#CIMIE16
EDUCATIONAL RESEARCH WITH SOCIAL IMPACT
Sevilla, June 30th and July 1st, 2016

Mathematics teachers´ continuing education: an investigation using GeoGebra software

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1. Objetivos o propósitos:

The use of techniques and technologies in classrooms is not a novelty. According to Lévy (1993), primary oral transmission was the first attempt that people used to establish the communication of their skills and knowledge. Later, writing had a fundamental role in the history of humankind, consolidating it as a collective of beings who learn and teach. In fact, writing has created new memory instances, allowing the decentralization of ideas from individual figures. Moreover, writing, consolidated in the form of book, supplied elements to enable us to record discoveries and ideas in order to promote the knowledge building, facilitating the disclosure of postulates, ideas, discussions, theories and theorems. In what concerns Mathematics, writing had a decisive influence on how one thinks about problems and their solution, inclusively enabling people to produce demonstrations (Borba & Penteado, 2001).

Digital Technologies improved this process. With the use of such resources, specifically in the process of learning and teaching Mathematics, it may be possible through consistent pedagogical techniques, introduce dynamism, experimentation and visualization to classes. Moving a point in a plane or displacing a function curve along an axis, are actions that may help the engagement of students in discussion and criticism processes. Obviously, this will not happen automatically: teacher's planning and guidance are mandatory in order not to lose the essence of the process. What we intend is to teach and learn Mathematics, using all and any technology as an element of mediation (Oliveira, 2007).

The dynamic geometry software is a very valuable resource in creation, planning and presenting interactive Math classes. Depending on the way to use, it can increase understanding of the student more than could occurs under static dimensions. However, the use of GeoGebra, for instance, does not warrant a good Math class. It is teacher responsibility to know how to use appropriate technology, linking it with a specific content. Consequently, teacher has to have a solid knowledge of the subjects to be dealt with, besides developing together with students, the ability to elaborate and solve "good Math problems", as proposed by Brousseau (2008), promoting the convergence between the construction of knowledge and the ideal interfaces to facilitate and dynamize this process.

2. Marco teórico:

From 2010, within the scope of Postgraduated Studies Program in Math Education at the Pontifical Catholic University of São Paulo, were started several research projects based on the continuous education of Primary School Math teachers for the use of technologies in their classes[1]. Some of these applications are described in Oliveira, 2009; Oliveira and Fernandes 2010; Oliveira and Gonçalves, 2013; Oliveira and Santos, 2013; Oliveira and Araujo, 2013. The main way to do this work with teachers is through pedagogical workshops in university informatics laboratories – interested teachers submit their entries by email with personal and professional data. Considering that the available number of places in a particular workshop is limited (around 20), the subscriptions are confirmed by order of arrival. Remaining requests are considered first for next editions.

From the point of view treated in this article, the projects main goal is to enable the development of skills related to the use of digital technologies for Primary Education mathematics teachers who teach at public schools. Moreover, the underlying work intended to promote the development of an understanding regarding the critical use of these resources.

In an objective way, the workshops intend to propose:

- Development of fluency to handle digital interfaces;
- Incorporation of technological resources in the teaching practice;
- Exploration and development of mathematics through the use of technologies;
- Creation of teaching strategies that include interactive media (GeoGebra, Logo, Scratch, among others).

[1] These project are supported by the National Council for Scientific Research (CNPq) – 401390/2010-1 and

These goals have as basis Oliveira's suppositions (2010), for whom the work of a Math teacher who uses technologies represents a cycle involving the above-mentioned steps. When getting in touch with digital interfaces, the education professional has to learn how to work with these technologies, exploring its uses and possibilities. At a next step, each technology becomes an integral part of the practices and modes of thinking Mathematics for the teacher (incorporation of technologies). Then, it becomes possible to think and develop Mathematics in a more refined manner using technological means as mediators. As a final step, teachers should be able to prepare reflexive and consistent pedagogic strategies with the use of such resources. Figure 1 illustrates this proposal.

