DEBATING FOR 'ONE MEASURE FOR THE WORLD': *SENSITIVE PENDULUM OR HEAVY EARTH?*

Panayota Kotarinou, Anna Chronaki, Charoula Stathopoulou

University of Thessaly

INTRODUCTION

A central part of mathematics curricula, almost worldwide, is an emphasis on learning about methods of 'measurement' from primary to secondary levels and employing them for calculating perimeter, area or volume in geometry. Broadly speaking, mathematics curricula (and therefore textbooks and teachers) refer to the use of 'meter' as a conventional unit that is globally accepted, without ever mentioning how and why it has been established as a commonly used unit, let alone organizing along with children an investigation into this matter.

Our aim in this paper is to discuss how a group of adolescent students has been engaged in a cross-curriculum project about the processes of establishing the 'meter' as a commonly used unit during the French Revolution. The potential of this particular project can be recognised at various interrelated levels: a) increasing students' awareness of mathematics as a socio-political product; b) cultivating a stronger sense of citizenship; c) developing students' creative and critical thinking in the realm of their involvement in social problems within a specific economic and historical context.

Mathematics and Society: opening a closed relation

In recent decades, mathematics education has been characterized by researchers' shift toward the so called 'social turn' (see Lerman, 2000: 23). This social shift consists of emerging theories that analyze meaning, thought and reasoning as products of social activity. This turn indicates simultaneously a research shift that results into the study and interpretation of phenomena related to mathematics teaching and learning taking into account social, cultural and political dimensions of the wider systemic context. Aspects of mathematics and mathematics education largely ignored in the past gain today a renewed interest within our scientific community. In the realm of these research directions Ernest's call for an urgent need to consider new philosophies is pertinent.

Ernest (2008) speaks about the need for a broader view of the philosophy of mathematics to emerge, including the relevance of a range of traditionally excluded dimensions such as: culture, values and social responsibility; applications of mathematics and their effectiveness in science, technology and other realms of knowledge and social functioning; and the learning of mathematics, its role in the transmission of mathematical knowledge, and in the formation of individual mathematicians (Mellin-Olsen,1987, Skovsmose, 1989, 1994, Restivo et al. 1993, Ernest, 2008). In an earlier article entitled "Mathematics and democracy" Ole

Skovsmose indicated that we cannot expect any development of democratic competence in school unless the teaching-learning situation is based on dialogue and unless the curriculum is not totally determined from outside the classroom. Such ideas seem equally relevant today. Since then a number of researchers have embraced such a standpoint (Valero and Zevenbergen, 2004).

Creativity, Critical thinking and Drama in Education: articulating a debate

The use of drama techniques in education has been proposed, among others, as a context that offers innovative ways for integrating different disciplinary curriculum areas and as a creative way for students to reflect on broader learning issues (emotional, cognitive, social, political). Drama in Education (DIE) can be a highly structured pedagogical procedure utilizing specific rituals and techniques of dramatic art aiming to focus participants' attention towards *the process* of participants' experience and not on the final product (Alkistis, 2000). It potentially constitutes a teaching approach that can embrace collaborative, active learning through experience, while giving participants the opportunity to develop acceptance, understanding, creativity, curiosity, self-consciousness, self-esteem (Alkistis, 1998 Wagner, 1999; Wooland, 1999).

The research results concerning the effects of Drama in teaching and learning Mathematics on students' understanding and retention of mathematical notions (Saab, 1987; Omniewski, 1999; Fleming et al., 2004; Duatepe, 2004) and in creating a positive impact on their attitudes towards mathematics (Kayhan, 2008, Duatepe, 2004) are very encouraging.

In an earlier study, Chronaki (1990) interviewed experienced maths and drama teachers who were involved in either long- or short-term cross-curricular projects aiming to teach mathematics and drama techniques. They all mentioned that, despite time and curricular constrains, drama techniques can provide the means to motivate children for active participation in mathematics problem solving. Being inspired by the work of Heathcote (1984), Way (1967) and Bousquet (1986) and confronted with the rigid structure of a maths curriculum reform in the early 80s, as well as specific needs for mathematical numeracy emphasised by the well known Cockroft report, some maths and drama teachers in the UK context of the late 80s turned towards exploring innovative cross-curricular connections in specific cross-departmental co-operations. Their inner motivation was mainly geared towards battling children's de-motivation and indifference for an abstract maths curriculum that stresses uniformity and fails to develop spaces for creative and critical thinking (see Chronaki, 1990 for more details).

