronomy news receive in selected South African online newspapers?

ii. How, if at all, can astronomy articles be used in science classrooms?

The study sought to understand what aspects of astronomy news South African online newspapers portray and whether teachers can use newspaper articles as an alternative tool in teaching science.

SCIENCE COVERAGE

Newspapers around the world, including South Africa, are overwhelmed with politics, fashion, celebrity news and other things that are not science related depending on the status and geographic focus of the newspaper because journalists focus on what their readers are interested in (Van Rooyen, 2002). Most of the available space in newspapers is devoted to politics and other trending news. Science and technology have very little news coverage in South African media. A study conducted by Van Rooyen (2002) found that less than 2% of editorial space in South Africa's top publications was devoted to science topics. A lack of communication between journalist, scientists and the society might be a possible reason for not producing much science news.

This study is concerned on how journalists frame astronomy news in South African online newspapers and how their coverage can help science students and teachers access information and use online newspapers as an alternative form of teaching. Conducting a research study about astronomy coverage by online newspapers is one of the ways to show the importance of informal learning in science education using newspapers. It will show the public, educators and journalists that online newspapers can play an important part in science teaching. There is already an abundance of information when it comes to astronomy, which is being distributed, by organizations such as the National Aeronautics and Space Administration (NASA), European Southern Observatory (ESO), and other organizations. Teachers who are willing to bring astronomy to life in their classrooms have an option to select online newspapers as one of the alternative resources used in teaching.

THE IMPORTANCE OF ASTRONOMY IN OUR EVERYDAY LIFE

Since from the beginning of time, people used to look up to the sky for them to get directions to sail across the oceans, they used the environment to agree when to plant their crops and to answer some of the questions of how we got here and where we came from. Astronomy is a branch of learning that gives context about the universe and it shapes how we view the universe and has continuously had a meaningful influence on how we view the world at large (Rosenberg, Russo, Bladon, & Christensen, 2013).

As our understanding of the world grows, we discover more planets and other bodies in the universe. These discoveries make science interesting and people are becoming more curious about the cosmos. The bright attractive colours of the universe fascinate schoolchildren and some of them want to study astronomy (Renee, 2012). Introducing astronomy to young children might answer questions in astronomy such as "How old are we?", "What is the fate of the Universe?" and certainly the most thought-provoking question, "How unique is the Universe, and could a slightly different Universe ever have supported life?"

Astronomy is breaking new records there are new discoveries or advancements in this field. Currently, all eyes are on South Africa because of the Square Kilometer Array project and therefore primary and high school students want to know about astronomy as a career including the advancements that are taking place concerning the SKA project (Rosenberg et al., 2013). Exposing children at an early age and other scientific advancements are vital for our students.

THE VISIBILITY OF ASTRONOMY IN SCHOOL CURRICULUM

Everything that has to do with space "astronomy" inspires youngsters to be interested in mathematics and science (Venugopal, 2015). Countries such as USA and England use astronomy to attract learners to special events or workshops. South Africa also uses a similar approach where schools take their learners to planetaria (e.g. the Johannesburg Wits planetarium) to show them artificial space that makes science interesting but there is no follow up after the workshops to sustain children's interest in science and mathematics (Venugopal, 2015).

The South African government, in partnership with NRF, is investigating new ways to make learning breathtaking. They have already recognized priority areas, which includes astronomy, among others. This subject has the potential to create a thought-provoking learning environment and it can introduce new ways of learning that make the learning process exciting, spellbinding (Venugopal, 2015).

In the late 1990s to early 2000s, the South African school curriculum was revised, and astronomy was shifted from the geography syllabus into the natural sciences. The current education system introduces astronomy into the curriculum as an entity designed to attract students to learn about science. In primary school, from grades 4 to 9, astronomy topics account for 11% of the curriculum while from grades 10 to 12 astronomy topics in physical sciences account for only 4% (Lelliott, 2007).

THEORETICAL FRAMEWORK

The purpose of the study was to analyse how astronomy news is framed in selected South African online newspapers, therefore, it was appropriate to select a theoretical framework that was related to the study, i.e., a theoretical framework that addressed issues of how the media, in particular, newspapers, portrayed science stories to their readers. The appropriate theoretical framework used was framing theory, which is perceived from diverse angles and can have implications for multiple values.

Goffman refers to framing as a theory as "a scheme of interpretation, that enables individuals to locate, perceives, identify and label occurrences or life experiences. Framing is used to represent the communication aspect which leads to the people's preference by accepting one meaning to another" [Goffman (1974) in Cissel (2012, p 68)]. While Kalvas, Vane, Stiplcova, & Kreidl (2011) define framing as a way in which information is presented to the audience. It suggests how something presented can influence the choices people make. It is a process where people acquire a specific conceptualisation about a topic and later change their thinking. Framing inspires decision-making practices by emphasising specific aspects and reject others, for example, newspapers frame the news from a certain perspective (Cissel, 2012). Often framing can influence the audience's perceptions and meaning-making.

METHODOLOGY

A mixed method was employed since it combines both qualitative and quantitative methods to deal with the different questions of the research study. A data-collecting instrument was not necessary; the data was available on the internet. I retrieved forty newspaper articles, twenty articles from the Mail & Guardian, and twenty from News24, from 1 January 2012 to 31 July 2015. I used a modified story analysis form to analyse data. This is a tool that is used in the newspaper content analysis. I adapted it from Lynch and Peer (2002) and modified to suit my study. Within the story analysis form, there are categories and sub-categories and these include origin, geographic focus and treatment, the Nisbet framework, framing techniques, article ID, date, article title and general reactions, among others (see example, appendix A) and these are some of the items analysed for each online newspaper.

RESULTS AND DISCUSSIONS

Question 1: How much coverage does astronomy news receive in selected South African online newspapers?

The finding shows that out of the analysed newspapers, 82% of the *Mail & Guardian* stories were predominantly general news. Whereas only 76% of *News24* stories were general news. Most of the science news is general news, and only likely to be covered by journalists if they are perceived as newsworthy or blended with political news. Figure 1 shows the percentage distribution of news treatment.

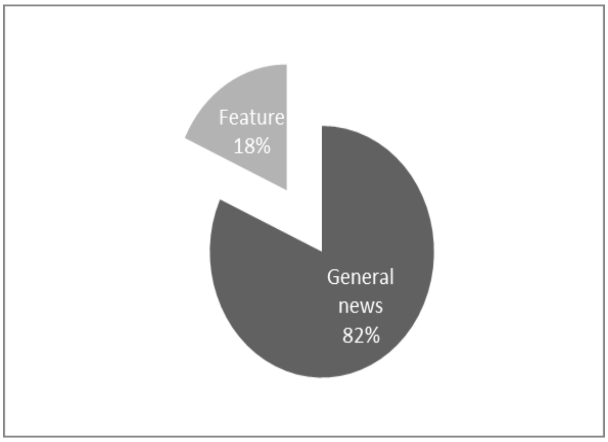

Figure 1: The *Mail & Guardian* news treatment

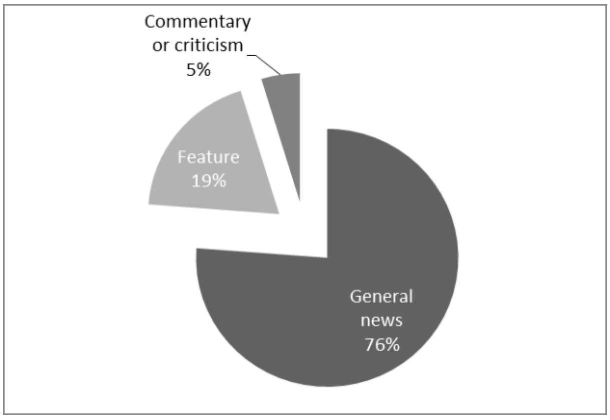

Figure 2: *News24* news treatment

The *Mail & Guardian* reported about astronomy news when there were new advances relating to SKA or if political leaders had visited the SKA project site. Almost 70% of the analysed articles were reporting about the SKA project, either about new developments, threats that may occur or ways of fundraising for the project. Astronomy/science news articles in newspapers are flooded with scientific jargon without any explanations for people who do not understand science termonologies.

Question 2: How, if at all, can astronomy articles be used in a science classroom?
In language classrooms, teachers use newspapers as an alternative when teaching, in science classroom teachers can incorporate newspapers to bring real-life situations to learners. Newspaper activities engage students in interesting and enjoyable learning and encourage learners to read further during their leisure time as newspapers store a vast amount of information (Laureta, 2009). There are various ways teachers can create an active classroom when newspapers are incorporated in the classroom (Laureta, 2009). Teachers can use newspapers as a prompt to introduce a topic by starting a tough class discussion about a topic. For higher grades such as grades 10-12, Veneu-Lumb and Costa (2010) devised some questions a teacher can use. Some of the questions are:

a. What is the story about? For example, is this a story that can help South Africa or not? In your own opinion, is this information important to you? Give reasons.
b. Name the place where the story is from or what is the name of the organisation writing this article.
c. Identify people that were quoted by the journalist e.g. politicians, scientists or a normal citizen. What is their involvement?
d. Did you know anything about the matter before reading about it? If yes, does the content contain new information that you did not know? If yes, what is it and does it differ with, what you thought before?
e. What was the journalist's purpose in publishing this article? Is there a hidden motivation, such as fear mongering, a political intention, or to achieve sale?
f. If possible, students can be requested to find the same story from other newspapers, compare them and determine whether that helps them to respond to some of the previous questions.

Figure 3: examples of question teachers can use when incorporation newspapers (Adapted from Venue-Lumb & Costa, 2010).

Teachers need to make tasks as real as possible and think about what people do when reading a newspaper in their own language and try to create questions that will relate to students' ages (Veneu-Lumb & Costa, 2010). As a result, yes, newspapers can be used in a science context.

CONCLUSION

Yes, teachers can use newspapers because they are useful in a science classroom if teachers use and supplement with textbooks and other teaching materials. The use of newspaper in teaching and learning of science is undoubtedly one of the effective ways of teaching science whether in an informal or formal learning and teaching context. Using newspapers increase students' knowledge and improves student's vocabulary skills to enhance conceptual understanding. Using newspapers in science classroom agrees with Feyerabend (1975) assertion that "anything goes" in the absence of a prescribed method of teaching and learning, science has methods and the choice of these methods ultimately impact on the learners; therefore, being different at times might bring positive results. This chapter made conclusions by answering the research questions with evidence from both kinds of literature and from the results in chapter four and five. It then addressed the limitations of the study and it made few recommendations on how newspapers can be incorporated in our South African science curriculum.

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XVIII IOSTE SYMPOSIUM

Future educational challenges from a science and technology perspectives.

Malmö, Sweden, 13-17 August, 2018

Is There a Gap to Mind in Preschool Practice When it Comes to Technology?

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Abstract

Research has indicated that there may be a gap between preschool teachers' general descriptions of technology and the technology content in their actual preschool practices. This study investigates this further and, if a gap is found, looks for possible reasons for it. The study was conducted in the form of research circles in two Swedish municipalities with 19 technology-minded preschool teachers. A mixed research design was used. The starting point for mapping the preschool teachers' descriptions of technology was an established questionnaire that placed technology into five categories. Following this, the teachers independently documented events at their preschools that they assessed as technology activities. The findings were that the most commonly chosen category in the questionnaire was technology as a *solution to a problem*. However, in their everyday examples the dominant activities related to the children's attempts to *use the artefacts*. The preschool teachers said that the children had to be introduced to the artefacts, their names and functions, before moving on to more advanced levels describing technology. There is thus a distinction between the preschool teachers' descriptions of technology and their everyday practices, where they themselves provide relevant explanations for the gap.

Keywords: preschool, research circle, technology

INTRODUCTION

The Swedish curriculum for the preschool includes several goals. Two specific goals relate to technology (Skolverket, 2016), namely that the preschool should strive to help each child to develop their ability to: 1) identify technology in everyday life and explore how simple technology works, and 2) build, create and construct using different techniques, materials and tools. Hence, it is expected that preschool teachers will understand what technology is and be able to translate this into pedagogical activities with the children.

What defines technology and describes its content is included in the research area known as the nature of technology. Some complimentary descriptions can be found e.g. in DiGironimo (2011) and Mitcham (1994). The syllabus for technology in the Swedish primary and lower-secondary school (Skolverket, 2011) can also serve as a guide for preschool teachers with regard to content and activities. A common aspect in these three examples is that technology is a human activity that meets our needs and requires knowledge and creativity in order to perform it, which results in a technological artefact or system. DiGironimo's example and the Swedish syllabus for technology also include a social aspect, namely that individuals, society and environments interact with technology over time, which affects the development of artefacts.

