Techno-Sciences and Mathematics: Vehicles for a Sustainable Future and Global Understanding

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Abstract. *Although, we do and teach sciences and mathematics, we seldom "look behind and beyond the class". Techno-sciences and mathematics can, and should, serve as vehicles for a sustainable future and global understanding. It has been found that the potential of using mathematics and science as languages that can convey meaning and evoke emotions which could raise learners' social consciousness and social responsibility is ignored. This paper discusses this finding and provides cross-curriculum teaching examples of restoring this neglected social aspect.*

Key words: Techno-sciences, mathematics, teaching methodology, social meaning, global understanding, sustainable development.

1. The problem

Today the development of social responsibility for sustainable development and global understanding has gained a renewed concern among educators. It is often debated that techno-science (technology and science) and mathematics, although they have generated enormous positive developments across all societal spheres, they have also brought world-wide problems, some of which are irreversible. This is largely due to the positivistic ideology that over the last three centuries has objectified and reified both people and the natural world, seeing them as separate and inanimate, rather than affectively interconnected. School curricula and teaching methodology are mainly used in the context of instrumental rationality and technical interest in knowledge, which does little to develop human self-realization and critical discourse [1, 2]. Indeed, educators are finding themselves increasingly dissatisfied with the distance between school curriculum and life outside the school as skills learned in school are rarely applicable to problems in the real world [3, 4]. Instruction that is confined to a limited range of contexts leads to inert knowledge in which facts and procedures remain isolated and are not activated in different problem-solving situations [5]. In the International Conference on Education, organized by the International Bureau of Education in Geneva, 1994, 102 ministers of education noted the urgent need to include global/international understanding in school curricula and in teacher-training courses [6]. Global understanding has been also connected with the quest for an education that is geared towards a sustainable future and social responsibility [7]. It is no longer considered enough merely to transfer knowledge to "empty vessels". A new philosophy of education is thus needed, which should aim at developing self-determination, judgment, solidarity, desire to action, and critical thinking. When pupils learn to make judgments and decisions, it seems likely that this process will have application outside of school and later in their lives. Science and especially mathematics curricula seem to be treated from a decontextualized perspective without social meaning [3]. If this happens, then science and mathematics are disassociated from social reality and do not serve as vehicles for better global understanding and sustainable development. The approach that has been adopted in this paper emphasizes the importance of anchoring or situating knowledge and practices in science, mathematics and technology in meaningful, real-world, problem-solving contexts. Our thesis is that knowledge is useful and meaningful to the extent it emancipates human minds, and not just satisfying material needs and wants. We should provide youth and future citizens with the capacity to re-establish the unity between people and nature as well as knowledge and praxis. We should also provide to future generations the right of choice to develop their understanding and capacity to tackle many of the problems they inherit from previous generations. In this context, educators and researchers should raise questions such as:

- What aspects of ourselves can we see through techno-sciences and mathematics?
- How can we look into the future through techno-sciences and mathematics?
- Do sciences and mathematics have social meaning and constitute a critical factor for social change?
- How can, for example, new technology helps: to integrate science and mathematics with other subjects; to promote more cooperative learning, to encourage the transfer of science and mathematics process skills to everyday life, and to improve student attitudes towards science and mathematics?
- How do science and math teachers help the kids make meaningful social meaning out of science and math problems?

Educating young learners for the development of social consciousness and responsibility towards sustainable living means also posing a set of self-reflective questions such as:

- What is my vision of what I would like our world to be?
- Are my actions consistent with the way I would like the world to be?
- What does the way I lead my life mean for the lives of others?
- How can I contribute in creating a more just, peaceful, and ecologically sound world?
- What can we do together as a local community, as a country and as a global community to promote sustainable development and global/international understanding?

2. Research framework

Based on the previous assumptions and positions, we set the following three research questions:

1. To what extent the Greek primary school curriculum in mathematics and sciences enables teachers to reconstruct their visions and practices of teaching in more emancipatory ways?
2. Are there any differences between young learners' interests in tackling issues of social concern and the contextualization of school knowledge in sciences and mathematics with issues of global concern?
3. How could sciences, mathematics and technology serve as vehicles for developing a sustainable future and increase global understanding?