Specific techniques such as the *'as-if'* create the context for teaching a concept, an idea or an event and offers opportunities for exploring mathematics in a variety of historical, social or cultural contexts. '*Teacher and students in Role'* is another basic drama technique -often supplemented with the use of open public '*debate'*. The use of *'debate'* in teaching can facilitate both knowledge acquisition and critical thinking (Huber, 2005; Snider, 2006). Furthermore, participation in activities of this type

familiarizes children with a holistic handling of issues, makes them able to justify their point of view, practices their mental flexibility and alertness, and enhances their ability of self-criticism and their conciliatoriness. Our project named '*Sensitive pendulum or heavy earth'* relies upon utilizing some of the above mentioned techniques with an emphasis on the dramatization of a public debate concerning the decision-making process of 'one measure for the world' that took place at the National Assembly during the French Revolution.

Historical events

By the end of the 18th century the diversity of weights and measures in France—about 2000 in total- was held responsible for great problems in economical dealings as well as the exploitation of people by feudal lords. This was because the majority was illiterate and thus incapable of making conversions amongst different measuring units. Due to the aforementioned reasons standardization of weights and measures was one of peoples' basic demands. The establishment of new units constituted a political decision. From the first year, the French National Assembly voted for uniformity in measurement units and sought new ones. In 1790, the French National Assembly accepted the definition of the meter as the length of a pendulum that has a period of 2 sec at latitude of 45^{o}, and asked the Academy of Science to propose the base of the metric system. The Academy responded to this request and recommended a decimal system of measurement. In 1791 a committee of the French Academy of Science—Lagrange, Laplace, Condorcet, Borda and Monge—suggested that the new definition for a meter be equal to one 10 millionth part of the quadrant of the terrestrial meridian between Dunkirk and Barcelona and this was accepted by the National Assembly. The unit was given the name "meter" in 1793.

THE PROJECT: 'SENSITIVE PENDULUM OR HEAVY EARTH?'

The project was carried out in the 2nd State Lyceum of Ilion in Greece, in a low socio-economic area of Athens, during school year 2007-8. During this project, a role-playing debate was organized, which was a simulation of the confrontation in the French National Assembly. This particular debate entitled "The sensitive pendulum or the heavy earth?" was carried out twice with 11th grade students of two different classes. This confrontation concerned the choice of a length measurement unit, through the two aforementioned different approaches. The topic of the debate was selected to show students the confrontation, the protagonists and the historical context within which the unit 'meter' was introduced in order to help them comprehend that scientific theories are the result of both intellectual and social interaction.

Preparing the 'debate', seven teaching hours were required over a period of three weeks. In history-class, a powerpoint presentation concerning the establishment of the meter helped students to realize the problems stemming from the use of many different units of measurement. Extracts from a documentary film about the French Revolution introduced them to the ambience existing before and during the first two

years of the French Revolution. During the subsequent discussion, pupils started pondering why the choice of weights and measures by feudal lords was a privilege for them. They finally found out that the increase of size of the unit of volume resulted into an increase of taxes. The role of scientific unions concerning their decisions not only in scientific subjects but also in social and political ones was discussed.

During the language-class, the teacher helped students translate and understand texts concerning the origin and life, as well as the ethical and political role of scientists and other historical issues emerging in this revolutionary period.

The students were divided into 6 groups and had to locate their arguments for preparing a 'debate', reading extracts from Denis Guedj's book *"Le metre du monde"***.** Each group chose a representative to take part in the debate. The teachers in charge were present all the time to support the teams in their work. Students' ability to argue about the choice of the pendulum is directly correlated with their comprehension of its governing laws**.** Therefore, the students were taught the pendulum principles in physics- class and were also familiarized with the notion of the pendulum isochronism phenomenon. In the debate, in order to create a suitable atmosphere, simple settings and costumes were used. In order to find out the way the members of the Assembly were dressed and how they spoke, the children watched David's famous painting 'The Oath of the Tennis Court' and dramatized scenes from a documentary with Robespierre speaking in French Assembly.

