# Problem solving with environmental themes in Math classes

**Cláudio Cristiano Liell**
**Arno Bayer**

**ABSTRACT**

This study, which is part of a doctoral research, presents data from a continued formation in environmental education and mathematics for math teachers, focusing on the problem-situations elaborated in this formation and that involve mathematical contents with environmental themes. The problem-situations addressed the issue of water, waste, pollution, wildlife, vegetation, energy, the permanent preservation areas – PPA and involved the contents of statistics, rule of three, percentage, proportion, operations with natural numbers, perimeter, area and measures of length, mass and volume. The created situations were used by teachers participating of the formation, in the final grades of municipal and state elementary schools of São Sebastião do Caí. As testimony and analysis of these teachers, this work influenced their practices in relation to environmental themes, because they worked with activities that relate everyday situations with formal education, raising environmental awareness and the interest of students by environmental themes within contextualized proposals.

**Keywords:** Problem solving. Problem-situations. Environmental awareness.

## Resolução de problemas com temas ambientais nas aulas de Matemática

**RESUMO**

O presente estudo, que é parte de uma pesquisa de doutorado, apresenta dados de uma formação continuada em educação ambiental e matemática para professores de Matemática, focando em situações-problema elaboradas nessa formação e que envolvem conteúdos matemáticos com temáticas ambientais. As situações-problema abordaram a temática da água, dos resíduos, da poluição, da fauna, da vegetação, da energia, das áreas de preservação permanente – APP e envolveram os conteúdos de estatística, regra de três, porcentagem, proporção, operações com números naturais, perímetro, áreas e medidas de comprimento, massa e volume. As situações criadas foram utilizadas pelos professores participantes da formação, nas séries finais do ensino fundamental da rede municipal e estadual do município de São Sebastião do Caí. Conforme depoimentos e análises desses professores, este trabalho influenciou as suas práticas em relação aos temas ambientais, pois trabalharam com atividades que relacionavam situações cotidianas

**Cláudio Cristiano Liell** é doutorando em Ensino de Ciências e Matemática (ULBRA), Mestre em Ensino de Ciências Exatas pela UNIVATES (2012). Atualmente, é Secretário de Educação de São Sebastião do Caí – RS e professor das Faculdades Anhanguera, CESF e FAMUR. Endereço para correspondência: Rua Antônio Prado, 161, 95760-000 – São Sebastião do Caí, RS. E-mail: cristianoliell@hotmail.com

**Arno Bayer** é Doutor em Educação pela Universidad Pontificia de Salamanca (1997). Atualmente é professor titular da Universidade Luterana do Brasil e professor orientador do Programa de Pós-Graduação em Ensino de Ciências e Matemática (PPGECIM). Endereço para correspondência: Av. Farroupilha, 8001, 92425-900 Canoas, RS. E-mail: bayer@yahoo.com.br

Recebido para publicação em 26/08/2016. Aceito, após revisão, em 8/11/2016.

com o ensino formal, despertando a consciência ambiental e o interesse dos alunos pelos temas ambientais, dentro de propostas contextualizadas.
**Palavras-chave:** Resolução de Problemas. Situações-problema. Consciência Ambiental.

## INTRODUCTION

Nowadays, mankind happened to have a lifestyle that led to the formation of a world with imbalances, generating environmental and social degradation and there is no consensus on how to build a development that integrates social justice, environmental sustainability and economic viability.

Education has a key role in this matter, because it can decisively contribute to pedagogical actions and educational models that meet the changes that society has come to require and aim at forming people able to reflect on social and environmental issues.

According to the National Curriculum Parameters – NCPs (BRAZIL, 1998), UNESCO declared in 1968 that Environmental Education should not constitute a subject, but a topic to be addressed across the board in all subjects of the school curriculum. In this context, the classroom could be used as a space for dissemination of environmental awareness.

However, working with environmental issues in class results, not only in a concern, but also in a problem, because, according to Meyer (2000), we encounter a lack of training and knowledge of teachers for effective work in this area.

