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SCIENCE EDUCATION VS SOCIAL EXCLUSION: DEVELOPING INSTRUCTIONAL MATERIAL FOR THE INTEGRATION OF SOCIALLY EXCLUDED GROUPS IN SCIENCE CLASSROOMS

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Abstract
This paper focuses on making science easier to understand for all students. The traditional way of defining science teaching has in recent years proven to be limited. Hence the picture of the science classroom to date has been one where only those students with a natural talent to understand scientific issues are the most active ones within the whole science teaching process. At the same time those students who do not share this talent, not only are excluded because of the difficulty they face in understanding, but also they consider science obsolete as it does not touch upon their interests for their future. The science classroom is divided into two distinct groups that share no link of communication on the subject taught. And this most often extends to other subjects as well. This is mostly due to the fact that the conservative educational policy concerning science education refers to science as fact-based knowledge. In this context a fundamental feature of science is that it deals solely with scientific facts and excludes cultural, social, political or human values which would motivate all students to get involved. We aim to bring forth a different approach of science which is based on inter-communication among all students. We wish to point out the importance that lies behind scientific thinking which is that it facilitates all students to be able to take decisions on contemporary social, cultural, environmental and political issues as future citizens.

Keywords: *science education, social exclusion, scientific awareness, instructional material*

WHAT IS SOCIAL EXCLUSION?

What do the differences in the way children express themselves in the classroom signify? Frequently, the differences in behavior and self-expression are attributed to the social and cultural background which students come from. There are those who are more confident and self-assured and others who are shy, timid or indifferent. This picture illustrates the division that is always evident in the science classroom and leads to social exclusion of the latter group. How? According to Tsiakalos, social exclusion is the hindrance of enjoying the public and social wealth (2003). Within this context and drawing from Siatras' recent article that the public and social wealth in our days stems from having access to the technological and scientific progress, excluding students from the science classroom is exactly interpreted as social exclusion (Siatras 2011). In other words, if we do not make it our business as science educators to bring science to our students we shut a door for them for future advancement in society.

Another point that we'd like to clarify is the description of the diverse classroom in the essence that it is used in this paper. So far, because of the extensive movement of populations from one country to another, the word "diverse" illustrated a multicultural, multi-ethnical group of people. However, in this paper we adopt a broader view concerning diverse classroom because Greek schools are 'multicultural' environments even without the presence of the children of the minorities, refugees and immigrants if we consider the fact that it integrates children of surprisingly different cultural, linguistic and social background already formed by their families (Myers, 1992; Siatras, Petrantonaki and Sygiridou 2011).

In learning science it is often the case that those students who can afford it, opt for supplementary tutoring at home so as to achieve better performance in science classes. In the private, familiar setting they enjoy the exclusivity of a specialist, so in the classroom the division is definitely present. It is safe to say that the division in question does not derive from the teacher. However, the teacher may often foster such discrimination in the classroom setting, not because s/he favors the students who can afford private tutoring. Rather because these students make the lesson a more interesting process for the educator as well, and help to move the teaching process forward with their interventions. It is easier for teachers to decide that it is impossible to make some students understand the meanings and concepts of science. So, rather than change the entire teaching strategy and venture to approach those students in a different, more fun, more comprehensible way. The science teacher "accepts his fate" and does his best to be lenient on the weak students. But what is the cost of that decision? The latter group of students is almost automatically excluded from the chance of developing scientific thinking and that impedes not only the understanding of more challenging concepts that will be found later on in the textbooks, but worse! They are deprived of the chance to further their critical thinking and mature through the process of learning about matters that are a very important part of their daily life, such as questioning political decisions concerning for example recycling, air pollution and so forth. And missing out on social wealth has already been mentioned.