In the debate all students adopted the role of a responsible citizen, member of the French Constituent Assembly, who had to take decisions about crucial matters, in this specific historical context. Certain students played the role of historical figures as Talleyrand, Bailly, Prieur, Condorcet, Borda. Prieur spoke in favor of establishing new units, Borda presented the proposition of the French Scientific Academy, while Talleyrand spoke in favor of the pendulum and Condorcet in favor of the meridian. Some students, as members of the Assembly, spoke either for the pendulum or for the meridian. During the debate students participated vividly either acclaiming or disapproving the speakers. Before reading the real decision of the French Assembly, all of them- in the roles of citizen members of the assembly- voted in favor of the meridian as the most appropriate unit of measurement, without knowing the real decision of the French Assembly.

PRELIMINARY ANALYSIS: QUESTIONNAIRES AND VIDEOTAPES

The project has been evaluated through the analysis of students' answers to a questionnaire and of particular episodes of the process as they were captured by means of videotaping the debate performance.

The reason for distributing a questionnaire was primarily to identify whether the project had any impact on students' knowledge concerning measuring units. The majority of students, even a month after the debate, answered correctly to questions

involving the establishment of the meter and the laws of the pendulum. The students emphasized that this activity engendered the development of critical thought, familiarization with a more rounded approach, active participation and cooperation with each other. More importantly than what they learned, they emphasized the way in which they learned; they pointed out that they all took part, worked together, took the initiative and felt enthusiastic. Furthermore they liked the seriousness with which the debate was carried out; the good organization and the role play which made them believe that they were really taking part in the French National Assembly.

A preliminary analysis of the videotaped debate performance permitted us to identify a number of episodes related to processes of knowledge construction and values building such as: discussion of mathematics and physics; changing stereotypic images of mathematics; training skills in argument; and gaining a sense of becoming responsible citizens. Each of these is briefly analysed below:

Discussion about mathematics and Physics notions

Students discussed about arbitrary and conventional measures, connecting the conventional unit of length measurement with justice. From their arguments in the debate we concluded that students had understood the laws of the simple pendulum as they referred in their argumentation to the dependence of the period of a pendulum on π and on g, the acceleration due to gravity.

Changing the image of the nature of Mathematics

Instead of having a conventional lesson, in which the emphasis is in solving standardized and decontextualized problems, students faced a problem, not only mathematical but at the same time social and political. The social conditions were presented as decisive for taking decisions, while at the same time the ethical responsibility of scientists as an active member of society came to the fore.

Training in argumentation skills

Both sides had to prepare strong arguments to support the definition of the meter. The team in favor of the pendulum used the argument that the pendulum was a rational solution, simple, cheap in construction and easy and functional in use. The second team claimed that the definition of the meter as a part of a meridian was a global solution, not easy and cheap, yet accurate and reliable , as it was not dependent on approximate values of the numbers π and g.

Fostering the sense of citizenship

Through the whole procedure, the value of public and responsible dialogue was brought out. During the introduction of the debate, the necessity of innovation ‘in order for the people to stop being victims’ was underlined. Also, the exploitation of people by feudal lords through the use of arbitrary units of measurement was also emphasized by the students. The need for release from kings’ units was emphasized, as these were local and also defined in an arbitrary way. Students associated the

common meter with human rights while both teams argued that the 'meter' had to be defined in a way that could be understood by every citizen.

SOME CONCLUDING REMARKS

According to Ernest (2008) the adoption of mathematics as a cultural construction, as much from a historical perspective as from the perspective that examines knowledge in relationship to the context, can endow a human element to school mathematics once more. We believe that with all the aforementioned activities this aspect of mathematics as a socio-political 'tool' came to the fore. With this role-playing the central role of the historical and social context in the ways mathematics could be utilised was brought to light and students were able to experience this dimension of mathematics, not only mentally but emotionally and physically. We believe that such projects can help to achieve the major goals of education, *i.e.*, responsible creativity and an ethical [world] citizenship.

However, although maths teachers may start their involvement with dramatic techniques in the context of cross-curriculum co-operations with enthusiasm, such attempts soon seem to arrive at dead-ends given the time and space constraints created by a rigid demand for content coverage and national assessments. Teachers in Greece in the early 21st century, like teachers in the UK in the early 80s –and perhaps today- are faced with the same need to motivate students' engagement with mathematics and to support them towards 'changing' their image of a subject that suffers stereotyping through varied social terrains. As a maths teacher heavily involved with drama techniques in the UK claimed '*..children in drama are collaborators'* and '*..gradually trust themselves and their own abilities*'. However, the same teachers did not continue to utilise drama in their maths classes as they become prevented due to time, resource and energy requirements for cross-departmental co-operations (see Chronaki, 1990). This very fact denotes a paradox: *on the one hand,* drama techniques aid students' motivation and conceptual understanding of mathematics, and *on the other hand*, broader curriculum structures (such as guidelines and assessment) prevent teachers, even experienced ones, from utilising them as a legitimate resource on a continuous basis.