In some talks with math teachers, it was found that many of them share at meetings and moments of rest, the anxieties and difficulties on addressing the cross-cutting theme Environment in their classes. It seems that these professionals have the desire to contribute to the students' education so they adopt lifestyles and ways to develop their respect for the operation and limits of nature.

The raised issues originated a doctoral project to answer the following question: could a continued formation in environmental and mathematical education influence the classroom practices of math teachers relating environmental topics and contribute to the development of environmental awareness in the students?

Considering the context above, it was organized and provided an 80-hour continued formation in environmental education and mathematics to math teachers from the final grades of elementary school in the city of São Sebastião do Caí, in order to verify if those involved would modify the conception of environmental education and classroom practices in relation to environmental topics.

Among the activities of this formation, which will be presented in this study, we highlighted the development of mathematical problems relating contextualized mathematical content with environmental topics, because, for Dante (2004), working with problem solving is one of the trends in education, which enables the study of contextualized themes, with possibilities of questioning.

This article addresses how the problem-situations were developed and used in class, and will also address the perceptions of teachers regarding the learning of mathematical knowledge and its relationship with environmental themes regarding the interest and change of students' attitudes facing the environmental situation.

## PROBLEM SOLVING

> One of the main goals of mathematics teaching is to make the student think productively and, for that, nothing is better than introducing problem-situations that involve, challenge and motivate him to want to solve them. This is one of the reasons why the problem solving has been recognized worldwide as one of the fundamental goals of mathematics in the 1st degree. (DANTE, 1991, p.11)

Mathematical educators have studied since 1980 the formulation and resolution of problems due to its great importance to the learning of mathematics. Some experts even consider the tendency to problem solving in elementary school as the main reason for learning and teaching mathematics, because it is through it that we start the student on thinking and applying mathematics.

Nowadays it has been required more and more thinking individuals that know how to interconnect the knowledge they possess. However, it seems that school education has not been very encouraging for this to happen, because with respect to the teaching of mathematics in schools, we see the prioritization of teaching rules and application of appropriate formulas to find certain answers.

We need to break the dichotomy between the way mathematics is taught in schools and the way it is used in solving everyday problems. For this, it will be needed to contextualize the mathematical teachings, relating them to the reality experienced by students through topics that are current or of the students' interest.

> Problem solving is based on the presentation of open and suggestive situations that require the students an active attitude or an effort to find their own answers, their own knowledge. The teaching based on problem solving presupposes to promote in the students the mastery of procedures, as the use of available knowledge, to respond to variables and different situations. (POZO; ECHEVERRÍA, 1988, p.9)

Pozo and Echeverria (1988) also point out that, to teach problem solving is not enough to provide students with effective skills and strategies, it is important to develop in them the attitude to face learning as a problem for which an answer must be found.

According to Dante (1988), the problems should be linked to facts and events of the student's daily life, so, newspapers, magazines, real estate selling ads, polls, misprints, among others, may be used.

> It is, therefore, essential that the study of mathematics be trampled in problem-situations that enable active participation in the construction of mathematical knowledge. The student develops his reasoning participating in activities, acting and reflecting on the reality that surrounds him, making use of the information available. If we want to improve the present state of knowledge, we must wonder about how can, in fact, our student develop critical thinking and logical reasoning. (SMOLE; CENTURIÓN, 1992, p.9)

For Lopes (1994), teachers, on developing the work with problem solving:

> [...] must clearly establish the objectives they intend to achieve. To develop a good activity, the least important is whether a problem is of application or puzzle. The main thing is to analyze the potential of the problem on the development of cognitive skills, procedures and attitudes and on the building of concepts and acquisition of facts from mathematics. The best criterion to organize a repertoire is to select, or even formulate, problems that allow the students to think about their own thinking, placing them in front of different situations. (LOPES, 1994, p.40)

Onuchic (1999) states that,

> […] when teachers teach mathematics through problem solving, they are giving their students a very important and powerful way to develop their own understanding. As students' understanding becomes deeper and richer, their ability to use mathematics to solve problems increases considerably. (ONUCHIC, 1999, p.207)

The presentation of a problem-situation to the student deepens the understanding of existing concepts and favors the formation of others. Through problem solving the self-confidence of students is developed, increasing in them the ease of mathematical problem solving in new situations and making the ability to reason and interpret evolve.