One wonders at which point it becomes so challenging to teach science comprehensibly. Well, one answer coming from the teachers themselves is that the textbooks are usually not much help. In the course of time textbooks transformed to complex educational material that can be combined with supplementary educational material such as the educational software programs (Kokkotas and Pilioura s 2007). Despite the fact that the scholars mean it as an advantage that the science textbooks have advanced this way over the time, there is quite enough room to question whether the teaching material has not become too complex for the young minds it addresses. Also, according to many scholars the textbooks remain incomplete as they do not include or even hind the importance of the history or philosophy of science (King, 1999; Martin and Osborne, 1996; Matthews, 1992, 1994, 2000). "Since knowing the history does not affect the way [the students] solve problems and answer questions from the textbook test bank, students may feel that they can learn science without spending time on the history of science" (Mahootian 2011). And that is not only the opinion of the students but of their teachers as well. Despite the fact that the historical facts of the renowned scientists' lives make an excellent tool to evoke students' interest in science, they are more often than not overlooked as unimportant story-telling or –reading that contributes but little in science teaching and is merely time-consuming.

The particular use of the textbook relies on the fact that it serves two purposes simultaneously. It materializes the goals of the curriculum in place and at the same time meets the needs and matches the abilities of all the students, assists the student in his individual learning (Kokkotas and Piliouras 2007). By nature the goals that the textbook should accomplish are overreaching. Not because the writers are not able, but because in the real world no two people will ever read the same book and acquire the same messages. However, there is often a misinterpretation of the use of the textbook and the misinterpretation lies in the notion that the biology or chemistry or any book is the core of the lessons. Notably, Kokkotas and Piliouras mention that 70% of the class activities are based on the textbook (2007). Textbooks are there to "assist" as Kokkotas and Piliouras claim, to give general guidelines that the teacher should move along, to set the rough limits of the material that is expected to be acquired by the student by the end of the school year. How this goal is to be materialized is an entirely different question. We are not of the opinion that science teachers should do away with the textbooks. But when textbooks are too constraining for a diverse classroom it is not necessary to teach religiously from them. In other words, science teachers can be creative and use instructional materials other than the textbook as long as the social goals of science teaching are kept at the heart of the lessons.

The second issue that is addressed in the question of social exclusion and its presence in the science classroom is the teaching process. We could claim quite safely that there are two major trends in the procedure of teaching science in the school curricula currently: one is the traditional point of view that has been in use in the last fifty or sixty years. The traditional method is mainly based on the textbook as the central tool of the science classroom and the explicit distinction of the theoretical part of science which should be linked – somehow – to the experimental. They are both expressions of science, but not the same. The connection between the two is not made explicitly. It is something abstract and elusive, missing from the textbooks and therefore unnecessary to be explained within the typical limits of the syllabus. In describing the science classroom, Tselfes claims that the teacher follows "those processes that he learned as a student, when with his unforgettable 'group-gang' of colleagues, he attended the school's labs (rather pleasant although mandatory courses). Good times…" (2007). Naturally, the scientist/specialist is familiar with the phenomenon he is planning to teach, but is he familiar with the process of teaching it? In teaching science one must be prepared to deviate from his original lesson plan in order to accommodate all students' demands and skills, in order for the gap between scientifically-competent and scientifically-challenged students to be as small as possible. So, it seems that the traditional way that we were taught as students and have been taught to use in our teaching is not very successful. But, we learned, one may argue. Indeed, but what is the number of "we"? Are "we" the majority of our generation? Definitely not. "Levels of scientific literacy are disturbingly low" and there is a tendency away from the science classroom (Matthews, 1994). So, "we" is not the general picture. It is time we understood that "[i]f science is taught merely as a technical subject devoid of its cultural and philosophical dimensions, then the positive results of science education are less able to fructify in society" and that calls for the re-definition of science teaching (Matthews, 1994).