Research shows that a teacher's knowledge about technology and the nature of technology plays an important role in children's technological learning (Jones, Buntting & de Vries, 2013; Rohaan, Taconis & Jochems, 2010). In relation to this, preschool technology education faces a challenge in that teachers' concepts of technology have proved to be narrow, because they either describe it as computers and other electrical devices (Öqvist & Högström, 2018) or include everything, thereby rendering the concept fuzzy and difficult to grasp (Elvstrand, Hallström, & Hellberg, 2018). While technology is often described by preschool teachers as artefacts, or as everything, preschool technology education has been shown to consist of primarily construction activities (Elvstrand et al., 2018; Skolinspektionen, 2012, 2017). Sundqvist (2016) found that the same preschool teachers who described technology as electrical devices also talked about technology education as block-building activities. Thus, there seem to be a gap between preschool teachers' general concept of technology and the content they include in their technological activities with the children. Sundqvist (2016) speculated that a possible explanation for this was preschool teachers' limited knowledge of technology and how they connected it to the descriptions in the curriculum. In this study, we investigate this issue further by mapping preschool teachers' descriptions of technology to determine whether or not they reflect the technology activities that are carried out in their preschool work. The differences can be described as a gap, in which case we look for possible explanations for it. The study seeks to answer the following research questions: Is there a gap between preschool teachers' descriptions of the content of technology and the activities involving technology with the children? If a gap is identified, what are the reasons for it?

METHODOLOGY

The study was conducted in two research circles in two Swedish municipalities with 19 preschool teachers. The research circle method is part of participatory action research, in which professionals and academics meet as equal partners to improve skills and knowledge concerning an issue in practice (Stringer, 2007, p. 19). One of our research circles involved six participant preschool teachers and two academic leaders, while the other research circle involved 13 participant preschool teachers and two academic leaders. One of the academic leaders participated in both circles. The participating preschool teachers were selected by their preschool managers. The basis for the selection was the preschool teachers' own interest in technology. In both research circles, the preschool teachers worked at different preschools. The research circles lasted for a full year.

Each research circle meeting lasted for approximately two hours and the data for the study was collected during the first three meetings of seven in each circle. This limitation is due to our design. In the first meeting of each research circle we discussed the content and definition of technology, and in the two following meetings the preschool teachers presented examples from their own practices in the preschools. The meetings were video recorded and transcribed verbatim.

A mixed research design has been used. The starting point for mapping the preschool teachers' descriptions of technology was a questionnaire, Technology Profile Inventory (Collier-Reed, 2006). The Discreet Option Type version of the questionnaire was translated and adapted to a Swedish preschool setting. The questionnaire describes technology in terms of five categories: artefacts, the application of artefacts, the process of artefact progression, the use of knowledge and skills to develop artefacts and a solution to a problem. These categories align along a complexity dimension, from a concrete to an abstract description of technology. All the participating preschool teachers responded to the questionnaire (n = 19) before the research circles met. The first part of the data analysis generated aggregated questionnaire responses. The responses were then discussed in each research circle in order to determine how the participants interpreted and understood the various questions in the questionnaire. This resulted in rich answers about technology as knowledge content.

Following this, the participants independently documented events in their preschools that they regarded as technology-related. Each preschool teacher then presented these events in their respective research circle. In the circles, they were asked to describe the situation or context in which the activity appeared and how technology was reflected in it. In the follow-up discussions we used Collier-Reed's five categories and asked the preschool teachers to describe which categories they thought best described the technology in the event. This led to discussions in each circle. Based on our interpretations of the discussions, two of the researchers used Collier-Reed's (2006) category system through a directed content analysis (Hsieh & Shannon, 2005) in order to place the mentioned activities into an appropriate category. This was done with 59 examples generated in the second meeting of each research circle. Consensus was reached for the categories in all the examples. One of the researchers then independently categorised 20 additional examples from the third meeting of each research circle. Thus, a total of 79 examples were identified and categorised in the second part of the data analysis.

The third step in the data analysis was a comparison. The preschool teachers' questionnaire responses and their descriptions of technology in the follow-up discussions were compared with the coding of the technology events in the child-related situations. Here we looked for overlaps in and differences between the descriptions of the technology content in general and the preschool practices.

RESULTS

In total, we received 19 completed questionnaires, yielding 94 analysed responses. Figure 1 shows that the most common category was technology as a "solution to a problem". As can be seen in the figure, there is a clear difference in frequency to the second most common category "the process of artefact progression", with a further drop in frequency to the category "the use of knowledge and skills in developing artefacts". The categories "artefacts" and "the application of artefacts" received low responses. In total, the three of Collier-Reed's (2006) most advanced categories cover 96 % (90/94) of the preschool teachers' responses.

The preschool teachers' descriptions of technology as an advanced subject, e.g. problem solving rather than common artefacts and the use of them, was confirmed in the research circle discussions. The questionnaire statement "Having wires coming out of things makes them technology", that describe technology as an artefact, was dismissed by one of the preschool teachers, who stated that *"We have electricity everywhere, that technology already exists"*. Another remark from a preschool teacher was: *"If you go down to a child's level, then that's technology, just plugging that cord into the socket is technology to a child."*

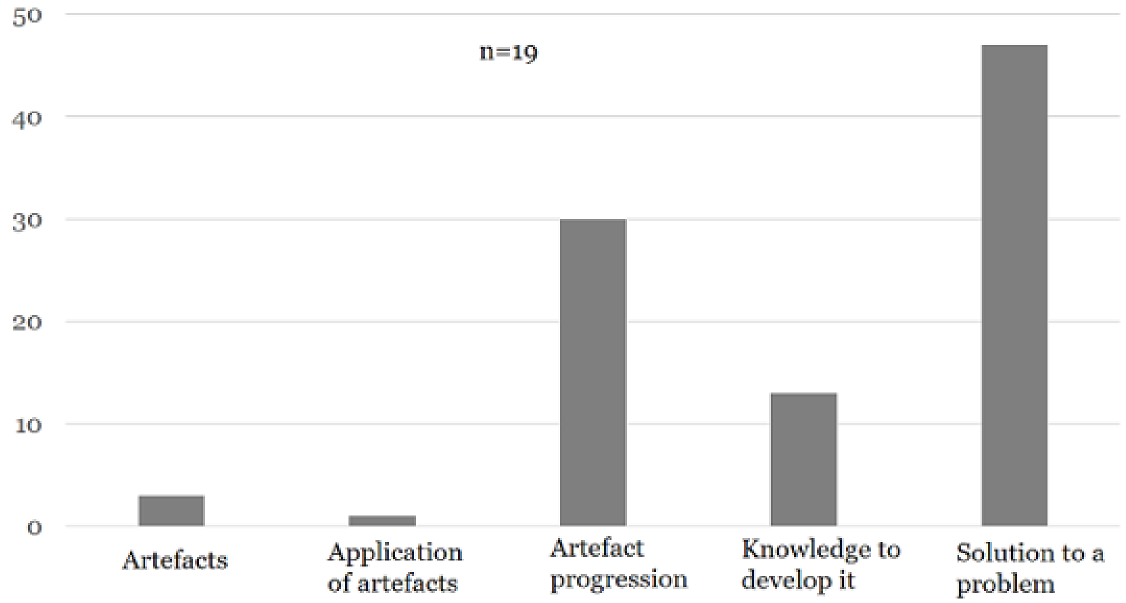

Figure 1: What technology is according to the preschool teachers (19 responders) placed in five different categories.

Similarly, a statement in the questionnaire defining technology as using an artefact - "A door lock becomes technology when a key is turned in it and the levers move to lock it. Otherwise it is just a lock" - was problematised by one teacher in the discussion in her research circle: *"It is also technology, though it is so narrow"*. She followed this up by saying: *"Technology I think is broader .... Technology, this lock, that you made the lock. But the lock itself is not a technology, but what you do with it is"*.

Hence, the preschool teachers presented an image of technology as an advanced subject. However, as can be seen in Figure 2, when presenting examples of their everyday preschool practices with the children, a different representation of technology emerged. In total, 79 different examples of technology-based activities were identified in the six analysed meetings, three within each research circle.

Some of the activities with the children are linked to the category "artefacts" with examples of the introduction of technical concepts and terms. However, the category "the application of artefacts" dominates, with examples of activites such as turning on/off the light, flushing the toilet, taking picures, using an iPad and using a hammer as a tool. At the same time, there are also examples of the categories "the use of knowledge and skills in developing artefacts" and "solution to a problem", especially in the activities involving older preschool children aged 4 to 5 years.

An example of knowledge and skills is given of two girls, both aged 5, constructing with Lego®. The preschool teacher reports:

> *"Now we have to make a staircase so they come up [to the second floor of the house]", the girls said. Then I asked: "How are you doing a staircase then?" Then they showed me and were so eager that they both spoke at the same time. They dealt with the Lego building blocks and clearly showed how they put them together and merged them so they fitted like a staircase from downstairs to upstairs. Then they assembled the stairs and continued to build their house."*

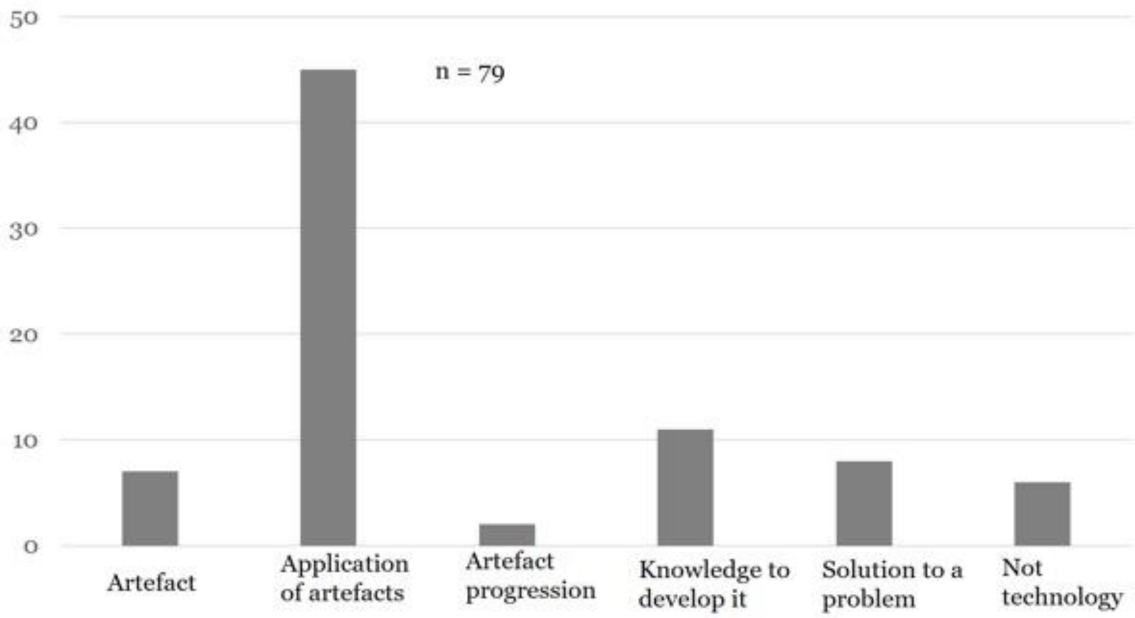

Figure 2: Categorisation of the preschool teachers' technology activities (n = 79) with the children.

In addition to Collier-Reed's (2006) categories, a new category had to be introduced to describe the data "not technology". Here, six examples containing mathematics or science that the preschool teachers had identified as technology were included.

DISCUSSION

It is clear from the differences between Figure 1 and Figure 2 that there is a gap in the participating preschool teachers' descriptions of technology and the practices involving technology with the children. In contrast to previous research (Öqvist & Högström, 2018), in their general description of technology the preschool teachers do not emphasise the application of artefacts as technology. However, these categories are prominent in the preschool activities. On the contrary, the preschool teachers regard artefacts and their use as too narrow a description and prefer more complex ones, such as a solution to a problem. We have identified three reasons for these differences: the survey's design and selection of participants, that preschool teachers need to see technology by 'putting on technology spectacles', and children's development during their preschool years. These reasons are elaborated on below.

The construction of the questionnaire may have affected the results, in that only one category out of five could be chosen for each main question. As the preschool teachers had a well-developed view of technology, they chose a more inclusive and abstract answer that pointed to a category such as "solution to a problem" rather than "artefact", even though they may have regarded both as valid. Their own reasoning when discussing the alternatives point to this. If a different group of preschool teachers, including less technologically interested staff, had answered the questionnaire, the result may have been different. The reason for suggesting this is that earlier research has shown that, in general, preschool teachers' knowledge of technology is relatively limited and that they also are aware of that (Elvstrand et al., 2018; Öqvist, & Högström, 2018).

The preschool teachers also addressed the challenges of seeing technology in their everyday activities with the children and how to point out the technological content to them. They did not always think or see that artefacts, or the everyday use of them, was technology. One example is that to a child, plugging a cord into a socket is technology. Well established technology also tends to be invisible to the preschool teachers. They frequently expressed the need to put on "technology spectacles" to see the technology and use it in everyday sitations.