To study these questions we were based on the following taxonomy of 10 global issues related to sustainable development used in a previous study of ours [8].

1. Population (population growth, overpopulation, infertility, population management and control).
2. Poverty and economic progress (the gap between North and South, East and West, aid, debt).
3. Environment (pollution, ozone depletion, acid rain, green-house effect, global warming, deforestation).
4. Human rights (social justice, self-determination, gender equality, language rights, the right to freedom, health and education, equality).
5. Peace (armament, disarmament, international conflict management, conflict resolution, peacemaking-peacekeeping).
6. Food and hunger (malnutrition, food as a basic human need and right, world hunger, consumerism).
7. Resources (use of natural resources, waste of resources, renewable resources, recycling).
8. Biodiversity (protection of nature and wildlife, endangered species, animal rights).
9. Cultural diversity (multiculturalism, racism, xenophobia, minorities).
10. Science and technology (biotechnology, bioethics, positive and negative aspects of science and technology).

We carried out a content analysis of all mathematics textbooks of the six primary school grades and the two science textbooks of the 5th and 6th grades entitled "Research and Discover". The number of mathematics textbooks amounted to 12: two volumes in each grade, with a total of 1650 pages. The two science textbooks entitled amounted to 623 pages. We also elicited primary school pupils' visions of what they would like

their world to be. This question was addressed to 164 primary school pupils in one school in the city of Rethymnon, Crete and 137 primary school pupils in selected classes of six schools in the metropolitan area of Athens. Schools' selection was based on convenience and not random sampling.

3. Research results

Tables 2 and 3 indicate that although primary school pupils have informal knowledge related to issues of sustainability, the knowledge mathematics and science school textbooks transfer to them does not reflect the curriculum results presented in Table 1. As found in other works referring to the United Kingdom "the instruction learners receive in a decontextualized manner does little to guide them in relating their prior knowledge to formal knowledge in a meaningful web of information" [9].

Table 1. Integration issues of global sustainable concern to mathematics and science curricula.

Global Issues	Mathematics				Sciences	
	Grades				Grades	
	1-3	4	5	6	5	6
Population	-	-	-	-	-	-
Poverty	-	-	-	-	-	-
Environment	-	1		1	2	2
Human rights	-	-	1	-	1	-
Peace	-	-	-	-	-	-
Food/Hunger	-	-	-	-	-	-
Resources	-	-	2	2	1	2
Biodiversity	-	-	-	-	-	1
Cultural diversity	-	-	-	1	-	1
Science & Tech	-	-	-	-	-	-

Table 2. Pupils' visions of what they would like their world to be (Rethymnon).

Global Issues	Grades						
	1	2	3	4	5	6	T
Population	-	-	-	1	-	-	1
Poverty	-	-	3	9	2	-	14
Environment	1	3	20	-	9	7	40
Human rights	-	-	-	3	2	-	5
Peace	-	3	3	14	3	14	37
Food/Hunger	-	-	-	2	-	1	3
Resources	-	-	-	1	4	1	6
Biodiversity	-	-	4	9	4	1	18
Cultural diversity	-	-	1	6	-	3	10
Science & Tech	-	-	-	-	-	-	-

Table 3. Pupils' visions of what they would like their world to be (Athens).

Global Issues	Grades				
	2	4	5	6	Total
Population	-	-	-	-	-
Poverty	2	-	18	10	30
Environment	8	20	32	30	110
Human rights	-	-	46	40	86
Peace	-	25	50	30	105
Food/Hunger	-	-	10	7	27
Resources	8	30	5	5	48
Biodiversity	1	4	10	-	15
Culturaldiversity	-	9	10	10	20
Science & Tech	-	-	5	4	9

More specifically, the results summarized in Table 1 show that the primary school curriculum in science and mathematics is decontextualized and lacks a connection to the issues that society is confronted. In mathematics curriculum the very limited global issues found concern those of forestation (twice), recycling (twice), water saving (twice), the right of land to non-land owners and a statement about the numeric systems developed by Arabs, Greeks and Romans. All the issues, besides the last one were integrated in arithmetic problems.