## MATHEMATICAL LEARNING AND ENVIRONMENTAL EDUCATION

According to Búrigo (2009), mathematics can no longer continue to be seen as a linear matter, primarily concerned with facts and capacities, as a science predominantly

related to numbers, mechanically taught and generally characterized by paper and pencil activities. It must, beyond providing a mathematical literacy dedicated to understand the influences that the subject plays in the scientific, technological and social community, also have an approach that links acquirements among themselves reflexively.

We must consider that the student comes to school bringing a culture built in the community he lives in, and teachers should take into account this fact in the preparation of their classes, because according Maccarani (2007), mathematical education aims the formation of the student as a whole, using the mathematical knowledge integrated to other fields of knowledge, starting from the reality that the student is inserted in and also, in a certain context.

The great challenge of mathematics educators is to prioritize the student in the foreground, making mathematics teaching contributes for this student to have a more critic view of reality. This contribution will not be given only through the content learned, but also, according to Caldeira (2001), by its insertion in a political dimension in its form of transmission and assimilation.

The interaction of the knowledge acquired by students in their experience with the knowledge generated by the school's educational action, enriched by discussions regarding social, environmental, political, among others implications, will provide the students the conditions for their daily critic acting.

Unfortunately, due to fragmented practices, there is a great distance between what is taught in schools and what is used to solve everyday situations, then the student is only an observer of his reality and not an active and transformer being. A mathematics teaching proposal focused on environmental issues through problem solving could be an alternative to break this great difference between teaching and doing math.

However, the absence of specific formation in environmental education for teachers reflects the difficulty of carrying out work at the school focused on this topic, encouraging an even more fragmented learning process. Many readings indicate that this is due to a formation or specialization, which does not extend its field of investigation beyond the boundaries of disciplinary knowledge. This thinking is corroborated by Cifuentes and Prestini (2006, p.46), when they say that this difficulty comes from the teacher's education, as "teachers have to think and implement a proposal that they themselves have not experienced at any time of their lives".

For Costa (2009), there is a deficit in educators' qualification in undergraduate courses with regard to work with environmental education, and the solution would be to provide teachers an education through curriculum environmentalization of environmental education.

According to Freire (1996), an intimacy should be established between the fundamental curricular knowledge of students and the social experience they have as individuals, because then, environmental education would become contextualized and the student an active being in the social context and a conscious of their actions citizen.

Therefore, the approach of the program content needs to take into account social, cultural and environmental diversity of students.

As recommended by the Tbilisi Conference (UNESCO, 1997), Environmental Education must be focused on "solving local/concrete environmental problems" and constitute itself as a "generator theme" for discussion in society on how to produce and consume things.

For Novicki (2006), the resolution of local/ concrete environmental problems, as a learning situation, should be related to the following competence to teach: involve students in research activities and knowledge projects for the construction and deconstruction of knowledge and its transformation.

During the use in math classes of the Environment crosscutting theme, teachers will not only be providing students tools to understand phenomena, but also offering subsidies through the use of mathematics in the environmental every day, so that they realize their true role as citizens and social transformers. This interaction between mathematical knowledge and environmental issues in the search for a better understanding of the environment we live in, makes the learning of mathematics and environmental knowledge become significant and transform people's behavior, in order to promote a better quality of life.

This new way of working in the classroom allows students to undergo the process; develop the condition to hear the other; reflect from the existing knowledge toward the constant construction of knowledge; perceive the teacher as organizer and coordinator of the process; finally, build a culture of knowledge and know-how with knowledge.