When the preschool teachers were confronted with the gap, they themselves motivated it with a progression. According to them, the children needed to be introduced to the artefacts and their names and functions before moving on to more developed or complex levels of technology. It could also be noted that the activities of the older children (5 to 6 years of age) were sometimes at these more developed levels.

CONCLUSIONS

Despite the developed technology competence amongst the preschool teachers taking part in this study, the results show a gap in the content and description of technology between its general definition and the selection of preschool activites with the children. They also show the competence and experience of the group when they collectively present complementary ideas to explain this gap. These insights will probably enable them to close the gap if this is deemed necessary. We also note that the activities in the preschool include examples from all the technical categories included in the study's framework. The children are thus given opportunities to meet technology in several categories in the preschool activities.

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XVIII IOSTE SYMPOSIUM

Future educational challenges from a science and technology perspectives.

Malmö, Sweden, 13-17 August, 2018

Expansion of Science Education Within the Museum Using Body Movements of Multiple People

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Abstract

For children, the museum is an important place to acquire scientific knowledge through experiences and conversation. However, the main learning method in the museum is through observation of exhibits and reading explanations on text panels, which constitutes passive learning. Few opportunities to discuss those experiences and engage in conversation exist. Therefore, it is difficult for young children to learn sufficiently and obtain knowledge efficiently. These issues should be solved to improve the quality of science education in museums. With the purpose of solving these issues, we developed a collaborative immersive learning support system in the museum that enables children to learn through body movements and conversation. Children can adequately obtain knowledge by thinking hard when moving with multiple people. Based on this consideration, we developed content that can be manipulated by body movements of multiple people. For instance, people cooperate to observe a fossil projected on the screen surrounded by other exhibits and answer quizzes. We expect children to efficiently gain knowledge of fossils through this system. The study was performed at the Museum of Nature and Human Activities, Hyogo, Japan.

Keywords: Museum; Learning support system; Body movements; Collaboration; Multiple people

INTRODUCTION

The museum is an important place of learning for children to acquire scientific knowledge (Falk & Dierking, 2012). One of the most important reasons is that children can apply their own level of understanding without worrying about evaluation. In addition, they can tell whether their understanding is correct through experiences and conversation (Haneyman, 2007).

However, the primary learning method in the museum is through observation of exhibits and reading explanations, which constitutes passive learning, and there are no opportunities for experiences or conversation. Therefore, it is difficult for young children to learn enough and engage in the acquisition of knowledge. The difficulty of learning the most important radiolarians when learning paleontology, especially in museums, is considered a problem (O'Dogherty *et al*, 2009). These issues should be solved in order to improve the quality of science education in museums.

Various methods have been proposed to address these issues. The use of conventional learning materials such as radiolarian models made by 3D printers is available (Iwasaki, *et al*, 2009). However, since this only involves seeing the model, it cannot result in efficient acquisition of knowledge and will only have a slight impression on learners. Furthermore, since it is immersed in observation alone, it is contrary to the museum's intention of observing through conversation and experiences. In addition, group learning methods have been proposed. Group activities using mobile terminals are regarded as important in the field of computer supported cooperative work because they can strengthen interactions with museum exhibits and explanations (Luff & Heath,1998). For example, Papadimitriou *et al.* proposed providing two children with a personal digital assistant equipped with a radiofrequency identifier reader so that they can learn while searching exhibits and explanations (Papadimitriou *et al*, 2006). Grinter and colleagues proposed a voice guidance system so that children can acquire information in pairs (Grinter *et al*, 2002). However, although these studies allow information to be obtained cooperatively from exhibitions and explanations, actual observation with a microscope is performed by one person. Moreover, the proposed means of learning support do not address children's need for real experience. Consequently, the fundamental problem of cooperative observation of fossils has not been solved. Children should receive opportunities to cooperate and encounter near-real experiences.

Sociality, cooperation, and knowledge clearly cannot be obtained without actual experience gained from interaction with others to achieve some goal. In particular, play is a good opportunity for children to gain such experience. Studies have revealed that children develop a deep understanding when cooperating and playing (Dau & Jones, 1999). When children use body movements while cooperating, the learning environment becomes more natural (Grandhi, Joue & Mittelberg, 2011), and they can retain more of the knowledge being taught (Edge, Cheng, & Whitney, 2013).

Our system is based on these ideas. We developed a collaborative immersive learning support system that enables children to learn through body movements and conversation. For instance, it can help acquire fossil knowledge through active learning that moves the body and lets learners talk about fossils with multiple people. This system acquires motion information of multiple people at the same time through a sensor and operates the contents based on the information. It spreads over the entire field of view across multiple screens and expects to leave strong impressions on learners by immersing them in the virtual environment.

In this paper, we describe a prototype developed to evaluate the usefulness of the current system as a first step towards realizing cooperative immersive learning support. Evaluation experiments were carried out at the Museum of Nature and Human Activities in Hyogo, Japan. The content of the evaluation was a knowledge acquisition test. We tested twice in total before experiencing the system and after experiencing the system. We compared the test scores before and after that and evaluated whether learners were able to acquire knowledge through system experience.

Collaborative immersive learning support system

System overview

We describe the system we are developing. We are developing a collaborative immersive learning support system to allow multiple people to collaborate through conversation and body movements to learn more efficiently and with a stronger impression. Multiple fossils can be observed. This system supports the learning of radiolarians (O'Dogherty *et al*, 2009). Radiolarians are zooplanktons living in the sea that emerged in the Cambrian Paleozoic Era. Because they changed forms during that period, their geological age can be easily determined. Radiolarians are very important as learning materials because they are index fossils. As shown in Figure. 1, radiolarians in each era have common features (O'Dogherty *et al*, 2009). Jurassic radiolarians are round. Triassic radiolarians are sharp like drills. Permian radiolarians have a unique shape like a fish. However, when they are observed with a microscope in a museum, it is impossible for multiple people to collaborate efficiently despite the important material. Furthermore, there is no system that allows multiple people to observe with the microscope while simultaneously improving cooperativeness. Children do not notice the common features of radiolarians such as the Figure 1. For these reasons, we focused on supporting learning of radiolarians. Our proposed system allows observation by multiple people; children can cooperate to find the characteristics of each era of radiolarians, which supports efficient learning. Observation with multiple people realizes the following points: get new awareness from others' awareness, apply knowledge to different problems, and notify others of your own awareness.

The system uses various sensors to measure the positions, attitudes, and body movements of people. Learners operate the system based on this information. The screen displays the object of learning and changes in conjunction with the learners' body movements. This system gives learners a natural learning environment. In addition, real observations of cooperative behavior among multiple people are incorporated to provide learners a more realistic experience than just viewing exhibits or videos.

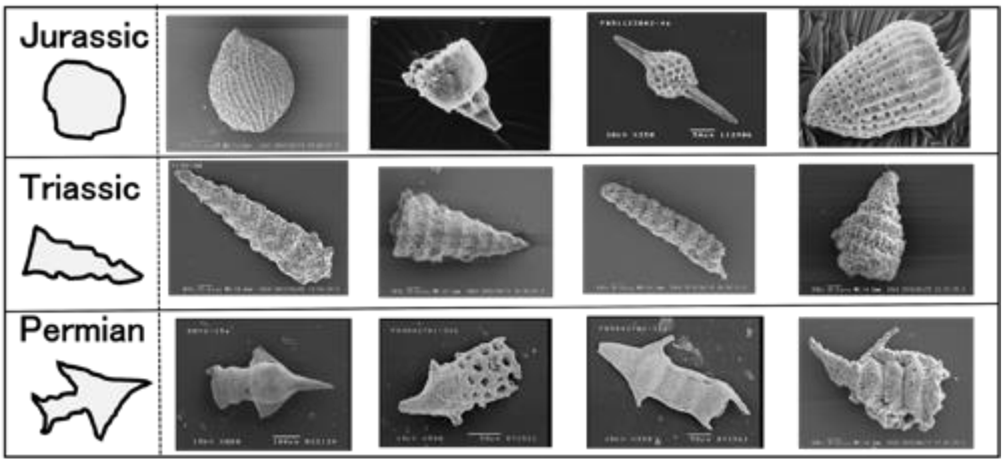

Figure 1: Radiolarian.

System overview

To realize a cooperative immersive learning support system, we are currently developing a system for learning about radiolarians where two people cooperate through conversation and body movements. In the proposed collaborative immersive learning support system, multiple people cooperate, observe and answer quizzes while using conversation and body movements.

This system consists of a Kinect sensor, control PC, projector projecting on the ground, and projector projecting forward. Microsoft's Kinect sensor is a range image sensor. We simultaneously acquire skeleton and depth information of multiple people using a Kinect sensor. Based on this information, body movements are recognized and the screens surrounding the learner change.

The system has been developed with the aim of acquiring knowledge about radiolarians by learners. The system consists of three parts: collaborative selection (Fossil selection), collaborative observation (Fossil observation), and collaborative consideration (Quiz game). The beginning of the system is about collaborative selection (Fossil selection). Two learners to observe Permian, Triassic, Jurassic radiolarians. In collaborative selection, two learners cooperate to observe radiolarians and look for common features, as shown in Figure 1. The learner on the right can select radiolarians to observe by pushing their hands toward the Kinect sensor. They can click on a radiolarian by pushing their palm toward the screen. The learner selects the radiolarians that they want to observe. On the screen, Permian, Triassic, Jurassic radiolarians are displayed.

The next is about collaborative observation (Fossil observation). The radiolarians can be zoomed in or out by the two learners approaching or moving away from the screen. As shown in Figure 2, when the two people move forward at the same time, the fossils of the radiolarians are zoomed in. When they move backward at the same time, they are zoomed out. In this manner, the two learners communicate and decide on the radiolarians that they want to observe, and the learner on the right takes action. As the two learners move forward and backward, they can observe the radiolarians together. Normally, radiolarians are observed with a microscope by a single person, but this approach allows two people to observe while communicating. Because two people are observing, we expect each to find different features. Because there is a time limit, cooperation in a limited amount of time is necessary. It is important during this time whether we can discover the characteristics of radiolarian era age.

The last is about collaborative consideration (Quiz game). In collaborative consideration, learners work on radiolarian quizzes based on the information gathered during collaborative observation. As shown in Figure 2, radiolarians of a certain era are displayed on the screen. Learners consider which era this radiolarian belongs to. Based on the characteristics found by each learner during collaborative observation, they share opinions and think about which era the radiolarians belong to. Based on the characteristics of radiolarians discovered by collaborative observation, it is important to be able to answer quizzes.

When answering quizzes, they choose the answer in the standing position. The quiz answer screen is displayed at their feet, and since the standing position blinks (see Figure 2), the answer can be selected while moving the whole body. If the two learners do not stand on the same correct answer, they cannot complete the quiz. Therefore, the two learners must share their opinions to answer quizzes.

In this way, we expect the two learners to acquire knowledge of radiolarians efficiently while exchanging opinions and moving their body with two learners. We aim to acquire knowledge about radiolarians efficiently.

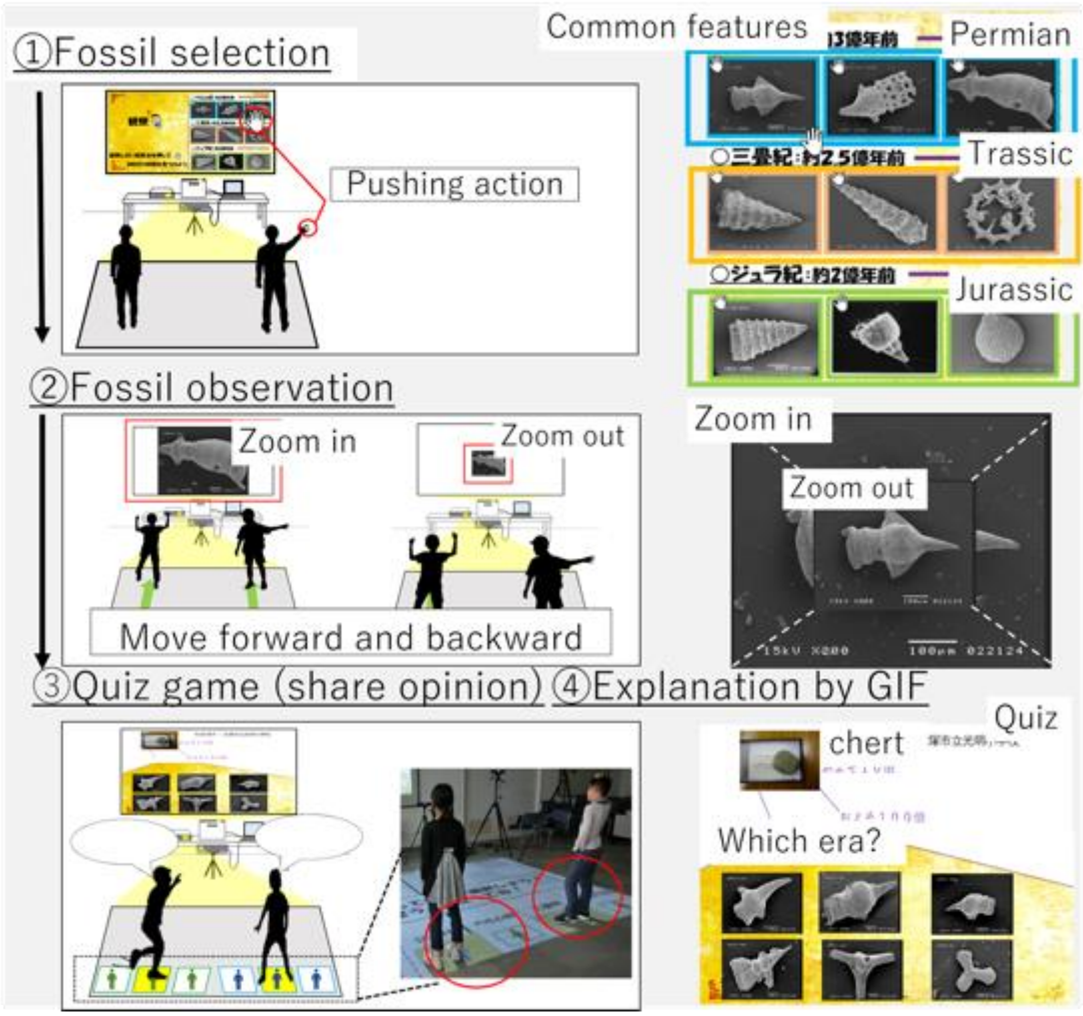

Figure 2: System flow.