In the science textbooks "Research and Discover", the global sustainability concepts found refer to a simple statement that certain animals are related to the ancient Egyptian and current Indian cultures. There is also a statement that many animals are in danger in Greece and that human beings are the main cause of their possible extinction. Air pollution is introduced along with a reference to the concept of Ozone, both with very simplistic approaches. In the Unit dealing with Water, there is a statement about water pollution and the problem of water scarcity. Waste is also mentioned in the Unit dealing with Environment Protection with particular reference to recycling. The picture does not change in the corresponding 6th Grade science textbook. The sustainability global issues found concern the concept of blood donor in the Unit dealing with the Respiration System, the concept of Acid Rain in the Unit about Mixtures and the concept of recycling again in the Unit dealing with Energy.

It is also surprising that not any kind of technology (e.g. multimedia, Internet, spreadsheets and audio-visual means) has been

integrated in mathematics curriculum and in the two science textbooks examined. It is a contradiction that science textbooks entitled "Research and Discover" do not integrate practices that learners can use tools of data manipulation, analysis, and presentation as well as resources and realistic episodes that could engage primary school learners in discovery and problem solving learning. One could expect from such textbooks to integrate new information and communication technology, giving the potential to young "explorers" get involved in investigative activities, raise questions, collect primary and secondary data, interact with peers and experts, take virtual field trips, visit museum virtually and so forth.

The results of this study show that beyond science and mathematical literacy, unfortunately, almost all mathematics and science lessons consist of content that is divorced from any significant understanding of social processes and realities. Accordingly, school does not engage learners in experiences that are relevant to life and their development as socially responsible and critically thinking citizens. Besides a mere statement about different number systems, mathematics is used from an ethnocentric perspective, totally associated with the Western culture. There is no material in school mathematical and science texts relating to the mathematical and scientific achievements of the "Others", such as Arabs, Indians and Chinese. Added to that, content and practice are fact-oriented without any notion of critical constructivism espoused by critical social theory and pedagogy. It is thus assumed that the potential of using mathematics and science as languages that can convey meaning and evoke emotions which could raise learners' social consciousness and social responsibility is ignored.

4. Cross-curriculum didactic implications

In light of the above findings, teaching global sustainable issues requires teachers to be creative, critical, resourceful and informed on these issues. Science and mathematics textbooks tend to be limited in their coverage of these issues and, even the ones integrated are tackled on the surface both in terms of breath and teaching method. Therefore, teachers must turn to more recent sources of information for designing lessons and for engaging learners in this process. There is a need to teach young learners to become responsible and participating members of their communities and develop their social consciousness and critical thinking through reflection, cooperation and inquiry. The contextualization of science and mathematics towards an education for a sustainable future and social responsibility implies that teaching integrates a reflective learning approach that engages learners in a continuous discourse and action. Critical discourse that leads to action, which in turn leads to discourse and so on, is firmly connected to political literacy. This is also related to cross-curriculum and inter-disciplinary approaches to teaching and learning. In this context, what would be same examples which show how to merge technology, science and mathematics with sustainable development and global understanding?

For example, the concept of air pollution could be introduced in connection to the concepts of global warming and greenhouse effect. There could be a scenario in which learners are asked to consider what may happen in the future if certain current trends continue. Cause and effect sentences contextualized with issues of global concern can be introduced in writing along with reading and speaking as well as in combination with other subjects. In the subject of language, the cause and effect relationship is both a way of thinking and an approach to teaching writing skills. Either through brainstorming and/or certain information elicited from various sources about global warming and the greenhouse effect, pupils could be asked, first, to think of all the causes of global warming, and then think of the effects. When, for example, a pupil makes a statement such as: "if global temperatures rise, the level of the sea will rise and this will cause disaster", the teacher should encourage discussion through search for evidence. Discussion could be based on the following questions: What will happen to the polar ice caps? What will happen to the world climate? Will that influence food production? Will the population migrate to avoid problems of food, famine and temperature? Where will they go? What will happen to the species? What could be some positive strategies for dealing with the problem? Assisting learners in searching the Internet can lead them to find various sources, facts, and tools dealing with global warming. For example, by visiting the address http://www.ncdc.noaa.gov/ there is the world's