The teacher, in line with the perspective of work suggested, will be performing a work that aims citizenship, which is announced in the National Curriculum Standards as a work that speaks with the transversality and interdisciplinarity. In addition, environmental degradation may be studied in an inter and transdisciplinary perspective in which mathematical knowledge can be worked out and the formation of students' critic awareness can be developed.

## THE STUDY CONTEXT

This study was developed with 8 math teachers and their students in the city of São Sebastião do Caí in four municipal schools that have the final grades of elementary school and two state schools. The first author of this study exercised the occupation of Education Secretary in the mentioned city and also of coordination of supervision of the same office.

The subjects are distributed below, as we see in Table 1.

TABLE 1 – Research subjects.

| Teacher nickname | Number of classes | Number of participating students |
|---|---|---|
| S1 | 3 | 90 |
| S2 | 4 | 99 |
| S3 | 2 | 49 |
| S4 | 3 | 53 |
| S5 | 3 | 62 |
| S6 | 3 | 51 |
| S7 | 3 | 99 |
| S8 | 1 | 29 |

Source: research data.

The distribution of the participating schools and involved teachers are given in Table 2.

TABLE 2 – Research subjects.

| Schools | Involved teachers |
|---|---|
| Gal. David Canabarro Municipal School | S1 e S2 |
| General São José Municipal School | S3 e S4 |
| Alencastro Guimarães Municipal School | S5 |
| Dr. Alberto Pasqualini Municipal School | S6 |
| São Sebastião State School | S7 |
| Felipe Camarão State School | S8 |

Source: research data.

## METHODOLOGY, RESULTS AND ANALYSES

This paper, which is part of the doctoral thesis project, was the result of a continued formation in environmental education given to math teachers and their students from state and municipal schools of São Sebastião do Caí in the year of 2014. The objective of this study was to verify whether the development of a formation in Environmental Education and Mathematics for these teachers could bring changes in the conception of Environmental Education.

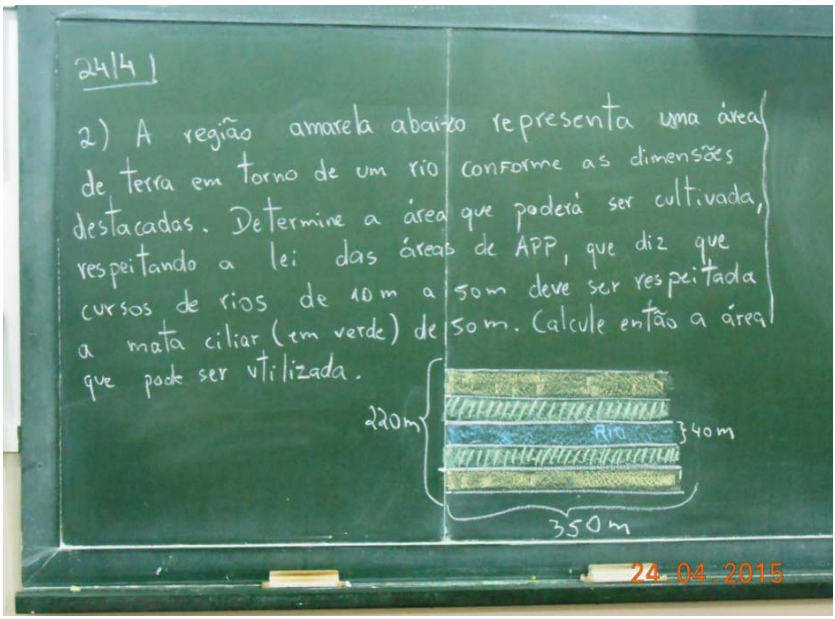
During formation, several problem-situations were developed with activities that integrate mathematical knowledge and environment. Some of these situations will be presented throughout this study.