Evaluation

Evaluation Method

We evaluated whether learners were able to acquire knowledge about radiolarians through experiences of the proposed system. The details of the experiment are described below.
Participants: 19 students of Kobe University elementary school; 13 5th graders and 6 6th graders (10-12-years-old, 11 boys and 8 girls)

Place of implementation: Museum of Nature and Human Activities, Hyogo, Japan
Procedure: Figure 3 shows the experimental procedure. We tested students to evaluate their knowledge before and after using the system. The test included 6 questions, each question involves selecting geological age from radiolarian photos. The test was conducted twice: once after the workshop and once after using the system. Figure 4 shows the contents of the test.

Figure 3: Experiment procedure.

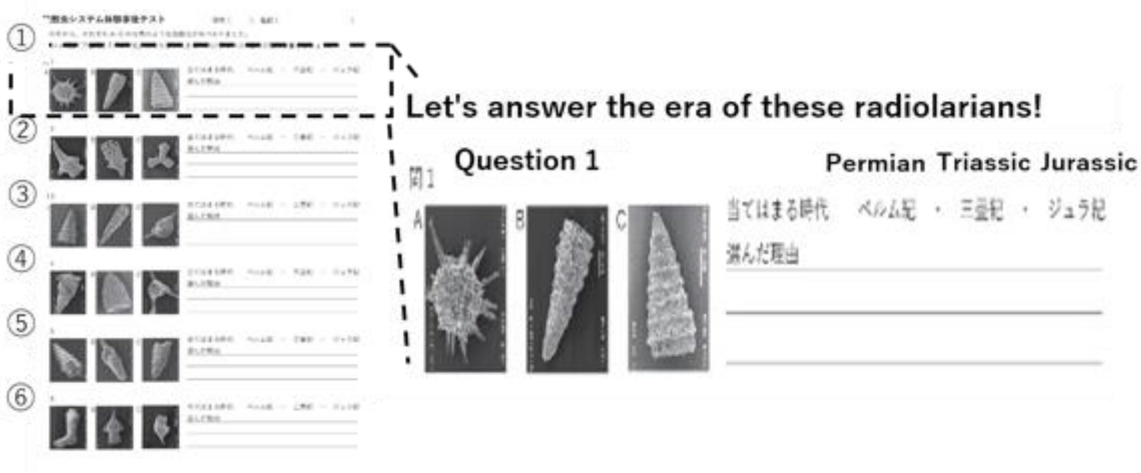

Figure 4: Test contents.

Evaluation Result

Table 1 indicates the points before the system experience and the points after the system experience. It is about all subjects. Thirteen subjects increased in points, four subjects did not change their points, and only two subjects decreased in points. Among them, it was possible to raise five points as in subject 11.

Next, we evaluate the results of all subjects. Prior to experiencing the system, the average number of correct answers was 2.2, and after using it, the average number of correct answers was 3.9. A significant difference (p <.01) was found between the scores before and after using the system, using Wilcoxon's sign rank sum test. Results showed that participants obtained some knowledge concerning the characteristics of radiolarians, which varies depending on the geological age, through using the system.

Table 1: Results of all subjects.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
B	4	3	3	2	3	2	4	1	1	1	1	2	4	1	3	1	1	1	3
A	6	5	4	4	3	4	5	0	3	0	6	6	4	5	3	5	1	5	6
C	+2	+2	+1	+2	0	+2	+1	-1	+2	-1	+5	+4	0	+4	0	+4	0	+4	+3

B:Before system experience, A:After system experience, C: Change in points

CONCLUSIONS

In this study, we described the result of developing and evaluating a prototype of a collaborative immersive learning support system that helps learners acquire knowledge of fossils while observing and talking about them with multiple people. We tested students to evaluate their knowledge before and after using the system. Results showed that participants obtained some knowledge concerning the characteristics of radiolarians, which varies depending on the geological age, through using the system.

Therefore, the proposed system can support the acquisition of knowledge of radiolarians.
In the future, we aim to further acquire knowledge about fossils through fossil observation using the system. For that purpose, we will develop a system that can learn with more people and conduct demonstration experiments at museums.
Experiments at that museum are already planned.

ACKNOWLEDGEMENTS

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XVIII IOSTE SYMPOSIUM

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The exhibition "Out of Water Diving": influences on students' conceptions about marine environment and about the relationship of this ecosystem with their daily lives

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Abstract

This work aimed to investigate the initial conceptions and check whether and how the exhibition "Out of Water Diving" (OWD) influenced conceptions about marine environment (ME) and the relationship of this ecosystem with students' daily lives. A structured questionnaire was used, which was applied before and after OWD and answers were analyzed by open categorization. 185 students from São Paulo (Brazil) answered the initial questionnaire and 155 answered the final one. The number of students who could establish the relationship with ME and their daily lives was low, but with slightly increasing after OWD (from 14% to 23%). Concerning the organism that students expected to find on ME, the chordates were the most cited (fishes, sharks and whales). However, the citations of some no chordate animals (starfish and jellyfish) and seaweeds were higher after OWD. Students reported that they had more interest about ME after OWD. It is not easy for students to establish relationships between their daily lives and the ME. However, our data indicate that the OWD had positive influences, as it aroused more interest about this environment and more students stated that they were able to establish relationship between their daily lives and ME.

Keywords: Coastal environments; Environmental Perception; Marine environments, Model of Ecological Values; The Coastal Questionaire (CEQ)

INTRODUCTION

Coastal and marine environments have a great ecological relevance, as well as it represents a significant source of natural resources to human consumption (Babier, 2017). However, these important ecosystems have been suffering a lot with pollution and overexploitation. Many of the largest cities in the world, where population growth rates are high, are located near the coast. Gray (1997) highlighted that these huge populations increase the pressures on utilization of resources in coastal areas and, in addition, lead to habitat degradation, fragmentation and destruction. Coastal and marine environments are sometimes overlooked based on an apparent distance between them and people's daily lives. Therefore, it is evident the need for Environmental Education programs to focus on this environment (Towata and Ursi 2017). However, recently, a review article highlighted that there are few numbers of this kind of programs in Brazil, despite the country's extensive coastline (Pedrini, Ursi, Berchez, Correia, Sovierzoski and Mochel, 2014). A critical step to develop Environmental Education programs, including the ones focused on marine ecosystems, is to understand the perception and the connectedness that people establish with these environments (Towata and Ursi 2017). Environmental Perception is a complex concept; however, we accept that it is the relation that people establish with the environment in which they are inserted, which occurs through perceptual and cognitive mechanisms (Whyte, 1977).

The interactive exhibition Out of Water Diving (OWD) is inserted in this context of Environmental Education activities focused on improving the perception about marine ecosystems. It is part of the Underwater Trial Project, from Institute of Bioscience, University of São Paulo (Brazil). The project is based on a holistic concept of Environmental Education, aiming at the development of the individual in terms of behavior, ethics and environmental values, instead of only transmitting ecological and biological concepts (Berchez, Carvalhal and Robim, 2005). This work aimed to investigate the initial conceptions and check whether and how the OWD influenced these conceptions of students about marine environment and about the relationship of this ecosystem with students' daily lives.

METHODOLOGY

The interactive exhibition Out of Water Diving (OWD) was composed by 13 posters and 7 play activities about diving, marine and coastal environments and their biodiversity, as described by Ursi, Pirani-Guilardi, Amancio, Ribeiro, Towata and Berchez (2010) (Figure 1). At the beginning of the OWD, participants received a guide sheet with questions to help them explore the materials. At the end, the participants could do the self-correction, since the correct answers were presented in the last poster. The themes of the posters were scuba diving, diving procedures, diving history, Physics in diving, Geology, tide, seaweeds diversity, seaweeds in your daily life, plankton, sea animals, environmental balance, environmental impacts and guide sheet responses.

The play activities were:

- model with diving equipment, in which participants can try to breathe with mouthpiece;
- game about decomposition time in the marine environment;
- herbarium of seaweeds that can be touch by the participants;
- "Touch-Touch" activity, which is composed by boxes with a hole where the participant put the hand and try to identify the object by touch;
- correlation game between types of diving techniques used over time and historical events (of the world and of Brazil);
- microscope with sample of marine plankton;
- projection on the wall of the phrase "Marine Biodiversity - I am also responsible", in which participants can take pictures.

Figure 1. Examples of one poster (a), the guide sheet (b), and some playing activities (c, model of diver; d, Touch-Touch; and e, decomposition game) of OWD.

It was done a semi-experiment, as described by Lankshear and Knobel (2004), in which the educational intervention was the OWD. This exhibition was placed at a public school of São Paulo city (Brazil) and it was used a structured questionnaire to collect data. It was applied around three months before and one month after OWD. 185 students (13-15 years old) answered the initial questionnaire and 155 students answered the final one. It was used four questions of this questionnaire in the present work (Table 1). The responses collected before and after the OWD were quantified and compared. The explanations of question 2 were analyzed by open categorization, using Straus and Corbin (1990) methodology.

Table 1. Question related to students' conceptions about marine environment.

Question 1
When you think about the marine environment, the 3 first words or expression are: ( ) entertainment ( ) food ( ) religion ( ) fear ( ) cleaning ( ) work ( ) curiosity ( ) pollution ( ) boring ( ) beauty ( ) health ( ) disease ( ) other: ( ) other:
Question 2
Is there any relation between your quotidian and the marine environment? ( )Yes. ( )No. If you chose "Yes", explain your answer.
Question 3
Write 8 marine organisms.
Question 4
Your interest about marine environment is: ( ) very high. ( ) high. ( ) medium. ( ) low. ( ) very low.

RESULTS

When asked about words they could associate with marine environment, “curiosity” and “beauty” categories were the most cited by students on initial (59 and 51%) and on final (68 and 62%) questionnaires. Additionally, after OWD, the percentage of some categories changed. For instance, “cleaning” and “health” decreased (respectively from 29 to 21% and 22 to 15%) and “food” and “entertainment” increased (respectively from 14 to 18% and 33 to 43%) (Figure 2). The absolute percentage of students who could establish the relationship with marine environment and their daily lives (Question 2) was low, but with slightly increasing after OWD, from 14% to 23%. The main relations cited in the initial questionnaire were “food” (44%) and “go to the beach” (12%). After OWD, the most observed answers were related to the “use of substances derived from sea” (33%), followed by food (30%) and the “necessity of no polluted marine environments” (17%) (Figure 3). The use of substances derived from sea was not cited in the initial question, showing that this subject was unknown or forgotten by the student, and OWD exhibition significantly changed this situation.

