CRITICAL MATHEMATICAL EDUCATION AND STS STUDIES: APPROACHES TO DISCUSS A RESEARCH

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Students of mathematical subjects in Brazilian universities show many learning difficulties and professors complain about the education they received in previous years. Official documentation presents suggestions that range from the usage of mathematical modeling and project work among others. Critical Mathematics Education (CME) and the studies of Science Technology and Society (STS Studies) are approaches that enable working with the contents of mathematics and other sciences in an integrated way with a critical and thoughtful vision. We have discussed the data collected in a research performed with High School students regarding these approaches and point out the possibilities of inserting context into mathematics teaching.

INTRODUCTION

Mathematics teaching in Brazil at any level is in crisis. This assertion is not original, nor recent since for decades we have been detecting learning problems in our students and proposing solutions that invoke many theories and different methodological approaches to support the proposals. In recent years, there is an increase in offerings of courses at undergraduate level, especially in private institutions, but also there was admission of students with scholarships and the ones who were admitted by means of the quota policy implemented by some public universities. Facing this situation, mathematics university professors started looking for the reasons to be blamed for the difficulties faced in teaching subjects such as Differential and Integral Calculus, the latter being the villain among all students of the courses of Exact Sciences.

One of the most recent complaints of professors is directed at teaching in the earlier educational levels, i.e., the mathematics that is not being taught properly in high school and the last years of junior high. On the other hand, teachers in those levels complain about the difficulties that students bring from the earlier school grades and in an attempt to reach the root of the problem everybody protests about the mathematical bases of the teachers in charge of the first four grades.

Besides students coming from regular high school courses, students coming from Adults and Young Adults Education – who in a few years learn all the contents that should have been developed in regular courses in more years, that due to personal, professional and mainly financial reasons they could not take - are also candidates to places in higher education courses.

Due to this scenario that in some points is very similar to other countries, it is important to think about possible approaches that may modify, even if in a small

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scale, a situation that afflicts professors, takes away the motivation of students and has economical, political and social consequences.

In this paper we present some common aspects of Critical Mathematics Education (CME) and the studies of Science, Technology and Society (STS Studies) with the objective of reflecting about the possibilities offered by these approaches to help students and professors to overcome somehow the difficulties of the process of teaching and learning mathematics.

THE OFFICIAL SOLUTIONS: PARAMETERS AND CURRICULUM GUIDELINES FOR UNDERGRADUATE COURSES

When we talk about suggestions for mathematics education, what immediately comes to our minds is the Brazilian National Curriculum Parameters (Parâmetros Curriculares Nacionais, PCNs) for School Education (Ministério da Educação e Cultura [MEC], 1998, 2000). These documents present a summary of what has been studied in terms of teaching and learning in any curricular component. We intend to mention here only the elements related to mathematics and specifically the topics that align with the perspectives in which we are focusing and are close to the mathematics of life and society.

For Elementary School, the PCNs indicate as general objectives among other items to "identify mathematical knowledge as a means to understand and transform the world that surrounds them" and "provide systematic observations of quantitative and qualitative aspects of reality". (MEC, 1998, pp. 47-48). For high school, the PCNs indicate among other objectives, the application of mathematical knowledge to "many different situations - using it in the interpretation of science, in technological activity and everyday activities" (MEC, 2000, p. 42). Also the development of skills related to the socio-cultural context demonstrating the need to "develop the ability to use mathematics in the interpretation of and intervention in reality." (MEC, 2000, p. 46).

In order to update the document, the Fundamental Education Agency (Secretaria de Educação Básica) of the Ministry of Education prepared the Curricular Guidance for High School (MEC, 2006), in which we found work suggestions concerning mathematics:

> In recent years, studies in mathematical education have also shown that an idea for making mathematics more effective in schools is that of mathematical modeling that can be understood as an ability to transform real world problems into mathematical problems and solve them, interpreting their solutions in real world language. (p. 84).

Further on after considering that this modeling has connections with problem resolution, this document also indicates that:

> Articulated with the mathematical modeling idea is the alternative of working with projects. One project may simulate the creation of organization strategies of school

> knowledge when integrating different disciplinary learning. It may be triggered from a very specific problem or from something more general, from a set of interrelated themes or questions. But above all it must have as its priority the study of a theme that is of the students' interest in a way that it promotes social interaction and reflection about problems that are part of their reality. (p. 85)

Initially PCNs had raised many questionings since not all approaches were familiar to teachers. Therefore many new clarifying documents focused more on content and with new references to studies at schools became necessary. Mathematics teaching formation courses started to spread the PCN and discuss its guidance at the same time teachers were receiving also new work guidance in the same courses (MEC, 2001) that point out competencies and skills to be developed by future teachers and professionals such as the establishment of relations between mathematics and other areas of knowledge, the intelligence about current issues and the understanding of the impact of the solutions found in a global and social context.