The problem-situations were elaborated, as environmental topics appeared infrequently or were nonexistent in the textbooks of mathematics of the final grades of elementary school used by the participants of the formation. Several meetings were

held to seek information in electronic media, local newspapers and magazines to the development of problems that explored the preservation of fauna and flora, solid waste, pollution, permanent preservation area – PPA, vegetation, water resources and energy. The mathematical contents involved in addressing these issues were: statistics, rule of three, percentage, proportion, operations with natural numbers, perimeter, area and measures of length, mass and volume.

Eighty problem-situations were created. These situations were worked by the teachers in their classes using printed material or writing on the board. In Figure 1, we have a problem-situation involving area calculation of flat figures and the environmental topic "APP areas" which has been exposed on the board.

FIGURE 1 – Mathematical problem on the board involving the environmental issue of APP areas (Professor S4).



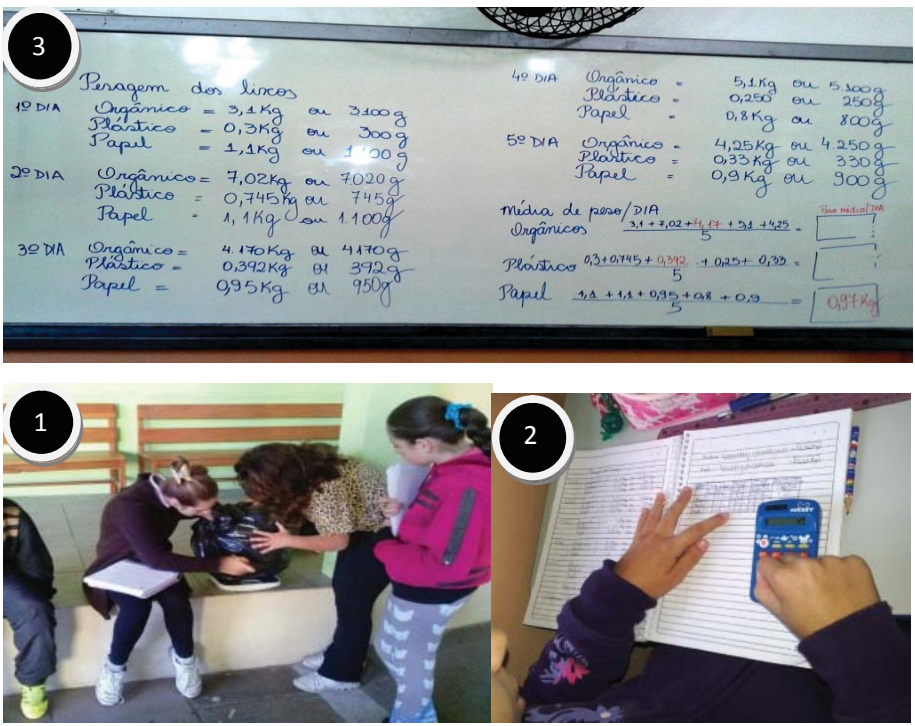

Source: research data.

The situations presented to the students were exploited by the teachers during the development of the mathematical contents that were being studied at the time, for they were not worked far from mathematical concepts studied at the time for each class. They were solved most of the time in groups, because the resolution required much discussion, questioning and decision making to solve the problems that were proposed.

In addition to the problems previously built that were presented to the students using printed material or writing on the board, there were many of them that resulted from situations generated through field research conducted within the school, outside or

around the residence of students. Figure 2 shows three moments[1] of a situation developed in class, originated from a research on waste produced in the school for a week, where the students did the measurement of waste produced per week and an estimated production per month and year. The result brought the involvement of all school sectors in search of less waste production and awareness of the importance of separating the materials found in it.

FIGURE 2 – Situation generated by field research.




Source: research data.

In some cases, the problems generated by field research, led other teachers of other subjects to participate in the theme proposed, through extra activities, as was the case of problems involving the fauna theme. The problem-situation stemmed from a field research to identify animals that the community had in their homes, generating graphics and using percentages to tabulate the data and report on the research.