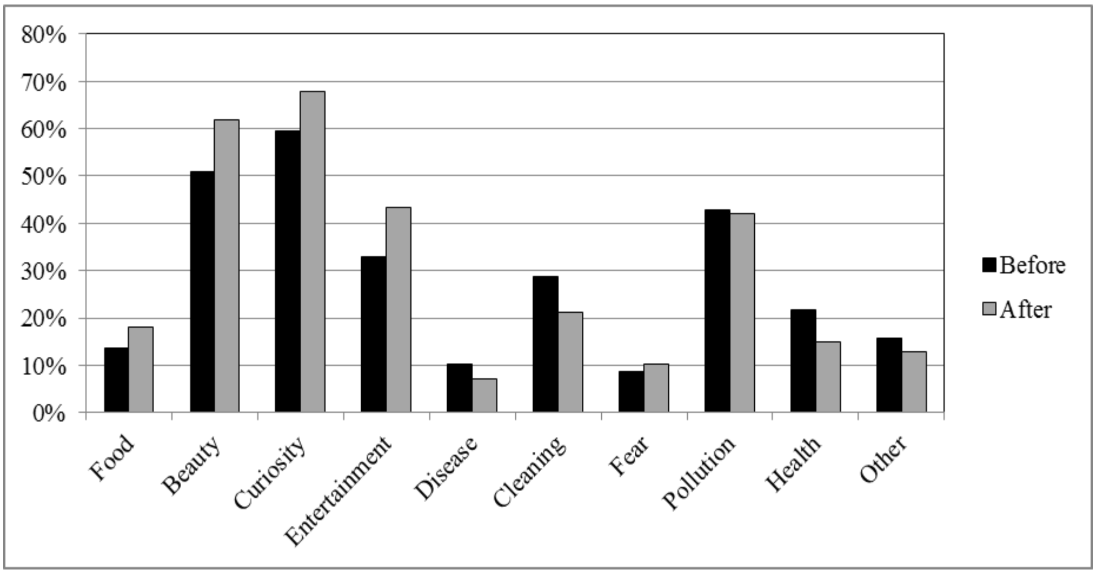

Figure 2. Occurrence (%) of words related to marine environment found on students answers before and after OWD.

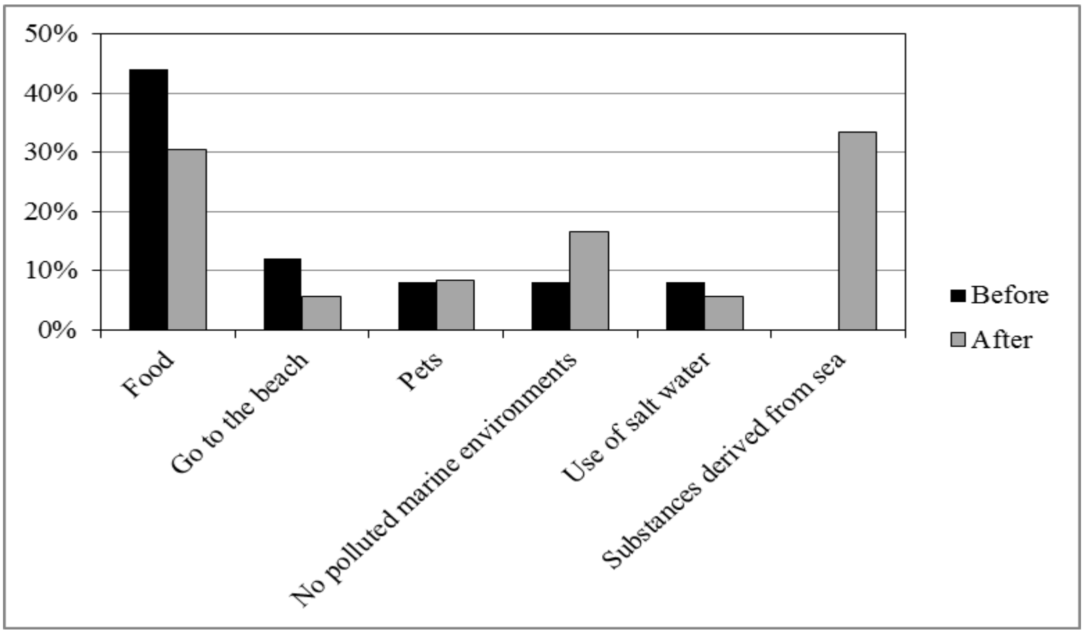

Figure 3. Occurrence (%) of categories found before and after OWD on the answer of students that can stablish relation between their quotidian and the marine environment.

When students were questioned about their interest about marine environment, we observed the following frequencies before OWD: very low or low - 26%, medium - 43%, high or very high - 31%. After OWD, the interest increased: very low or low - 11%, medium - 52%, high or very high - 37% (Table 2).

About the organism that students expected to find on marine environment, the chordates were the most cited organisms before and after OWD: fishes (81 and 77%), sharks (81 and 72%) and whales (72 and 67%). However, the citations of some no chordates animals, as starfish and jellyfish, and seaweeds were higher after OWD. The biggest increase was related to seaweeds, from 27 to 59%.

Table 2. Occurrence (%) of categories found before and after OWD on the answer of students related to the interest about marine environment.

Category	Before OWD	After OWD
very high	10	6
high	21	31
medium	43	52
low	20	10
very low	6	1

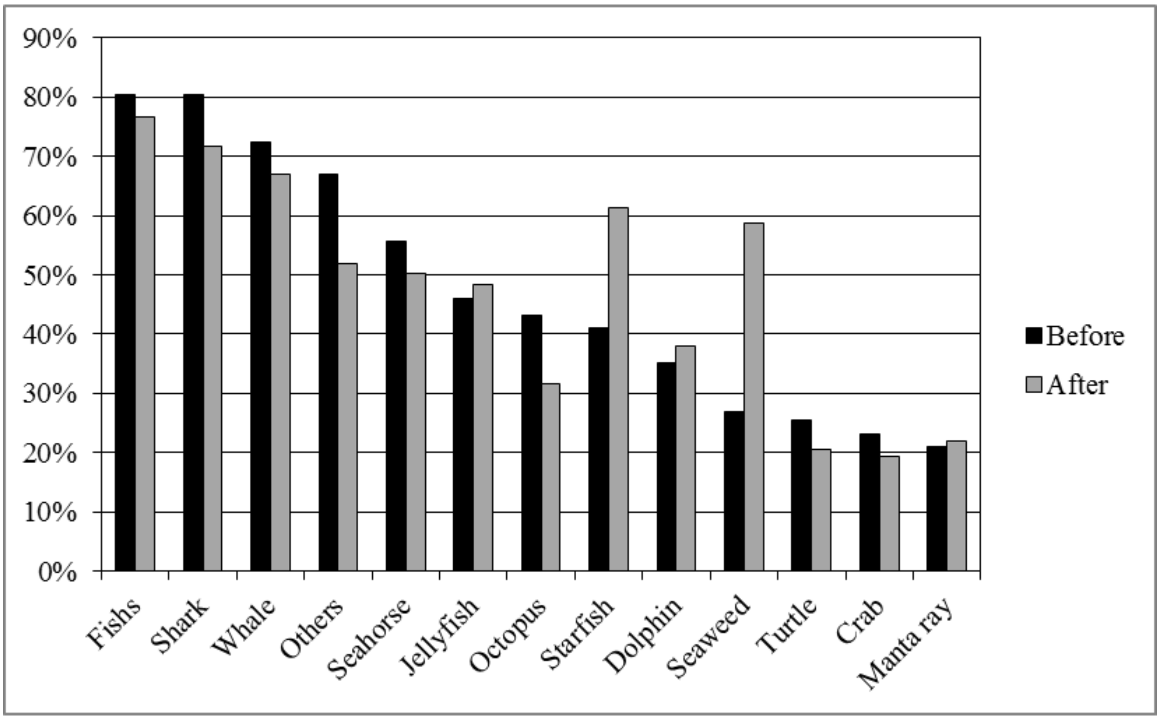

Figure 4. Occurrence (%) of categories found before and after OWD on the answer of write eight marine organisms.

DISCUSSION

The results highlighted that it is not easy for students to establish relationships between their daily lives and the marine environments, corroborating some other investigations conducted in Brazil (e.g. Katon, Towata, Berchez and Ursi, 2014; Katon, Towata, Berchez, Oliveira and Ursi, 2013; Savietto, Katon, Towata, Berchez and Ursi, 2014). Probably, the physical distance is an aggravating factor. This situation partially changed after OWD, when a greater percentage of students recognized a relationship between their daily lives and the marine environments. However, students show a vision more focused on what Amérigo, Aragonés, Frutos, Sevillano and Cortés (2007) define as the anthropocentric dimension of the environment. To these authors, the anthropocentric dimension is distinguished by the fact that man does not see himself as part of the environment, being a more selfish view of the man-environment relationship. Students also present a predominantly utilitarian conception, in which the environment is considered as the set of natural elements at the disposal of man (Flores and González-Gaudiano, 2008). Towata and Ursi (2017) discussed that stimulating students to do this correlation is a great challenge, because establishing connectedness seems to be even more difficult to marine environments than to land ecosystems. In this situation, the necessity of Environmental Education program to focus on coastal and marine ecosystems is significant. These programs can be a privileged context for bringing participants closer to the environment and conservation issues. The results of the present work agreed with this idea, because they indicated that the OWD had positive influences, as it aroused more interest in marine environment and more students stated that they were able to establish a relationship between their daily lives and the marine environments.

When thinking about the marine environment, students related to the marine environment with curiosity. After the OWD, this occurrence is even greater, which is a positive result, since such curiosity may promote actions to further increase knowledge about this environment. Children's natural curiosity has been seen as an intrinsic motivation for learning, which is very important in early childhood education (Sagoff, 1974). According to Pietrocola (2004), scientific activities become interesting and instigating when they are able to excite our curiosity. Science can be a source of pleasure if it can be conceived as creative activity. Imagination must be thought of as the main source of creativity. Curiosity is the engine to put our imagination in motion. Thus, curiosity, imagination and creativity should be considered as the basis of a teaching that can result in pleasure.

Other encouraging point was that students recognize a greater variety of organisms after the exhibition. The percentage of citations about seaweeds more than doubled after OWD, which is especially important when we think about the phenomenon called "plant blindness" when people are not able to recognize or value plants, as well as their importance in the daily life and their aesthetical and ecological value (Wandersee and Schussler 2001). This phenomenon can be related to physiological, evolutionary and cultural factors, including the small amount of attention given by the media to this subject (Wandersee and Schussler, 2001, 1999; Hershey, 2002, 1996; Balas and Momsen, 2014; Salatino and Buckeridge, 2016). We can expect that the "plant blindness" concept can also be applied to seaweeds, that are a no-monophyletic group, nevertheless traditionally related to plants. Then, OWD can be recognized as a tool to minimize this blindness when associated to marine environments.

CONCLUSIONS

An important step to promote the habitats conservation is to recognize and value their biodiversity, and we interpreted that OWD is a good example of activity that can stimulate students' interest and knowledge about these issues. Therefore, we hope that our data can be subsidy for the evaluation OWD exhibition by its creators in a continuous improvement process, as well as to inspire new educational programs that focus on marine environments.

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Environmental perception and relationship with marine and coastal environments: the perspective of basic education students from a Brazilian coastal city

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Abstract

The aim of this work was to investigate the environmental perception of marine and coastal ecosystems of students from a coastal city of Brazil. We used a questionnaire composed by "The Coastal Questionnaire" (CEQ, a Likert-type response instrument based on Wiseman and Bogner's Model of Ecological Values) and by an essay question (Is there any relationship between your daily life and the marine and coastal environments? If you answered "yes", explain this relationship.). The questionnaire was applied to 360 students from Ubatuba (Brazil). Most students were located in the Preservation+Utilization- category (81%), followed by Preservation+Utilization+ (16%). Only few students were located in Preservation-Utilization- (2%) and Preservation+Utilization+ (1%). About the relationship of marine and coastal environments with daily life, 51% of students answered "no", 46% answered "yes" and 3% did not respond. The main explanations were related with living in coastal environments (31%), recreation (27%) and affection (22%). It is believed that the results were positive, specially related to Preservation component. However, they highlighted that Environmental Educational programs that focus on marine and coastal environments may have a special attention to promote relationship and to minimize consumerist and utilitarian student's views, which became evident on the explanations of the essay question.

Keywords: Coastal environments; Environmental Perception; Marine environments, Model of Ecological Values; The Coastal Questionnaire (CEQ)

INTRODUCTION

Different people may have completely different perceptions to the same environment. Therefore, Ursi, Towata and Saito (2015) highlighted the relevance of studies that focus on environmental perception (EP). It is important to know EP to plan actions aiming to increase population knowledge about the ecological, economic and social importance of distinct environments. In this way, White (1977) recognized EP as a fundamental step for development and improvement of Environmental Education programs.

Although there is not a consensus about EP concept, due to its complexity (Ursi and Towata, 2018), it can be considered as the relations between the individual and the environment which occur through perceptual and cognitive mechanisms (Bell, Greene, Fisher and Baum, 2001). Environmental values and attitudes are also an important part of EP. Some of the most emblematic approaches in EP researches aim to understand how individual are distributed on a continuum biocentric-anthropocentric view.