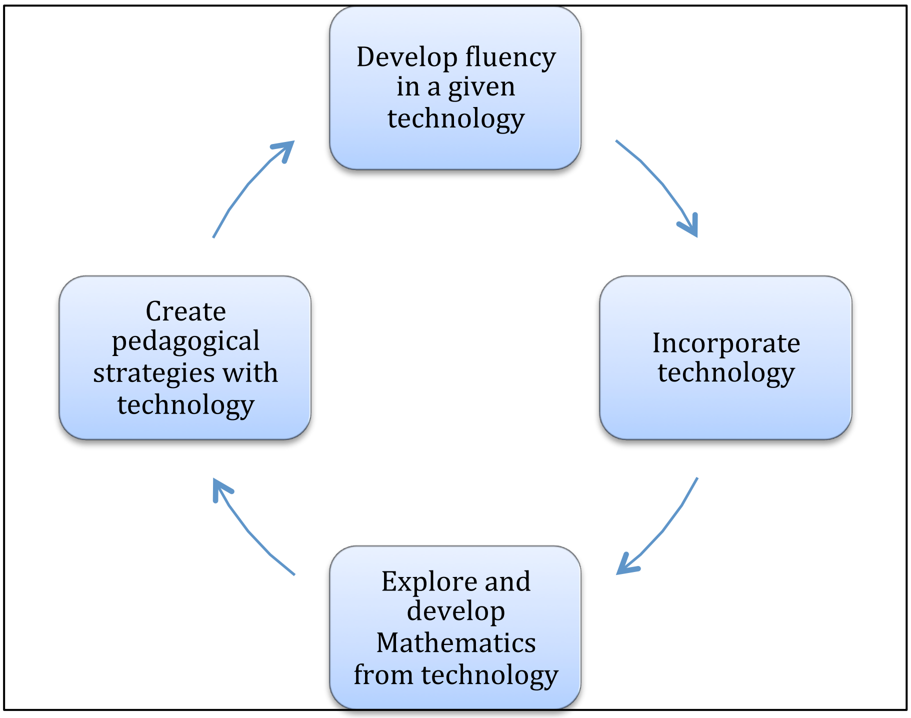

Figure 1. Technologies appropriation process by Mathematics teachers

Based on the mentioned goals, teachers have been invited to participate from free workshops developed at the University laboratories, encompassing subjects such as "Geometric Loci", "First and second degree polynomial functions", "Conics", "Tales Theorem", "Matrices and determinants", "Trigonometric relationships in the right angled triangle", "Prime Decomposition and Prime Sieves", among others.

The theoretical grounds for such initiative take into account recurrent factors in the daily activities of public school Mathematics teachers, among which may be mentioned problems regarding schools' technological infrastructure, excessive workloads and low wages, low student motivation, too high expectations from the community, lack of peer cooperation among other important issues (Huberman, 1992; Mariano, 2006). These elements end up influencing the process of continuous education of teachers who do not have the resources to invest in refresher courses and revision of the mathematic contents with which they are working. Thus, several studies pointed out to a series of didactic difficulties, besides those relative to mathematics (Oliveira, 2010; Garnica, 1997).

The pedagogical workshops herein described try to relate curricular mathematics contents explored by primary school teachers with the possibility of use of digital technologies – GeoGebra, specifically – as a mediator in the teaching and learning process. These workshops enabled the study of elements related to the use of technologies by teachers, besides also offering training opportunities. In this paper, the analysis considers a mathematic task carried out by teachers using GeoGebra from a qualitative viewpoint, under the light of content analysis (Bogdan & Biklen, 2001). Nineteen mathematic teachers participated of this investigation, all of them with similar professional profile: acting at public schools located in the State of São Paulo, with 5 to 10 years of experience in the position, working in less privileged neighborhoods and initial university training in Mathematics.

3. Metodología:

Among the twelve activities proposed in the "Geometric Loci with GeoGebra" workshop, we decided to describe and analyze one of them in this paper, in order to provide a synthesis: the activity that yielded more discussion among participants. The statement was the following: "A car is located at 3.5 km from Parque Raul Seixas (point A in map) and 4.5 km from Praça Jequitibá (point B in map). In which places the car could be? Open the corresponding file, locate the map and solve the activity at GeoGebra" (Oliveira & Araujo, 2011). Figure 2 was available to students when they opened the respective files.

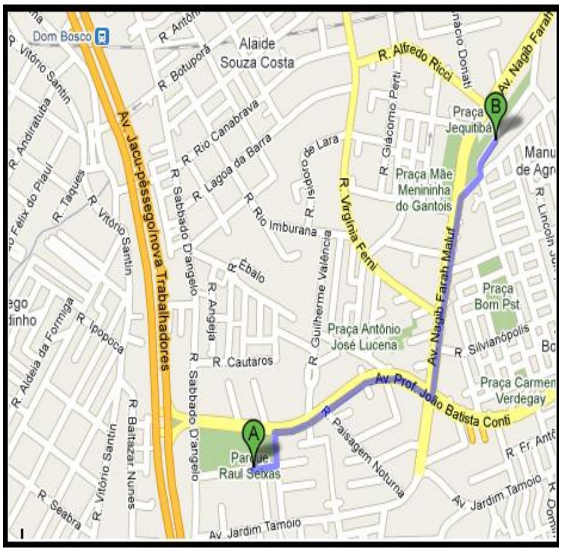

Figure 2. Map associated to activity proposed to teachers (Source: Google Maps)

Figure 3 shows a proposal to solve this activity. From the mathematical viewpoint, one tries to mobilize the notion of circumference as geometric locus from equidistant points from the other given point (the center of the circumference), although at no moment this has been mentioned to them.