This leads to the second trend of science teaching, the modern one. The modern way of teaching does not necessarily introduce new scientific subjects to be taught, although some new topics, such as ecology, have been included. What is new in the modern methods of teaching is a more discursive presentation of the scientific topics. Students are encouraged to question whatever confuses them and is not clear. We aim to sharpen the minds of our students, to guide them to rethink the information provided, so that we make sure they comprehend. However, to reach to that point of maturity, each student goes through several years of learning that form his character and perception. If someone is predisposed to develop critical thinking, then this will probably manifest itself early on. But the majority of students take some time and guidance to reach to that point. That is the reason why the activities we have designed in science teaching concern children of elementary school primarily and until the ages of thirteen and fourteen, which in Greece are the first years of secondary education.

CLASSROOM ACTIVITIES AND OUR GOALS

In our view, until the age of fourteen all students should be able to understand and handle the scientific topics analyzed and discussed both in the textbook and in the classroom, and a scientific debate should be held among all students without exception. We therefore propose some differential ways of teaching science which we consider to be closer to the goal of acquiring scientific and critical thinking without excluding anyone. We aim not necessarily to acquiring matter-of-fact knowledge, rather to helping students realize the reason they need to be able to develop more complex thinking is so that they can reap the benefits in their maturer, more active life as members of the society. In developing those lesson plans (methods) we emphasize interactive learning using ICT, cooperation and peer-teaching for older students in the secondary education. Part of our goal at the ages of 13 and 14 is that our students become more independent in their learning, rely less on the teacher and make their own decisions based on their critical thinking. For younger students we use narratives, the project method, classroom debates and to a lesser extend peer-teaching.

Specifically we aim to:

- Motivate the students to exchange information amongst them
- Learn to debate on topics peacefully and justify their formed opinions
- Stand critically against their original opinion and justify the reason of acceptance or rejection of it
- Assist each other in explaining, listening and solving problems either of the team or of a fellow-student.

At the same time we try to eliminate impeding behaviors, such as:

- Selective cooperation
- Shooting down of ideas
- Withdrawal from the collective procedures
- Rejection of ideas and solution without providing justification
- Creating tension or polarization in the team

We base our goals to the redesigned identity we wish to attribute to science, so that it becomes friendlier to the learner. Our original aim to clamp social exclusion – which is still present – from the science classroom becomes obvious in listing the characteristics of this new identity. In random order the fundamental principals in the new trend of science teaching are:

1. The learning process in science is a dynamic and constant developing process
2. The learning of science includes the scientific knowledge (the scientific content) but it also includes practices that are required so as to enable scientific inquiry and research (that is the development of scientific skills) as well as technological designing
3. The collaborative research is a fundamental orientation in the learning of science
4. The learning process is infinitely more effective when it makes use of the alternative perceptions and/or ideas of the students.
5. The role of the cultural tools in the learning process (scientific software, materials for experiments, etc) is decisive, when properly utilized
6. Emphasis should be placed on the critical and reflective nature of the learning process.

In truth, the principals are not entirely new. The difference lies in the effort of trying to develop new ways of teaching science so that the social, cultural and environmental issues are more aptly touched upon and constitute a milestone in the edifice of life-long learning.

In this project, we used narratives such as children's literature and animation movies which introduce scientific issues through collaboration and promotion of the science understanding. For example, pupils during the project had the opportunity to see the animation movie titled "Azur and Asmar". Via this movie many nature of science issues were represented, such as the understanding of science in two different cultures. Students had a chance to discuss the different representations of the nature of science and realize that science isn't something rigid rather a notion tied to culture as well as socially related to the values of the society they have been developed in. We felt it was important to point out the different representations of the same scientific phenomenon, because that practice automatically facilitated the alternativeness of the concepts of science. This example exonerated the different ideas that each child might have had in their mind and of course it facilitated discussion and debating.