[1] The moment one is the collection and weighing of waste produced in the school for a week. At the moment 2, students organize the data collected and perform calculations in their notebooks estimating monthly and annual production of waste generated by the school and at the moment 3, the teacher and the students expose and analyze the elaborated data.

In teacher S6's school, the science teacher decided to participate and organized a photo contest with the pets, as the Portuguese teacher organized an essay contest titled "My pet is awesome". Figure 3 illustrates part of the work[2] performed on teacher S6's school.

FIGURE 3 – Problem-situation that generated involvement of other subjects.


Source: research data.

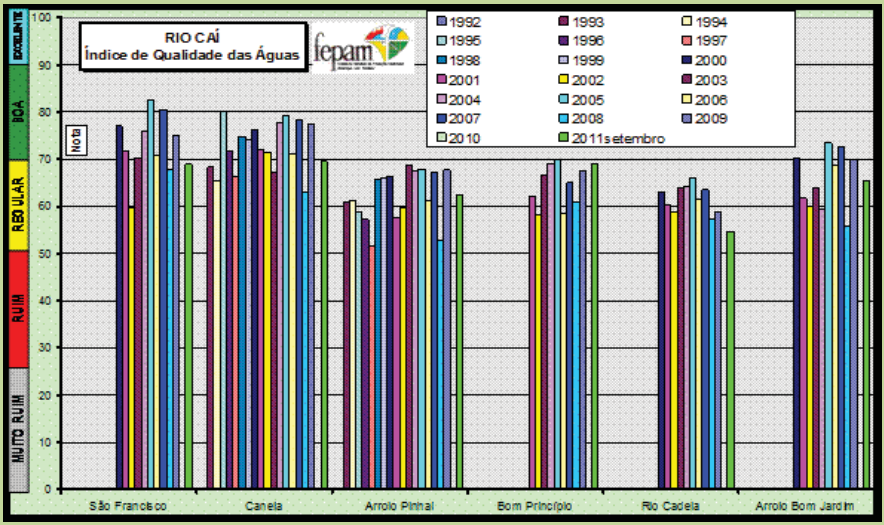
Many of the created situations involved local problems sought in the students' daily lives and substantiated by responsible agencies. Below, in Figure 4, we have a printed

[2] Figure 3 illustrates three moments of a problem-situation generated by a field research where all the animals of the school community were tabulated. Picture 1 shows the data collected by all students and teachers from teacher S6's school; at the moment 2, we have the percentage and rule of three calculations made by the students for the distribution of collected data in graphics and, in picture 3, we have part of the exhibition of the students' pets, where the most beautiful pet was chosen.

problem that was presented to the students, whose data was obtained in FEPAM RS and pointed out the quality index of water in the town districts and cities at its border.

FIGURE 4 – Local problem-situation.

21. *Fepan provides water quality index of some known rivers. In the image below, we see that the upper section of Caí River, in San Francisco de Paula and Canela, has shown grades in the Good range (above 70). The middle section in Bom Princípio presents predominance of quality in the Regular range (50 to 70), indicating no trend. The lower stretch of the Arroio Cadeira and Arroio Bom Jardim also features quality in Regular range.*




*Source: Fepam RS -State Foundation of Enviromental Protection*

*We ask:*
*a) According to Fepam's chart above, which section of Caí River has the worst quality levels of water? And the best ones?*
*b) According to the chart, Caí River also passes through Bom Princípio and, in this city, in which year was the quality index measured better?*
*c) In the city of São Sebastiao do Caí, the chart shows measurements of streams' parts known as Arroio Cadeia and Arroio Bom Jardim which culminate into Caí River. In which streams was the quality index better?*

Source: research data.

Many of the problems have been adapted to the reality of the students and the school. An example is shown in Figure 5, which records an activity performed in a school that has a suspended garden due to flooding in the neighborhood. Students in 6th grade tabulated the teas cultivated in the garden and, then, they built column charts to represent the herbs.

FIGURE 5 – Problem-situation adapted.


Source: research data.