The Wiseman and Bogner's Model of ecological values can be considered an evolution of this approach, which has a two-dimensional nature (Figure 1). Preservation (P) and utilization (U) are two important but not necessarily related components of EP. Preservation is a biocentric dimension and utilization is an anthropocentric dimension. The model allows for individuals to be placed in one of four Cartesian quadrants:

• P+U- position might be expected from a strong environmentalist, someone with deep concern about conservation;

• P-U+ position might be expected from someone with apathy toward conservation issues and a view of nature as a source of natural resources to be used for the benefit of human development;

• P+U+ position might be expected from someone with a strong desire to protect the environment, but at the same time believe that the primary purpose of nature is to benefit humans;

• P-U- position might be expected from someone with a lack of interest in the environmental issues.

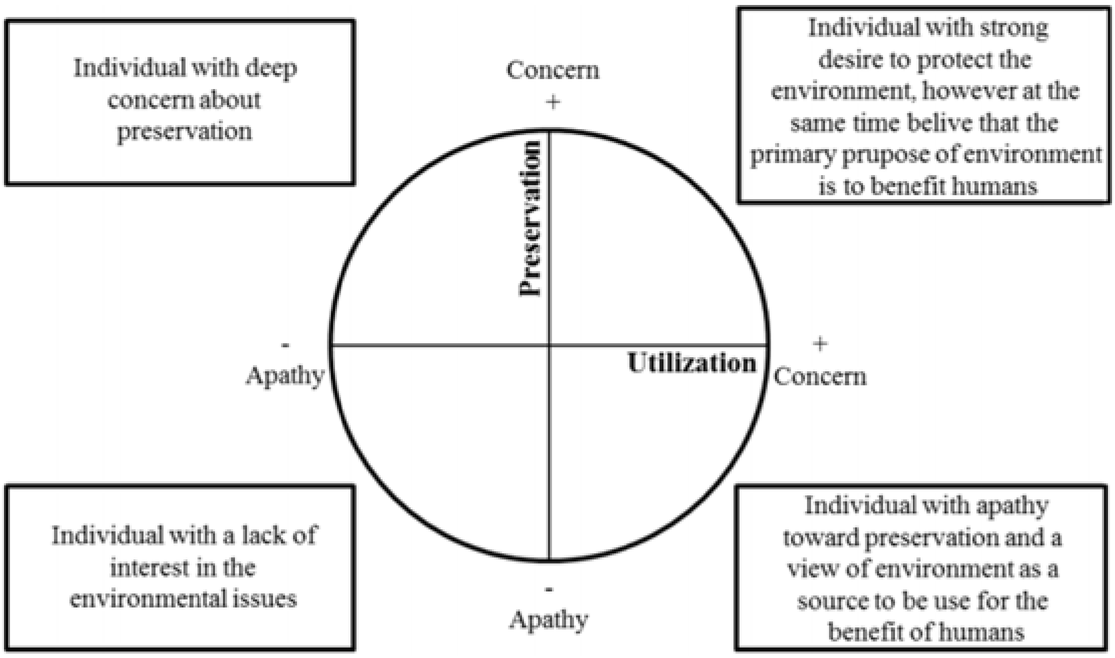

Figure 1. Representation of a two-dimensional model of Environmental Perception. Ursi and Towta (2018), adapted from Wiseman and Bogner (2003).

Bogner and Wiseman (1999) developed a measurement instrument that consists of a list of items with Likert-type responses, grouped into 2 secondary factors: Preservation (composed by 3 primary factors - intent of support, care with resources, and enjoyment of nature) and utilization (composed by 2 primary factors - altering nature, human dominance). Johnson and Manoli (2008) simplified the instrument and developed TEQ - "The Environment Questionnaire".

More recently, Ursi and Towata (2018) adapted the items of TEQ to investigate specifically the EP about marine and coastal ecosystems, developing CEQ - "Coastal Environment Questionnaire". The author emphasized that any research instrument based on the Model of Ecological Values focused especially on these important ecosystems could not be found previously on literature.

Coastal ecosystems need to be seriously approached on environmental discussion, since they are at the complex and dynamic interface between the land and the sea, and are occupied by dense human populations, many of them living in rapidly growing megacities (Michael, Post, Wilson and Werner, 2017). Coastal and marine environments have been suffering several damages due to this population growth, pollution and other human activities (e.g. temperature change, increased acidity, decreased oxygen level, habitat destruction) (Babier, 2017; Fauville, 2017).

In this context, the present work investigated the EP about marine and coastal ecosystems of students from a coastal city of Brazil (Ubatuba), intending to subside future Environmental Educations programs on the region. The aims of the investigation were:

- to evaluate the position of students in relation to the categories in the Model of Ecological Values;
- to understand if and why students establish relationship with marine and coastal environments.

METHODOLOGY

A questionnaire, composed by: (1) essay question "Is there any relationship between your daily life and the marine and coastal environments? If you answered "yes", explain this relationship."; and (2) CEQ was used as research instrument. CEQ was developed by Ursi and Towata (2018) specifically to evaluate the perception about marine and coastal environments and was composed by 16 items with Likert-type response.

The instrument was applied to 360 students (12-17 years old) from 3 basic education schools from Ubatuba (São Paulo State, Brazil). The city is one of the most important tourism center in the Southeast coast of the country. The 3 schools are aimed at local population, and most of the students' families work in activities related with tourism or fishing. The students voluntarily participated in the research after signing a written consent form and receiving information about the research goals. The school principals also signed a consent form, agreeing with the research.

The explanations of the essay question were 330 analysed by open categorization, using Straus and Corbin (1990) methodology. CEQ responses were 330 analysed as described by (Johnson and Manoli (2008). Items of CEQ were statements with a five-point Likert-type response. Scoring involved assigning points, from one point for 'strongly disagree' to five points for 'strongly agree'. For each of primary and secondary factors means were calculated. For Preservation and its three primary factors, mean scores between 3 and 5 indicate a pro-environmental perception (P+) while mean scores between 1 and 3 indicate the opposite (P-). The opposite is true for Utilization and its two primary factors, mean scores between 1 and 3 indicate a pro-environmental perception (U-) while mean scores between 3 and 5 indicate the opposite (U+).

RESULTS

Most students were located at the Preservation+Utilization- category (81%), followed by Preservation+Utilization+ (16%). Only few students were located at Preservation-Utilization- (2%) and Preservation-Utilization+ (1%) (Figure 2).

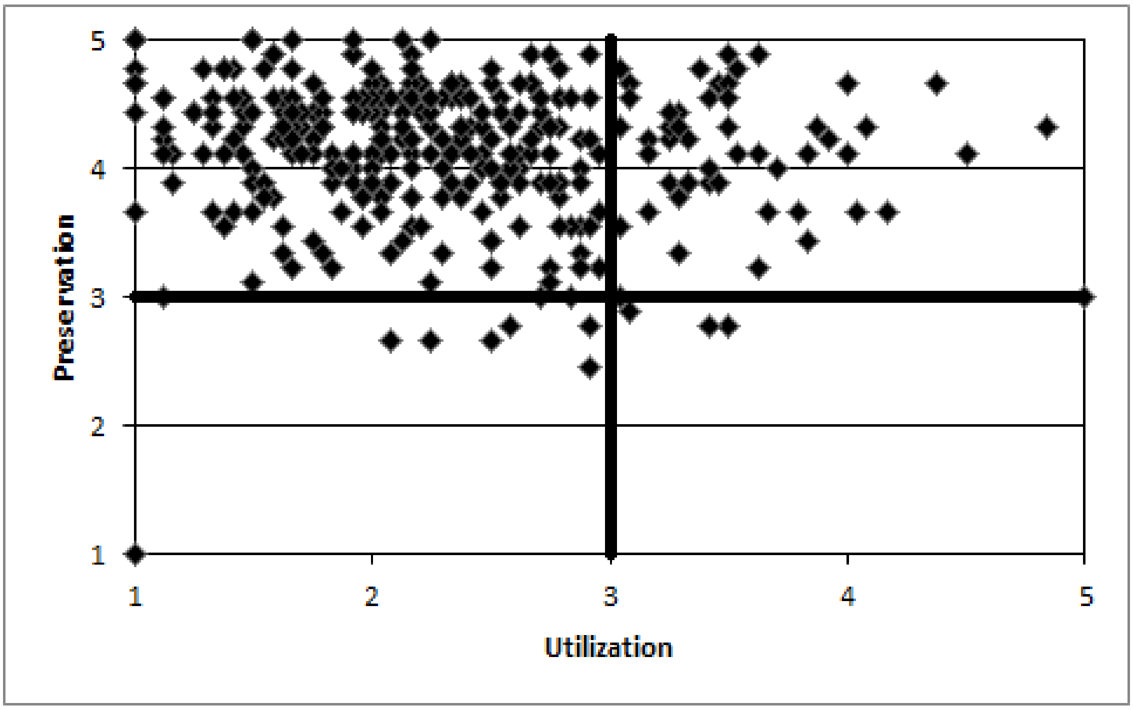

Figure 2. Model of Ecological Values quadrant scores for students from a coastal city (Ubatuba, Brazil).

About the relationship of marine and coastal environments with daily life, 51% of students answered "no", 46% answered "yes" and 3% did not respond.

The main explanations were related with living in coastal environments (31%), recreation (27%) and affection for these environments (22%). Global relationships, as garbage production influencing environment or the role of marine organisms in the production of oxygen, were observed only for 8% of the participants. The lowest percentages of occurrence were detected for the categories Nourishment (5%), Work (4%) and Responsibility (3%). A high percentage of the students (22%) did not explain their answer or give explanations that was not applied to the question (Table 1).

Table 1. Description and examples of categories found on explanations about the relationship of daily lives of students with the marine and coastal environments.

Category (% of occurrence)	Description	Example
Residency (31%)	Place/environment where student lives.	"Because we live on the coast and we get along with the marine environment."
Recreation (27%)	Visits to the beach, sports and recreational activities.	"I go to the beach a lot, I like to dive and see the environment."
Affection (22%)	Positive feelings about the place/environment.	"I really like the marine environment."
Global relation (8%)	Global relationships such as garbage production influencing marine and coastal environments or the role of marine organisms in the production of oxygen.	"Because everything that happens with the marine environment affects many things, the economy and our way of life." "Because marine algae are the main suppliers of oxygen."
Nourishment (5%)	Nourishment in general or some specific type of food.	"I eat a lot of fish."
Work (4%)	Work activities of the student of his/her family (eg. Fishing, tourism, trade).	"Because I work at the beach, selling açaí*." "Because it generates enough jobs for us who live here."
Responsibility (3%)	Feelings of care and responsibility towards the place/environment.	"When I can, I collect the garbage tha badly educated tourists leave on the beach."
Cannot explain (8%)	Student declares that do not know the explanation.	"I do not know."
Not applied (11%)	Answer has no connection with the question asked.	"We are human and they are animals."
No explanation (3%)	No replay.	

* Açaí is a typical Amazon fruit, that is very consumed as a cream in many parts of Brazil.

DISCUSSION

Previous investigations conducted in Brazil reported that students from coastal city establish more relationship with marine and coastal environments than students that live far from the sea (eg. Towata and Ursi, 2017). Nevertheless, the percentage is lower than expected (around

50%), as observed in the present research. Savietto, Katon, Towata, Berchez and Ursi (2014) also reported a percentage around 50% of students from coastal city that can establish relationship with marine and coastal environments. However, this percentage had a slightly increase after student's participation in the Environmental Education project called "Underwater Interpretative Trail", described by Berchez, Carvalhal and Robim (2005), that was focused on field activities, including snorkeling.

Towata, Katon, Berchez and Ursi (2013) also observed a positive influence of Environmental Education activities on the establishment of relationship with marine and coastal ecosystems. For students from São Paulo city, the percentage grew from 20 to 50% after the participation in the interactive exhibition called "Out of Water Trial". Before the activities, the relationship was based mostly on nourishment and pollution. After the activities, the explanations were still focused on nourishment, however also focused on some new categories, as the use of products derived from seaweeds on daily lives. These results highlighted the importance of project that focus on coastal ecosystems to help people developed proximity with these environments.

It is possible to notice that the main relationship that students can establish with coastal environments are usually related with utilitarian reasons, especially residency, nourishment and recreation, as also observed by Katon, Towata, Berchez and Ursi (2013) and Katon, Towata, Berchez, Oliveira and Ursi (2014). In this work, it was not detected a strong presence of nourishment, but affection was reported in a higher frequency (around 20%), which can be considered an encouraging result. Authors, such as Pooley, Psych and O'Connor (2000) or Hinds and Sparks (2008), had already emphasized the importance of affection in the process of Environmental Education and, as a consequence, in the promotion of environmental conservation.

Comparing the results of this research with the other article using CEQ for evaluated EP specifically about marine and coastal environments (Ursi and Towata, 2018), it can be observed that the categories found to EP of students were similar, since most students were located at the P+U- category, followed by P+U+. Data obtained by Johnson and Manoli (2008; 2011), when they investigated students' Environmental Perception in general (using TEQ, with situation more related to land ecosystems), was also similar with the data observed in the present research, being participants placed mostly in the two categories related to pro-environmental perceptions (P+U- and P+U+).