Teaching science through narratives is a good example because the division of the classroom is very obvious. In interviewing pupils whether they like science or not they will answer “yes” or “no” depending on how much of it they understand. Sometimes in the formal classroom setting the teacher is pressed for time and will not go back and re-explain a challenging concept. Or actually the teacher would re-address a particular lesson when s/he found out that the majority of the class has not understood. Using narratives to explain science is not a new idea, but in the Greek reality it is an unlikely idea. However, in using a narrative with primary school children we achieved a lot more than with the traditional teaching. Students were in a more relaxed state of mind and did not strive to follow their quicker peers. Also, being involved in a story – which students could reproduce privately afterwards – was more personal and each child acquired greater responsibility for their individual learning, even though they didn’t realize it. Finally in using a narrative, we actively engaged students to participate in the course, especially when we asked them to dramatize the story at the end of a number of lessons. In our particular example, using an narrative to teach all these concepts, was highly productive, both because children were captured by the idea of science within a story and because the narrative was followed by activities such as “Write about your favourite character of the story and explain why you liked him/her” or “Draw a picture of the scene that made the greatest impression on you.” The children could choose freely which of the two activities they wanted to do. Eventually, we proposed that a class book be made, so two groups were organized “the writers” and “the illustrators” and worked on the story. Not only that but we noticed that the students were more willing to do science after the end of our project and often volunteered to present the lesson as a narrative when they were examined on a daily basis.

Finally, for the older students who were in their first two years of secondary education the activities were based almost exclusively in ICT skills. The reason for that is twofold. Currently there are great efforts being made to implement scientific software in public schools. The more ICT keeps improving, the better are the chances that of using animation and simulation in the teaching of science (Kokkotas and Piliouras 2007). The benefit from that is that abstract concepts such as the atom and its structure can be perceived using the visual aid of a picture on a computer screen. Although the experiential approach to understanding science harbors several dangers, nevertheless, it can facilitate understanding. It is up to the teacher to protect his/her students from the shortcomings. The development of the scientific program that we used was an amateur one, as we are not computer experts. Therefore, the program was a simplistic one that included a limited number of topics. However, we managed to use as part of the teaching. In fact, we took the liberty to design the whole layout of the kind of lesson we wanted to materialize and then ask the teacher to follow it. The layout consisted of the introduction to electricity via the formation of the lightning. The teacher had about fifteen minutes to explain the forces that create the lightning every time it rains and then the students could press a button on the computer keyboard and see the actual movement of some clouds and the formation of the different poles between the sky and the earth that resulted to the lightning. The most interesting part of this activity was that students were paired in front of each computer screen and were free to discuss the phenomenon with each other. That way we aspired to encourage peer-teaching and free information flow among the student-body. There were another couple of topics developed that way.

CONCLUSIONS

The activities developed were successful, mainly because all values and topics that were taught were directly related to the development of critical thinking, to using their judgment to decide on several issues both personal and interpersonal. The environment we aimed for and achieved in creating was one of collaboration, fruitful discourse and acceptance of the diverse voices that were present. Despite the fact that we didn't aim to directly address issues of multi-culturality, as our classroom consisted of children of a singular nationality, however the children seemed to understand the concept of differentiation. We were able to gauge the results quantitatively and through participation in the lesson as well and both we and the teachers were satisfied by the results. At the end of our trial-lessons we were confident that our students had quite grasped the scientific concepts taught. However, we were excited to accompany the students to a field trip that was recreational and witness a little play that benignly mocked our efforts. Our enthusiasm fed on the noticeable impression the designed activities had left on the students and that alone compels us to carry on. Their purpose as is taken from their site is to "bring university researchers together with middle school and high school educators to improve instruction in science." We believe that there is a lot to be done still in this field and in the future educational faculties will impress us with the development of sophisticated technological tools for science teaching. After all, properly developed educational software can provoke the involvement and motivation of students to the learning of science (Kokkotas and Piliouras 2007).

By designing activities that present the science concepts through narratives, dramatization, computer-based activities and finally peer-teaching we did not aim to simplify the concepts, merely to simplify the way these concepts were generally and widely understood. There is limitless room – in our opinion – for the development of more such activities and it depends on the teachers' creativity to bring them to light.

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