Analyses relating to the change in student attitudes towards environmental issues and perceptions about student learning were described by teachers in a classroom observation form, throughout the development of the classes which dealt with mathematical problems with environmental themes.

For the teachers of 6th grade, students had difficulties in interpreting the mathematical problems with the topic, because to them, the students were used to solve only algorithms and not contextualized problems that needed to be interpreted for choosing the correct mathematical operation to be used on solving the situation. The statement of teacher S8 confirms this finding by saying *"[...] for problems with more than two lines, many students did not complete the reading and came to me so I give the operation to be performed... they had difficulties to interpret [...]"*.

According to Pozzo (1998), if for students, the practical activities from the beginning are mere exercises of applying some algorithm, it will be very difficult to modify these acquired habits and the students will show resistance to reflect and make decisions on how to face the problem and will always wait that the teacher or the book simplify their task, reducing it once more, to a simple application exercise.

> Although it is necessary to exercise skills, much of this exercise can be carried out in the context of meaningful tasks that represent real problems for the students. A good balance between exercises and problems can help students not only to consolidate their skills, but also to know their limits, differentiating known and already practiced situations from the new and unknown ones. (POZZO, 1998, p.161-162)

According to all the teachers, students' interest in the problems was very significant, because students were being awakened to very important environmental situations within the school. This interest may have been motivated by the context provided by the problems, because when teaching is approached to the daily lives of students, it is perceived by them as applicable and, thus, foments the motivation to learn.

According to the teachers in their analysis, contextualization served as learning motivating action, because it was given meaning to the concepts belonging to formal mathematics. According to the NCPs (2000), the formal mathematical knowledge must be transferred, and that will be possible through the contextualization of this knowledge. This contextualization can act as motivating action of learning when the teacher gives meaning to a concept that belongs to the formal mathematics. Also when teacher brings a content of interest or that is part of the context of the students, because the importance of the subject being studied and its applications are shown, motivating them to learn.

For all teachers, students understood the contents worked and realized the need to reformulate the habits and how to care about the environment. For teacher S6, *"[...] the change of thought was visible, I believe that many changes in attitudes will occur over time, I notice positive comments from students about the problems [...]"*.

This change in attitude is also validated by the statements and comments made by students during the activities:

> Why recycling, if the city puts all together again? (Students from teacher S6).
>
> That is why sometimes we have refrigerators on sale which do not spend much, type 'A'. The electric shower spends a lot of electricity, much more than the lights in my house. What are the different trash cans for, if they mix up everything? At home, uncle takes half-an-hour showers, what a waste! (Students from teacher S6).
>
> Can in RS state happen the lack of water as in SP? (Students from teacher S6).

For teachers, beyond the mathematics contribution to the interest and concerns of students about environmental issues, this subject start to be seen by them as a useful and essential tool. They realized that math is important and may be used and applied in a variety of problems, giving subsidies to interpretation of events that occur around us, such as the issues that permeate environmental topics found in the activities developed by the students. This is ratified by the following statements:

> [...] the problems brought new information ... students asked if it was true what was written on the problems (Teacher S2).
>
> [...] students discussed between themselves the information given by the problems, warning that they did not know the situations were so serious ... as the waste of water we have in the running taps. This led them to be more careful. (Teacher S6).

> [...] the problems bring data that students have no knowledge, and as they performed the calculations they realized that small actions make big changes in the environment (Teacher S7).
>
> [...] the students are not used to math classes like this ... there was much participation and interest from most students. The students researched and debated a lot, finding a lot of information on the environmental issue. Many students commented that it did not seem to be a math class [...]. This experience was rewarding (Teacher S1).
>
> Students ask me ... teacher, is it true what is written here? It cannot be that we are doing this [...]. The problems have informed and aware through questionings and numerical calculations "(Teacher S4).
>
> [...] resolutions caused enough controversy and brought a lot of information. Students become aware enough and enjoyed math with the current situations of the environment (Teacher S5).