Taking into consideration all these elements pointed out by the official documentation, one might think that applying the suggestions proposed would provide a mathematics education committed to reality and other areas of knowledge, developed with the help of methodologies well-known to professors. However how do these educators understand the work done with modeling? Is there only one single accepted definition for this approach? Working with projects and with modeling are distinctive proposals? How can the future teacher determine the relations between mathematics and the other areas of knowledge if he or she does not receive an overview of those areas during his or hers education? And how can the impact of the solutions found for the proposed problems be measured and criticized?

We do not assume that any of the approaches discussed below will be able by themselves to give the answers to so many inquiries, but we will present some of the results of a study performed with high school students. We hope that their analysis may show the path to news experiences in classroom that take into account ideas from Critical Mathematics Education and STS Studies.

CRITICAL MATHEMATICS EDUCATION AND STS STUDIES

In Brazil Critical Mathematics Education is a perspective that has been promoted by means of papers and books by the Danish researcher Ole Skovsmose. In his own words,

> [...] critical mathematics education is concerned about the different possible roles which mathematics education could play in a particular socio-political setting. (Skovsmose, 2007, p. 74)

Borba and Skovsmose (2001) discuss the ideology of certainty in mathematics, mentioning the absolutist basis of this ideology employed by society when mathematics is needed to economical or political decision-making and justified by the purity, impartiality and trustworthiness of this science. Skovsmose (2007) also

mentions the fact that mathematics has a formatting power, for instance when mathematical models are used to manage economy and built indexes are the basis for decision-making.

Skovsmose (2000) proposes also the creation of landscapes for inquiry involving environments that support research works in which students explore real problems reflecting about them.

Transversal themes, interdisciplinary studies, some methodological approaches proposed by PCNs, such as mathematical modeling itself and the work with projects can be approached with a critical view. However it is necessary to take into consideration the education of teachers in regard to this kind of activity. How are these aspects being dealt with in initial or continuous education courses? We have to consider that many mathematics teachers performing in Basic Education do not have postgraduate degrees and some of them do not even have full undergraduate degrees in mathematics. How can we make these ideas accessible to them? This is a challenge that is becoming permanent especially if we observe that in official tests such as the National High School Examination, the text of the questions show an interdisciplinary view.

But there is also another focus that may be involved in the development of the critical thought and the relation of mathematics with the real world and other sciences: the STS studies. Developed in the mid 1960s and in the 1970s, Science Technology and Society Studies emerged as a response to the doubts raised by the scientific and technological advancements generated since the 19th century. When questioning current paradigms over science with the spreading of Kuhn's ideas and reconsidering the role of technology, ecological and pacifistic social movements have exposed the consequences of a disordered growth of science and technology and the dangers to social well-being (Auler, 2003; Nascimento & von Linsingen, 2006).

In educational terms, the STS focus is present especially through science teaching where there is focus on real and current subjects and problems such as the environment, natural resources, space exploration, the cloning of living beings etc.

As for mathematics teaching, the experiences with STS studies are few in Brazil with highlight to some that have been approached in interdisciplinary combined projects. (Angotti & Auth, 2001; Pinheiro, 2005). Nevertheless we see possibilities of discussing the historical development of mathematics and its influence in the development of society as well as in its destruction, the discussions about the harmful use of data in mathematical and statistical models, the debate about the power of exclusion of mathematics by the ones who own its knowledge among other aspects that have already been pointed out by the Critical Mathematics Education (Cury & Bazzo, 2001). This way it will be possible to show students that mathematics is a human construction and inquire about the "absolute certainties" of this science, helping them to make decisions about problems in which mathematical contents are involved.

Pinheiro (2005) highlights the recommendations of the high school PCNs to create a critical, ethical citizen integrated to the labor world and able to keep continuously learning. However the author herself mentions that it is hard to create a critical citizen with the teaching and learning currently employed and that it is an urgent need to think of new ways of working. She suggested the adoption of the ideas of CME and STS studies, despite the fact that there are no "tested formulas".