Chronaki (2000), based on the analysis of two teachers employing art-based activities in their maths classrooms, referred to such paradoxes as teachers having to deal with and bridge hegemonic and often conflicting discourses about what mathematics teaching should involve in a school classroom and about what might be the place and role of art related themes. It is obvious that such issues are rooted in broader debates concerning links amongst art and science related discursive practices. Since today there is renewed interest in revisiting this long-lasting bridging of art and science (e.g. Presmeg, 2009) there is a need to reconsider this line of research.

NOTES

D. Koutli, teacher of Physics, and teacher-librarian and N. Apostolopoulou the head-master of the school have also participated in the project.

REFERENCES

Alkistis, K. (1998). *The book of dramatization*. Athens: Ellinika Grammata.

Alkistis, K. (2000). *Drama in education.* Athens: Ellinika Grammata.

Bousquet, M. (1986). What makes us play? What makes us learn? *Prospects*, 16 (4), 465-474.

Chronaki, A. (1990). *An investigation of the potentiality of using drama in the teaching of mathematics in secondary school*. Unpublished Master Dissertation. University of Bath.

Chronaki, A. (2000). Teaching maths through theme-based resources: Pedagogic style, 'theme' and 'maths' in lessons. *Educational Studies in Mathematics,* 42, 141-163.

Duatepe, A. (2004). Drama based instruction and geometry, *10th International Congress on Mathematical Education,* July 4-17, 2004, Copenhagen, Denmark.

Ernest, P. (2008). What does the new philosophy of mathematics mean for mathematics education, *Proceedings of 25th Panhellenic Congress in Mathematics Education of Hellenic Mathematical Society,* Volos, November 21- 23, 2008.

Fleming M., Merrell C., & Tymms P. (2004). The impact of drama on pupils' language, mathematics, and attitude in two primary schools. *Research in Drama Education,* 9 (2), 177-197.

Heathcote, D. (1984). In L. Johnson and C. O'Neil (Eds.) *Dorothy Heathcote: Collected writings on education and drama*. Hutchinson.

Huber, R. (2005). *Influencing through argument*. New York: International Debate Education Association.

Kayhan, H. C. (2008). Effect of creative drama as a teaching method on attitudes towards mathematics, *Proceedings of International Congress of Drama/Theatre in Education* (pp. 277-278), Ankara, November 21-23, 2008.

Lerman, S. (2000). Social turn in mathematics education research. In J. Boaler (Ed.), *Multiple perspectives on mathematics teaching and l earning* (pp. 19 - 44). Palo Alto, Calif: Greenwood.

Mellin-Olsen, S. (1987). *The politics of mathematics education*. Dordrecht: Reidel.

Omniewski, R. (1999). *The effects of an arts infusion approach on the mathematics achievement of second-grade students*. Doctoral dissertation, Kent State University, Dissertation Abstracts International, 60(05), 1389 A.

Presmeg, N. (2009). Mathematics education research embracing arts and sciences, *ZDM*, 41(1-2), 131-141.

Saab, J. (1987). *The effects of creative Drama methods on mathematics achievement, attitudes and creativity,* Dissertation, Education D., West Virginia University.

Skovsmose, O. (1994). *Towards a Philosophy of Critical Mathematics Education*, Dordrecht: Kluwer Academic Publishers.

Snider, A., & Schnurer, M. (2006). *Many Sides: Debate Across the Curriculum*, New York: International Debate Education Association.
Valero, P., & Zevenbergen, R. (Eds.) (2004). *Researching the socio-political dimensions of mathematics education: Issues of power in theory and methodology*. Dordrecht: Kluwer.
Wagner, B. (1999). *Dorothy Heathcote. Drama as a Learning Medium*. Portsmouth: Heinemann.
Way, B. (1967). Dev*elopment through Drama*. Longman.
Wooland, B. (1999). *Teaching Drama in the public school*. Athens: Ellinika Grammata.