Figure 3. Proposal to solve the activity with GeoGebra

4. Discusión de los datos, evidencias, objetos o materiales

At a first moment, only seven teachers finished the task without presenting any mathematical doubt, seven others tried to ask to researchers to get answers related to the involved mathematical concepts, while five teachers concluded without questions but in a wrong manner, as evidenced in Figure 4.

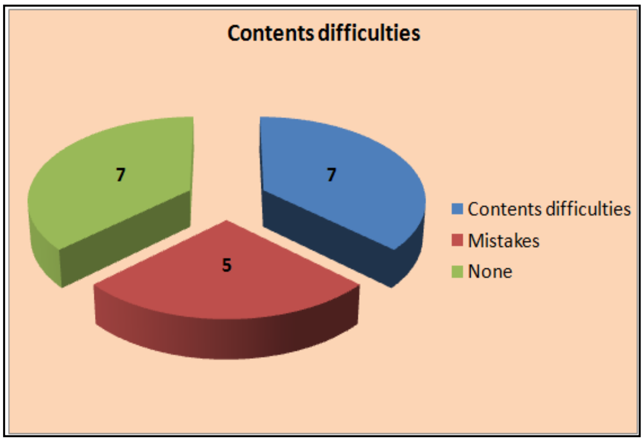

Figure 4. Contents difficulties

Regarding the circumference as a geometric locus, twelve teachers resorted to it as a way to propose an answer. As already mentioned, only seven did it correctly, i.e., five teachers used the circumference but did not solve the task.

Regarding presented difficulties, teachers claimed they were related to the understanding of the problem, to the use of the mathematics content in question and to the GeoGebra interface.

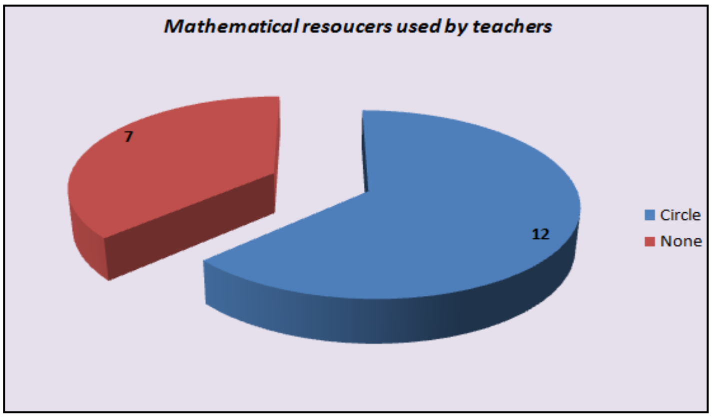

Figure 5. Mathematic Resources Used by Teachers

With regard to the difficulties related to the interface, teachers mentioned that such problems result from the didactic use of the computer in general. The reasons they pointed out were the following:

- Absence of a specific training for the use of computers as teaching-learning interfaces;
- Excessive workload, which does not allow them to attend specific courses;
- Never took part from distant education initiatives nor learned how to use virtual learning environments;
- In general, Brazilian public schools have numerous infrastructure restrictions (computer labs do not have a sufficient number of equipments nor have adequate programs).

After gathering the preliminary results herein mentioned, the researcher suggested participants should gather in small groups and discuss the involved mathematic concepts, searching solutions in a collaborative manner, without the presence of those teachers who had already solved the problem correctly. Next, each teacher returned to his/her computer in order to implement what has been discussed. All twelve remaining teachers were able to solve the problem correctly at this second step.

Invited to expose their impressions about the activity and its difficulties, most participants reported that the axiomatic method used almost exclusively in their school lives did not help them in the problem-solve approach in their practices – and they really had difficulties in understanding underlying issues as in the described case. Thus, one may ascertain that the difficulties and errors had a stronger relationship with the interpretation of the problem and mobilization of necessary mathematical knowledge to solve it, than the lack of knowledge of Mathematics in itself. When asked about the factors that were decisive for they could understand the problem and solve it consistently, the twelve teachers who had not performed the activity in the first time pointed two important elements:

- Collaborative approach;
- Possibility of doing different experimentations with GeoGebra.