It is believed that the pro-preservation position of students, which was reported for both land and coastal environments, can be considered a positive result. However, it is important to deal with the pro-utilization position. By working with the concept of sustainable development, the Environmental Education programs could promote better models based on the wise use of resources, with concerns for equity and durability (Sauvé, 1996). Consequently, the pro-utilization position could be minimized by educating the citizen to be more conscious about the use of resources (Ursi and Towata, 2018).

CONCLUSIONS

Most students were located at pro-preservation categories of the Wiseman and Bogner's Model of Ecological Values, which can be considered as a positive result. However, the occurrence of 17% of students located at pro-utilization category highlighted the importance of programs that focus on marine and coastal environments, having a special attention to utilization of these ecosystems and trying to minimize consumerist and utilitarian student's views. It was also evidenced by the results related to the relationship with marine and coastal environments, in which it was possible to detect explanations mostly focused on residency and recreation. However, the affection by the environment was also well remembered, suggesting that developing Environment Education through emotion and sensibilization can be a promising approach.

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XVIII IOSTE SYMPOSIUM

Future educational challenges from a science and technology perspectives.

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Factors influencing the uptake of renewable energy technologies in Nigeria: Implications for science and technology education policy and practice

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Abstract

Despite her abundant renewable energy resources, Nigeria is still heavily reliant upon fossil fuels to meet the nation's demand for electricity. Contrary to the national renewable energy targets proposed by the government, implementation consisted only of pilot projects and there is lack of widespread acceptance. This paper is part of a study that explores the attitude and the behavioural intentions of the Nigerian public to Renewable Energy Technologies (RETs) in relation to sustainable energy behaviour in order to generate policy implications. A mixed method approach consisting of a survey and focus group interviews was employed. This paper identified lack of information, cost, concern for health and environment, corruption and security as hindrances to the uptake of RETs in the country. Relevant energy education of the citizens was recommended.

Keywords: Attitude; Climate Change; Renewable Energy Technologies (RETs); Sustainable Development; Science and Technology Education.

INTRODUCTION

Acceptance plays an important role in the successful adoption of Renewable Energy Technologies (RETs). Air pollution, human-induced climate change, energy supply insecurity, and cost increases are some of the problems associated with fossil fuel that have given rise to the implementation of renewable energy technology across the world. There is a global trend of decarbonisation and several governments worldwide are trying to integrate large-scale renewable energy into their energy – mix. However, lack of public acceptance had greatly impact the deployment of renewable energy projects in many countries.

Studies have shown that while there is a general acceptance of RETs, there are local oppositions to the implementation of specific technology (Kaldellis, 2005; Rogers, Simmons, Convery, & Weatherall, 2008; Walker, 1995). It has been observed that the survey method of research cannot gain an in-depth analysis of attitude as functions of sustainable behaviour relating to public understanding and acceptance of RET (Devine-Wright, 2005; Ek, 2005; Wolsink, 2006, 2007a). General public surveys that lack clear conceptual framework on attitude formation are insufficient in studying the nature of public attitude to renewable energy (Van der Horst, 2007; West, Bailey, & Winter, 2010; Wolsink, 2007b). Instead of general survey studies, there is a call for studies that explore the life experiences of the public.

Using a mixed method approach, this study explores the attitudes of the Nigerian populace towards RETs in order to establish what informs these attitudes and to determine the level of acceptance of RETs in the country. This paper elicits the non-technical barriers to the acceptance of RETs among the populace. The findings are used to derive implications for Science and Technology policy and education in the country.

This work is part of a larger study. Some aspects of the work has been presented in conferences and have also been published in a journal (Wojuola & Alant, 2017a).

METHODOLOGY

The explorative nature of this study necessitated the use of methods that can document the lived experience of the participants and can at the same time be generalised to the entire population. To achieve this, convergent parallel mixed methods research approach was used. Initially, a pilot study was carried out in Ibadan with 30 participants who did not form part of the study. Mixed method research approach was used to collect data from Ibadan, Asi and Akobo in Oyo State of Nigeria. Studies have shown that Oyo state has great potentials for generating energy through renewable sources. Solar radiation in the state was estimated to about 1822 kilowatt hour per meter square per year (Ohunakin, Adaramola, Oyewola, & Fagbenle, 2014) and the annual mean wind power density lies between 67.28 W/m^2 and 106.60 W/m (Adaramola & Oyewola, 2011). The state also housed a renewable energy project named "Cows to Kilowatts Nigeria" (Olugasa, Odesola, & Oyewola, 2014; Wojuola & Alant, 2017b).

Data collection for the quantitative part was by means of a survey method using a self-administered questionnaire. The target population comprised different categories of Nigerian public and the age range was between 20 -59 years. The questionnaire was divided into two sections; the first section refers to demographic data of the respondents. This included age group, gender, highest level of education achieved, occupation, and location. This was followed by the second section where the closed-ended questions were asked. This section examined the knowledge, perceptions and attitude of the participants about renewable energy technologies. About 421 responses were obtained from the 600 questionnaires sent out for the survey.

Four focus group discussions were used to supplement the information obtained from the survey. Two of the focus groups held in Ibadan; one in Bodija a commercial area of Ibadan and the other at Mokola an industrial area. The remaining two focus groups held at Akobo and Asi respectively. At the beginning of each focus group, the objectives of the study were clarified for the respondents. It was also made clear to the participants that participation and cooperation were voluntary. When cooperation was confirmed, consent letters were signed by the participants. Each focus group interview lasted for about one hour and a total of 23 participants consisting of different categories of the public participated.

RESULTS

Of the 423 responses that were received in the survey, two were rejected due to incompleteness. As a result, 421 responses were used for further analysis. The data revealed that 52% of the participants were male and 48% were female. The age group of the participants ranged from 20–60 years. They were grouped into four age groups as shown in Table I below.

Table I: Age groups of survey participants

Age Group	Frequency	Percentage
20- 29	192	45.6
30 - 39	114	27.1
40 - 49	81	19.2
50 - 59	34	8.1
Total	421	100.0

Educationally, the most frequent qualification was graduate/HND (46.5%), followed by postgraduate (20.1%), secondary (14.3%), OND (8.3%), undergraduate (4.8%), NCE (4.4%), and primary (1.0%) education. Three people did not indicate their level of education. In terms of occupation, teaching maintained the highest percentage at 31.9%, followed by students at 24.0%, civil servants at 12.4%, youth corpers at 8.3%, company workers at 6.5%, trading/marketing at 5.7%, farming/agriculture at 5.0%, crafts and trades at 2.9%, and others at 2.3%. For the focus group interviews, 60.9% of the participants were male and 39.1% were female. Educationally, 13.04% of the participants had post graduate qualifications, 30.4% had bachelor degree, 21.7% were HND certificate holders, 8.6% were undergraduates 13.4% had O'level qualifications and 4.3% had only primary school education (Wojuola & Alant, 2017a). The participants were made up of different professions.

The participants were asked if there should be increase of RET implementations in Nigeria. In the survey, the majority of the participants were in agreement with increasing the use of RET in Nigeria. There was 85.6% agreement, 2.9% disagreement, 8.6 were unsure, and 3.1% were unconcerned. However, despite the fact that the majority of the participants were in support of the expansion, many of them also indicated that they are not willing to install RETs in their homes. The reasons for their unwillingness are summarised below:

- Too expensive – 28.7%
- Not reliable – 13.5%
- Unattractive – 3.9%
- Fear that it might not work – 9.6%
- Need more information – 29.8%
- Not Sure – 14.6%

It is good to note that the many of the participants expressed their need for more information about RETs.

In the focus groups, only five out of the twenty-three participants agreed that the use of renewable should be expanded in the country while the remaining participants expressed their fear that doing so would fail for various reasons. Those who were in favour of an expansion of renewables in Nigeria explained that using RETs would improve the state of energy in the country**.** Participant 12 stated:

> *"For me, we must increase our natural resources of energy that we have, things will improve and not depend solely on electricity to get energy. When we explore the sources like sunlight, wind, there will be improvement"(Participant 12)*

Participant 2 also explained that:

> *"That one will be better (RET). You will prefer to go for what you want like the issue of communication now…. It will not be NEPA alone o. Maybe solar, NEPA or more and you will decide which one you want to use. If this one is not good, I may abandon them and go for another one."(Participant 2).*

However, many of the participants argued that expanding the use of RETs should not be done (at the time of the study) for various reasons. The reasons given are as follows:

Lack of information

The participants were of the opinion that there is a need for them to have more information about RETs before the implementations can be effective. Participant 7 exclaimed that the level of education that the populace has about RETs is not sufficient:

> *"I want to ask a question? Did they educate people about this Renewable Energy? And they understand it, if people were educated and they know about it, I think we in the community can do it. If people are interested in it, they won't even bother about NEPA again" (Participant 7.*

From the viewpoint of the participant, there was no education on RET. These observations underscore the role of education in the integration of renewable energy in the nation's energy-mix.

Cost /Economic concerns

Some participants rejected the suggestion of expanding RET in the country due to the high cost of installation. Participant 14 of the focus groups expressed his concerns about the high cost of installing renewable:

> *"Like the solar thing, individual cannot afford it but the government can afford it" (Participant 14).*

This was corroborated by participant 1:

> *"For individuals to take up the project will not be cost effective." (Participant 1).*

Health/ Environmental concerns

There was concern regarding the health implications of using RETs. The participants were of the opinion that since they did not know whether RETs would affect health negatively, there was need for caution in their usage.

> *"One also has to look at health issue. For instance, if we are going to use waste or whatever, is it safe or cancerous at the end of the day? Because if you are using too much of something, how does*

it affect ones health? I guess in countries where RE is used, they don't expose these things or use it anyhow. They have to control how it is used."(Participant 23).

"If we start using RE it will affect our social, economic, and physical environment" (Participant 2).

These also pointed to the need for more information about RETs to be disseminated to the public.

Corruption
Corruption was another issue raised. Some of the participants argued that the implementation of renewable energy projects should not be left in the hands of government officials alone. Due to corruption, there may be no implementation, and the money assigned to the project would disappear. This is corroborated by the excerpt below:

"We must also have people in place that will make sure that the money is spent for the purpose. If not, you will just find out that the money is spent and there is no project."(Participant 22)

Another participant said:

"….we have economy in Nigeria, many things that we can use to solve the problem but where are they putting the money into? We don't understand and we lack so many things."(Participant 7)

Security
There was an expression of concern that RETs are prone to theft of equipment since they are normally placed outside.

P2:*"My own fear is um… the fear of people coming in because most of it are normally outside or on the roof. People may take it away…. Yes, maybe in a good way it can be done that it cannot be easily stolen."*

This concern is significant to the acceptance of RET by the public who may not want to invest so much in installing the technologies only to be stolen away after a few days.

DISCUSSION
Generally, the majority of the participants agreed on the expansion of RETs in Nigeria. This is in line with the literature in that survey studies have shown that people have a general positive attitude towards Renewable Energy (Ek, 2005; Liarakou, Gavrilakis, & Flouri, 2009; Wolsink, 2007b; Wüstenhagen, Wolsink, & Bürer, 2007). However, in the focus group interviews, only 30.4% of the population consented to the expansion of RET in the country. Many studies on the public's acceptance of RETs were based on general surveys, which are devoid of a theoretical framework. It has been argued that this is inadequate to depict the true picture of the public's attitude towards RETs (Devine-Wright, 2007). A mixed methods approach, which employed the concurrent use of focus group interviews in the first phase and a survey study in the second phase, was used in the study. Through this, the study has been able to provide some useful insight into the nature of the public's understanding of RET beyond what is achievable using only one method.

Based on the submission of the participants, there is a general concern about the cost of RETs. Financial constraints prevent the uptake of RET, as reported by the participants. According to Robertson and Gatignon (1986), technology that is complex is often very expensive, these characteristics make its adoption rate very slow. Anger (2010) indicates that 50% of Nigerians live below the poverty line and that most Nigerians do not have access to primary health care, water and food. He also argues further that the millennium development goals for poverty eradication and sustainable living will be unrealisable in the country unless some factors are considered. With this background, it is not surprising that cost was a concern to the participants in this study. Relevant energy education will make the populace willing to install RETs regardless of the cost.

Also, the participants expressed their concern over the effect that the implementation of RETs may have on health and the environment. This fear could be born out of a lack of detailed knowledge about RETs. Although the effects of implementation have been a major concern of the public, as detailed in the literature (Devine-Wright, 2007; Liu, Wang, & Mol, 2013; Omer, 2008; Upham, 2009), it has been proven that adequate knowledge dispels such fears and that the public normally has a more positive attitude to technology when their knowledge about how technology works increases.