For Cool (2006), social practices create friendly environments for learning math, but this mathematical learning can be taken as the own participation in social practices. For the author, teaching activities should promote more meaningful learning that leads to a favorable attitude to perform them, allowing the largest number of relationships between different contents. These activities should also facilitate the understanding of a reality that never presents itself compartmentalized.

## FINAL CONSIDERATIONS

The school mathematics should no longer take a neutral position, relying on the fact that it is a science that deals with numbers, an exact science and so rarely questioned. Therefore, this moment is essential, where the teacher can lead the student to not only handle the algorithms, but also to make him able to establish relationships between the results and the context, leading a reality for questioning.

It is a consensus among mathematics educators that the ability to think, reason and solve problems should be the main objectives of the study of mathematics. It is important to note that the content taught to students should be significant and that the student should feel that it is important to know that for their life in society or that it will be useful to understand the world in which he lives. Therefore, for the student to see mathematics as a useful and practical subject and appreciate its power, he needs to realize that math is present in almost everything and it is applied to solve real-world problems.

Among the analyzes conducted with the development of this study, we notice that students become active and participants in the construction of mathematical and environmental knowledge. Problem solving aroused the interest of other teachers, classes become more attractive and, especially, it motivated the development an ecological awareness in the students.

## REFERENCES


BRASIL. Secretaria de Educação Fundamental. *Parâmetros curriculares nacionais*: meio ambiente, saúde. Brasília: MEC/SEF, 1997.

_____. Secretaria de Educação Fundamental. *Parâmetros curriculares nacionais*: terceiro e quarto ciclos: apresentação dos temas transversais. Brasília: MEC/SEF, 1998.

COOL, C. (2006). *O construtivismo na sala de aula*. São Paulo: Ática.

DANTE, Luiz Roberto. *Criatividade e resolução de problemas na prática educativa matemática*. Tese (Livre Docência) Rio Claro: Instituto de Geociências e Ciências Exatas, 1988.

DANTE, Luiz Roberto. *Didática da resolução de problemas de matemática*. São Paulo: Ática, 1991.

DANTE, Luiz Roberto. *Matemática*: 1ª série. 1st edition. São Paulo: Ática, 2004.

ECHEVERRÍA, M.D.P.P.; POZO, J.I. Aprender a resolver problemas e resolver problemas para aprender. In: Juan Ignacio Pozo. *A solução de problemas*: aprender a resolver, resolver a aprender. Porto Alegre: Artmed, 1998.

FREIRE, P. *A pedagogia da autonomia*: Saberes necessários à prática educativa. São Paulo: Paz e Terra, 1996.

LOPES, Antonio José et al. Resolução de problemas: observações a partir do desempenho dos alunos. *Journal of Brazilian Society of Mathematical Education (SBEM)*. Year II – num. 2 e 3, 94th semester, p.33-40.

NOVAES, Eduardo S. *Desenvolvimento sustentável*. Available in: http://www.mre.gov.br. Last access: December 2nd, 2012.

NOVICKI, Victor. *Diagnóstico Sócio Cultural Ambiental*. Rio de Janeiro, 2006. Available at: <http://www.educacaoambiental.pro.br>. Acessed on: December 1st, 2012.

ONUCHIC, Lourdes de la Rosa. Ensino-aprendizagem de matemática através da resolução de problemas. In: BICUDO, Maria Aparecida Viggiani (Org.). *Pesquisa em educação matemática*: concepções e perspectivas. São Paulo: Unesp, 1999.

POZO, Juan Ignacio (Org.). *A solução de problemas*: aprender a resolver, resolver para aprender. Porto Alegre: ArtMed, 1998.

SMOLE, Kátia C.S. e CENTURIÓN, Marilia. *A matemática de jornais e revistas*. RPM, n.20, 1992.

UNESCO (United Nations Educational, Scientific and Cultural Organization). *Educação Ambiental*: as grandes orientações da Conferência de Tbilisi. Brasília: IBAMA, 1997.