According to this gathering of ideas from Critical Mathematics Education and STS focus, we believe that there are possibilities for new experiences in mathematics teaching under these approaches. But how could these ideas be introduced to classrooms? How are the perceptions of students in regard to mathematics, sciences and society? In order to explain these issues, we present below part of a study performed with high school students

SOME DATA OF AN INVESTIGATION

Data here presented are part of a master degree research with the objective of identifying the opinion of students about the subject mathematics, evaluating the relations established between mathematics and sciences and analyzing students' view about the relation between mathematical topics and everyday events. The study was performed among students of the second and third grades of high school in a public school of the Greater Porto Alegre, Brazil. In every step of the research we will highlight only the elements connected to the topic approached in this paper.

Initially 143 students of the second grade were submitted to a questionnaire with open questions. We pointed out the 23 students who stated that mathematics is the subject with which they least identify themselves and we will point out their answers to two of the questions. In the first one, students were requested to expose their opinion about the subject mathematics. The answers were separated in classes, according to the key idea of the students: mathematics is difficult (74%), it is useless (9%) and it deals with too many numbers and calculations (13%). The other question of the research asked whether the student could see any relation between the contents studied in the subject and everyday facts of his/her life. In case of an affirmative answer, the student was asked to exemplify. Forty-eight per cent of the students said that there was no relation between the subject and their regular lives. Twenty-six per cent mentioned a relation with money or trade business and twenty-two per cent answered yes, but gave no reason.

Due to these results we considered that we should go deeper into these topics and on the second step of the investigation performed on the next scholar year, we applied a new questionnaire to the third grade high school class that had participated in the first step as the kickoff of the activities we developed with those students. This time it was a multiple-choice questionnaire. From the questions presented, we point out here three of them. The first one used some of the answers gave by students in the previous questionnaire and asked their opinion about mathematics as a subject. More

than fifty per cent of the students considered that it is a difficult subject, that does not bring much meaning and most of the time is useless in everyday activities.

Then we tried to investigate how students see the relation between sciences and mathematics. In this question, 65% of students think that sciences use mathematics only for calculations to corroborate numerical data. We believe that these students have only been using given formulas in their physics, chemistry or biology classes and did not see any further relation among the many sciences.

The third question tried again to detect the role of mathematics in the lives of students from the answers given by them previously. The sum of the percentage of those who consider it important for trade business and to deal with money and the ones who mentioned its importance to economy and finances is 74% of the students, demonstrating that for them these are the most important uses of the subject. It is important to highlight here that most of these students face financial problems and many of them already work especially in sales.

After applying the questionnaire we brought to this class four texts taken from newspaper, magazines or the Internet, with current topics in which mathematics is present. Each group was asked to read a piece of text allocated to them and answer questions referring to the topic approached. We chose to report here the activity related to a text about health. People live everyday surrounded by quantitative data such as medicine instructions, weight and height tables, blood component measurements, etc. We wanted to verify if students were able to understand text information and solve problems related to the data.

Two groups of students worked with this activity, a group of four students and another of three. The groups had a tape measure and a pair of scales. First we asked them what is necessary to calculate the Body Mass Index (BMI) and students demonstrated to have an understanding of it. Next we asked them to calculate the BMI of each member of the group and classify the person according to the table that was part of the text: thin, normal, overweight and obese. In this case students faced many difficulties in the calculations. Besides that, one of the groups instead of dividing the weight by the square of the height, divided it by the double of the height. This kind of mistake seems to be common because many students, even high school ones, still use to multiply the base by the exponent of the power.

After performing these activities, the class watched a documentary, Einstein’s Equation of Life and Death, with the objective of bringing mathematics closer to sciences since the students did not seem to view any relations between these areas.

Then we applied a questionnaire with three open questions in which the students were asked to comment on the role of mathematics in society and sciences and the need of mathematical contents in their future and the possibility of understanding and discussing everyday topics involving mathematics. After a general evaluation of the responses of the students, we observed that they:

a) recognized the role of mathematics in the lives of human beings;

b) had a superficial overview about the relation between mathematics and daily facts, seeing no connection between the contents studied at school and the mathematical elements present in daily actions even after performing activities that involved the analysis of tables and graphs, calculation of interests and BMI.

c) believed that they need the mathematics learned at school to pass official examinations, university entrance exam and the four basic operation on an day-to-day basis;

d) considered it possible to understand and discuss topics that involved mathematics shown in communication media, only if they comprised contents already learned at school.