The fact that public education in RETs is an important factor that determines public acceptance has been established in this study. While there is a good science and technology policy in place in the country, the main challenge is in the implementation of this policy. Based on the findings of this study, there is a need for a review of the existing science and technology education policy. The content of energy education should be increased in order to help students attain desired proficiency levels that will ensure the acquisition of appropriate skills and development. There is also a need to incorporate sustainability into the curriculum such that students can be trained to live in and contribute to the development of society.

There should be a clear indication, in the form of instruction to teachers, of what the content of energy education should be. Government should recommend textbooks that are broad enough in content and are capable of covering every aspect of the curriculum. The textbooks should be such that they can facilitate effective teaching and learning.

Apart from schools, there is a need for relevant public education in form of public lectures, symposiums etc. Looking at the position of teachers as facilitators of learning, teachers' education should be focused on what they are going to teach in schools. The university curriculum for student science teachers must include energy education and sustainability. Also, there should be in-service training for teachers in order to update their knowledge. Assessment of energy education in the country should be carried out from time to time.

CONCLUSION

Nigeria has great potentials for renewable energy generation. However, there is a need for the government to put in place educational policies that will create more awareness and understanding of RETs in the country. Energy education should be introduced not only at universities, but in at all levels of education. Finally, relevant policies that address corruption and security issues in relation to RET implementations in the country should be put in place.

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Reflections on Teaching Sciences in a Historical-cultural Perspective

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Abstract

The work presented is the result of the discussions of the Course of Evolution of Scientific Thought I, of the Post-Graduate Program in Science, Technology and Education - CEFET / RJ. The discussions sought to reflect on why teach science, how to teach science and what science should be taught to students in Basic Education. In order to do so, it was sought, through references worked during the course and other authors, to draw a discussion in search of proposing a teaching of Science through the historical-cultural perspective. The reflections developed refer to the teacher's political role, his pedagogical practice as a reflexive practical act, with proposals that consider connections, as well as the manipulation and experimentation of nature. A teaching beyond the classroom and laboratories, which considers the cultural framework brought by students. And that seeks to work with more extensive projects, diversification of tools and proposals. The paper ends by highlighting the importance of drawing practical connections through social themes as a way to rethink the political and social reality in a conscious way, in favour of the criticism of the teacher and the student as a subject and social actor.

Keywords: Teaching Sciences; Historical-cultural perspective; Education; Teacher.

INTRODUCTION

The article reflects on ideas related to the Nature of Sciences based on a dialogue with the historical-cultural perspective. Before starting the discussion it is based on sciences such as the one conceived as a social construction, which implies looking not only at the historical context of its production, but also at the subjects involved in the process. For this, some authors who work in the Sciences and the Teaching of Sciences were brought within a context of complexity and where cultural issues are expensive.

In order to approach Science Teaching the work considers the reflections of Lemke (2006), with its central ideas of complexity, collaborative learning and being emotionally involved with what one learns, and Carter (2014) through his education studies in sciences, neoliberalism and activism / resistance. Weightings that allow us to see that the sciences are built collectively and that their validation depends on questions beyond their scientific achievements.

To draw this scenario in Brazil, it is necessary since Science Education depends on the subjects who do it and where these subjects legitimize themselves in their practices. That is to say, to work the Teaching of Sciences in a historical-cultural perspective allows to see that the Sciences are constructed of collective form and that its validation depends on questions in addition to their scientific achievements. Thus, the objective of the work is to carry out some reflections on why to teach science, how to teach science and what the sciences should be taught so that students of Basic Education use it for social issues that meet humanity and not the interests (Martins, 2015).

MAN, CULTURE AND SCIENCE

Considering man as a social being and as such, through language, establishes relationships with the other. In this way language can be understood as a social interaction in its most diverse matrices, such as verbal, sonorous, gestural and imaginary (Santaella, 2005). Regardless of type, support or materiality, the language is contingent, being the only way to access the other. White (2009) defends man as a unique animal, due to the fact that it symbolizes. This author proposes to bring the symbol as the basis of culture and positions man as a subject capable of creating, defining and assigning meanings to the external world and representing them by symbols, thus creating language.

> After the ability to symbolize became expression, the processes of creation and construction of the culture began. [...] Each culture contained articulated discourse, beliefs that could be (and were) expressed in discourse and customs, conventional attitudes, tools, utensils, ornaments and maybe clothes. (White, 2009, p.21)

The dialogue with the culture concept of Geertz (2012), which brings the idea of meaning webs, allows us to reflect on how the ideas produced by man make it possible to look at the Sciences as a producer of culture through a non-linear process, since the object of the Sciences is not empirical, but a composition. Thus, language is not restricted to communication alone. This alignment is a consequence of the mechanisms of meaning production among the subjects that produce and validate the Sciences.

Gadet and Hak (2010) point out that all science comes from the mutation that emerges from the ideological and conceptual field in relation to which it produces an openness through the activity that knowledge allows it and of the science itself. The authors clarify that science is, above all, the ideological science with which it breaks. Thus, the object of science is a constructed object and not an empirical object.

This process gives rise to multiple semiosis involving the creation of symbols, such as images, writings or sounds, and the interpretation of symbols by the subjects who access it. In this condition, the subject who creates the symbol, creates it according to an intentionality, which may be conscious or not. And the one who comes across him, acts as an interpretant creating chains of meaning and so the culture is being constituted and modified.

FOR A SCIENCE TEACHING VISUALIZING A SCIENCE LEARNING

Facing this scenario, the science teacher encounters multiple challenges, from the decision of the content to be taught that involves situations of reflection on the justification of this choice to questions related to methodologies and practices of teaching science. Concerns are recurring in approaching the conceptions of scientific knowledge present in the curricula of Basic Education with the skills and competences required when this subject positions himself socially. Thus, Kyle (1974, referred to in Schön, 2000, p.20) points out that "we know how to teach people to build ships, but not to know which ships to build." In this way, an education that values the cultural framework brought by the students, expands to become a site where the teacher finds opportunities to work the Sciences for social purposes, bringing to the classroom

issues of society and through collective discussion aiming at the public good to the detriment of the individual good. With this, Lemke (2006) presents new visions on the nature of learning, where he highlights principles that he considers more important to guide education, such as: extensive projects; exploration of spaces beyond the classroom and laboratories; diversification of learning tools, and the appreciation of the knowledge brought by students.
Lemke (2006) draws attention to learning that is built outside of school. With the diversification of the public, their communities and cultures the article discusses the possibilities of these collective factors as a fertile field that add value to collective learning. In this sense, it articulates reflections for an education beyond the technical one, that considers situations and leads to reflections from concrete strategies for the development of skills and competences.

In order to work the Sciences in this perspective, Lemke (2006) presents new visions on the nature of learning, where he emphasizes principles that he considers more important to guide education. The first is the work with extensive projects, which according to the author, allows specific activities to develop lasting learning by its practical nature. He then emphasizes the need to explore spaces beyond the classroom and laboratories, believing that in these various spaces where community activities are carried out, the student learns in a different way. Lemke (2006) also highlights the importance of the use of several media learning tools, such as books, videos, simulations, among others, so that the different languages present in these media can offer different learning spaces. As a fourth principle, the author highlights the importance of valuing the knowledge that students bring and evidences that students are in constant learning at school and especially outside it. At that moment it brings, the fertility gaze of diverse classes, where different genders, ages, cultures and social positions are factors that add value to collective learning. Finally, he argues that learning must go beyond knowledge about techniques, situations that lead to reflections from concrete strategies for the development of skills and competences are needed.

By looking at learning in science, the teacher encounters multiple challenges, from the decision of the content to be taught (Freire, 1987), which implies situations of reflection on the justification of this choice, to questions related to methodologies and practices of science teaching Schön, 2000).

Other pedagogical concerns of the school and faculty are: are sciences and culture parallel fields? Is there any intersection? Is every human production also a cultural / social production? Fourez's (2003) research shows that science teachers, students, parents of students, and citizens are affected by the crisis in science. Fourez (2003) points out that although there is a concern to improve teaching, it is still addressed in a traditional way, causing displeasure not only to students, but also to teachers. The research brings together some controversies about teaching, and concludes that in-service teachers should be encouraged to rethink and analyze the social issues of teaching their subject. Teixeira, Fernandes and Massena (2013) in their research on the main tendencies in works in the Teaching of Sciences observed that a great part of the work has indicated as solutions for the teaching the curricular reorganization. However, research on curriculum implementations has still been very discrete.

However, it is worth mentioning that the curricular subjects are related to external evaluation processes that indicate solutions to improve the quality of teaching (Coutinho, 2012). But quality is a polysemic issue, which is an obstacle to stable agreements on curriculum planning.

In the teaching of science, thinking about the historical-cultural perspective, we can advance from this problematization as the school community understands curriculum not as that set of contents that has been documented, pre-established of higher instances (Ministries and Secretaries). That school-centered curriculum as the only learning space. But it is possible to advance from the understanding of curriculum as a social construction, which is done in and by the school in communication and intertwined with other educational networks (Libaneo, 2006). Since knowledge is not something to be transmitted, consumed, but is being generated in partnership with other cultural subjects (Freire, 1987). Thus, Lemke (2001) highlights the political role of the teacher in his teaching. It shows the need for a look at culture as a social construction and shows how slow and procedural are the changes in subjects' conceptions.

> The practical reality is that we are dependent on one another for our survival, and all cultures reflect this fact by making the viability of beliefs contingent on their consequences for the community. This is no different in fact within the scientific research community than it is anywhere else. It is another falsification of science to pretend to students that anyone can or should live by extreme rationalist principles. It is often unrealistic even to pretend that classrooms themselves are closed communities which are free to change their collective minds. Students and teachers need to understand how science and science education are always a part of larger communities and their cultures, including the sense in which they take sides in social and cultural conflicts that extend far beyond the classroom (Lemke, 2001, p.6).

In the same line of thought, Schön (2000, p. 25) invites the teacher to look at his "reflexive practical teaching" in a bias of inter-subjectivity when it is necessary to work in front of what the other brings. This demands that the teacher develops sensitivity in the eyes and ears, as Carter (2014) argues through an education enlightened by the ethics of care, the author emphasizes that this care allows the teacher to work in order to bring the Sciences within a holistic perspective. Carter (2010, p. 2) does not neglect showing the teacher's need to accomplish his / her teaching profession in a different way from what he / she has done. It emphasizes the need for a science education that looks at future issues, even if distant, but that is contemplated from questions of the social and political order aiming that the subjects that are included in them remove fundamental aspects for their human development. What allows the teacher to act through connections of nature and not just dominate and manipulate (Carter, 2010). This proposal allows the teacher to act "in new ways of understanding, learning and teaching science oriented around connectedness rather than the mastery and manipulation of nature" (Carter, 2010, p. 6). Reflections that refer to a science teaching where it is possible for the student the opportunity to position themselves with their subjectivities and act in an active way in the learning process. In this way, the article proposes the teaching of science through social themes, where students can construct concepts from complex scenarios. A teaching beyond the reproductive tendency, which encourages criticality and participation as social subjects.

CONCLUSIONS

What makes man, historical human, is that he transcends nature and creates value. In this way, he approaches the real, pronounces himself and creates goals. Every technique developed by humankind is anchored in a human desire to change nature according to goals that demand of its will and that are affected by the historical and social context that it lives. For example, failing to walk on horseback caused him to gain speed and fatigue less, and thus a historical materiality was created for the purpose of taming the horse. Thus, man works to accomplish deeds that are reflections of the values he creates and so the culture is also created.

In this sense, the work highlights the importance of bringing discussions to Science classes in Basic Education, as a way to provide the intellectual construction of students through reflection on historical and technological achievements, taking into account that these constructions are based on interfaces of political, social and economic relations. And that power relations are present in the scenario creating spaces of colonization and decolonization in order to position subjects according to their place of speech.

Rather than redeeming contexts, enabling learners to experience from a historical-cultural perspective, is directing them to paths as subjects of the process. It leads them to reflection beyond technique, directing them to the development of skills and abilities that helps them to position themselves as social subjects. Teaching Science is transposing classroom space and transmitting information. For, to mean learning does not belong to a parallel universe, it is legitimation as a subject that goes through a path of doing beyond reasoning, an expression and experience of human activity. Once the teacher weighs the network of complexity of social practices that coexist in the beliefs of the social and natural world that connect in a community will contribute to meaning.

Through the multiple approaches of learning discussed in this text, one realizes how important and necessary it is to involve students in practical activities that are close to the reality in which they are inserted. In this way, they will have contact with an environment conducive to new meaning relationships, building different perspectives to deal with new knowledge and creating innovative actions of knowledge.

Therefore, how the teacher understands and builds his/her teaching directly influences the representations of his/her students' world. In this sense, Teaching Science in Basic Education in a historical-cultural perspective requires that the teacher rethink about the political and social reality critically, in order to define himself as an educator beyond the transmission of information.

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