largest active archive of weather data. Also at http://www.ncdc.noaa.gov/ol/climate/stationlocator.htm one can find weather data from specific locations.At http://www.epa.gov/globalwarming/ there is information about the greenhouse effect and what can be done to cope with this problem. If there is interest to connect this issue with the issue of animal endangerment, then at http://www.worldbook.com/fun/wbla/earth/html/earth.htm one can have in-depth look at global changes brought about by humans and examine the growing problem of species extinction. There is also an interview with one of the world's leading biologists on the importance of preserving Earth's species and a multimedia presentation on the problem of global warming. A useful guide and various resources for teachers and learners on global warming can be found at http://www.pbs.org/wgbh/nova/warnings/ Using technology learners can thus research real-time and historic temperature data locally/nationally and/or world-wide, analyze the data using mean, median, and mode averages, graph the data and draw conclusions. Learners can use a calculator or electronic spreadsheet such as Excel to compile their statistics and then represent the results graphically. The graphic representations provide good resources for summarization, interpretation and discussion as well as a means for communicating information.

Another example which shows that technology provides a powerful tool within the classroom both as an information resource and a means of communication is the Web-based project entitled "Passport to Knowledge" http://quest.arc.nasa.gov/livefrom/passport.html. This project concerns an ongoing series of "electronic field trips" via interactive television and the Internet. Scientists are available to provide help and guidance to young learners as they collaborate to do real world science research in real time. In that sense, learners become co-investigators with field researchers and experts, as they engage in problem solving which has direct application to real life. GLOBE accessible at http://globe.gov/fsl/html is another worldwide project dealing with hands-on cooperative learning concerning environmental issues. Activities involve learners in taking measurements, analyzing data, creating maps and graphs and reporting their data through the Internet.

It is generally assumed that one of the critical aspects of education for a sustainable future is the integration of culture, environment and peace. In bringing this integration, there is a need for developing a better understanding and interaction among cultures, especially by encouraging respect for and acceptance of cultural diversity [10, 11]. An example for the connection of mathematics with culture can be appreciated in the consideration of foreign artifacts with geometric design. Textile patterns and configurations in folk art reveal cross-cultural connections for geometric design and the principles of geometric symmetry. If for example learners explore the African, Indian or Islamic decorative art, they can find a lot about mathematical theorems [12]. Folk art design may thus serve as an attracting starting point in the mathematics classroom. In terms of teaching methodology, the use of traditional cultural design in the mathematics classroom provides alternative approaches to teaching, while at the same time promotes global understanding. Such considerations do not only relate to mathematics and global understanding, but also foster an integral approach to learning by incorporating a knowledge of history, geography and social-anthropology as well as developing a cultural and aesthetic literacy.

5. Concluding remarks

Greek primary school curriculum in mathematics and sciences does not enable teachers to reconstruct their visions and practices of teaching in more emancipatory ways. There are also considerable differences between young learners' interests in tackling issues of social concern and the contextualization of school knowledge in sciences and mathematics with issues of global concern. Accordingly, science, mathematics and technology as they have been introduced and practiced in primary school cannot serve as vehicles for developing a sustainable future and global understanding.

This study and the teaching examples provided indicate that if technology, sciences and mathematics are contextualized with issues of sustainable concern and global understanding, learners should take an active role in the learning process. This means giving the learners the right to take a share in the responsibility of acquiring skills, knowledge and personal meaning. Active participation requires the teacher and learner to

be involved in negotiation, discussion, decision-making, teamwork and other skills that are valued by society and in the world of work. It is a move away from the teaching model in which the learner is viewed as an object who passively receives knowledge that is solely externally instilled. The notion that people and young learners can do very little to change the way the world is today has been generated by an educational philosophy which separates education from political literacy and action. There is, thus, a need to restore the link between the school and society and contextualize science and mathematics with real life problems, supported by new information and communication technologies. The school can no longer be regarded as a sanctuary where students are protected from the social ills of the larger society [13]. It seems that when we suspend our preconceptions of what young people should know and how they should demonstrate this knowledge, we find that children can deal with complex issues in surprisingly sophisticated ways [14]. Exploring issues of global concern within the classroom and especially through sciences, mathematics and technology is a means of recognizing and validating the social, cultural, and political experiences learners bring with them to school. The early school years constitute an important time to lay the foundation for the development of an education geared for a sustainable future and global understanding.

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