Finally we interviewed six of the students to gain a deeper understanding of their opinions. They corroborated the ideas supported previously that mathematics is difficult and only deals with numbers and calculations. They did not relate the mathematics they study with the mathematics used in their daily lives, saying “it is not the same mathematics”. Even having enjoyed the activities proposed and the opportunity of learning the life and work of Einstein, students kept their opinion that mathematics classes are “always the same, correction of exercises, calculations and tests”.

INQUIRY ABOUT THE STUDY DATA UNDER THE PERSPECTIVES OF CME AND STS STUDIES

In the above report we demonstrated that the students of that suburb school group do not see any application of the contents studied in classroom in their daily activities or in topics mentioned in communication media. As we analyzed their answers to the BMI problem, we noticed that they were interested in the subject since young adults in Brazil worry very much about their body image and want their bodies to be according to the current fashion trends: thin and with well defined muscles. However when performing the calculations, not only in this activity but in all the four ones developed in class, they committed mistakes that made it almost impossible for them to answer the final questions of the task, since they needed coherent results in order to be able to talk about them. This shows us that the suggestion of working critically with problems and situations presented in mathematics classes, we cannot avoid the need of teaching content and methods that are inherent in this science. When commenting on the perspective for Mathematics Education, Matos (2005, p. 8), considers that the learning process of this science must include the appropriation of modes of understanding of the day-to-day mathematics but that

> Does not mean to set aside the concern about knowledge and the use of mathematical instruments and tools, but to transform the idea of school mathematics.

The debates about the BMI issue proposed to the students who participated in our research could include elements of Critical Mathematics Education and STS studies, since we could question current beauty standards and disorders caused by them, such as anorexia and bulimia, and also diseases resulting from bad nutrition and related to the excessive ingestion of salt or fat. We could also discuss the BMI itself, check its origin, the presuppositions in which it is based since it is an index almost unanimously accepted by doctors and nutritionists. We could even discuss the mathematics embedded in the packages of light and diet products whose tables with measurement units do not correspond to the ones we commonly use at home (a spoonful, a cup), and that some times may lead the user to an unbalanced nourishment. All these topics of discussion would meet the suggestions of the PCNs of integrating the knowledge of the school subject and give priority to themes that would interest the student and would also help students to create a critical sense about the data they found in their day-to-day activities.

There are many mathematical contents adjoining the BMI issue presented to the students, but it is necessary to prepare teachers to discuss them. Why are some contents emphasized in school books and programs? And particularly: why the others are not emphasized? (Matos, 2005). In Brazil one of the structured themes indicated by the PCNs is statistical literacy, but mathematics teacher education courses still give little emphasis to the teaching of probability and statistics (Viali, 2007). But information handling is essential to understand and whenever necessary, criticize and form an opinion about the data presented in communications media such as the result of opinion polls, for instance. Why do teachers avoid this topic? We may think that it may be difficult to show data without approaching the merit of the question, it is easier to keep the faith of an impartiality in mathematics.

We believe that it is important to spread the ideas of our research and the doubts that it brought so that more colleagues will get involved and engaged in debates about the theme and give some new suggestions to contextualize mathematics teaching.

FINAL CONSIDERATIONS

Wedege (1999) considers that mathematics is a contextualized activity and makes a distinction between two meanings of the term “context”: task context and situation context. In the first case she considers that

> ´Context` representing reality in tasks, word problems, examples, textbooks, teaching materials, is closest to the linguistic fundamental meaning. (p. 206).

In another definition the term refers to a context to learn, use and know mathematics, such as the school or workplace or even the context of mathematical education as the educational system itself. To clarify the distinction, Wedege (1999) exemplifies it with a Swedish study in which students worked a day-to-day problem that consisted of determining the cost of sending a letter by mail in mathematics class and in social

studies class. According to it, “the task-context is the same but the problem is solved in two different situation contexts.” (p. 207).

When we talk about contextualizing mathematics teaching, the situation context is the mathematics classroom. Considering the research above described, students were working in a contextualized task in which reality was represented in the problems they had to solve. But how far have mathematics teachers contextualized their teaching? We believe that it is not enough to employ problems that have elements of reality or semi-reality, which Skovsmose (2000) understands as a situation built for learning purposes and that simulates reality. It is necessary that the problem makes sense to the student and especially that he/she will be able to think about it not only mathematically, but also under a critical perspective, questioning the text, the data and possible answers.

Therefore we would be following the suggestions of the PCNs, introducing an interdisciplinary view of the tasks we have proposed to students and helping them to have an education involving contemporary issues that have to do with their communities as well as with their personal lives.

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