Besides, when was asked how they could use Geogebra to solve problems with theirs public school students, they mentioned that a planning taking into account the difficulties of their students would have to be prepared, in order to incentive them to search solutions with their own resources, such as happened with them. The term used to define this previous work recovered a concept they had encountered in the readings proposed by the workshop: "pedagogical strategy" (Oliveira, 2010). It would be necessary to create learning situations that would incentive autonomy and the development of conjectures. In these situations, the teacher would be a coach, and the student would go forward as possible, exchanging ideas and dynamically manipulating constructions. At the end, the teacher would recover the work done with everyone and would show mistakes and successes, formalizing knowledge. The teachers were surprised when the researcher informed them that this was the basis for the Theory of Didactic

Situations (Brousseau, 1987), that could be seen, according to Oliveira (2009), with a new element besides the teacher, students and knowledge. This new element is represented by the set of pedagogical strategies through which mediations are made between the three previous elements, as shown in Figure 6.

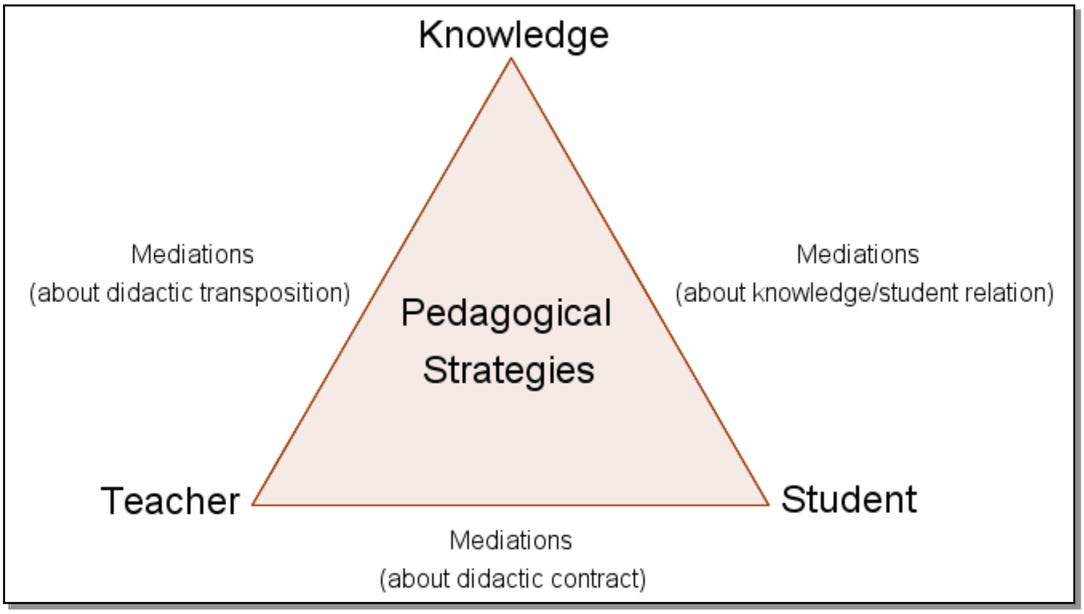

Figure 6. Brousseau's triangle in a scenario were technologies as being employed

5. Resultados y/o conclusiones

The perception that workshops may be useful in the professional development of Primary School mathematics teachers surfaced from the discussions and progresses that participants made along the activities that have been carried out. From initial difficulties to discussions and from errors in the tasks to their successful completion, we perceived an important possibility of continuous training using digital technologies as mediators. Even if a subsequent development and other researches are necessary, one may perceive that participants went through the development of fluency in the interfaces, indicating the possibility of incorporating the technologies to their practices. Some teachers even reported that they were already using GeoGebra with their students, proposing problems similar to those presented at the workshop they were attending. This also shows the perspective of exploring and developing Mathematics with the use of GeoGebra and consequently leads to the development of pedagogical strategies that allow give sense and organization in the building of knowledge. These were exactly the steps proposed in the processes of technological appropriation by mathematics teachers (Figure 1)

As to overcoming problem interpretation difficulties and mathematical contents, the strategy herein described that used GeoGebra allows for four dimensions seen as essential in the analysis we carried out:

1. Experimentation: dynamically testing different conjectures;
2. Visualization: perceives the maintenance (or not) of the proprieties of mathematical objects, confirm the result of the conjectures implementation;
3. Interaction: In Levy's conception (1993), GeoGebra offers a reactive interactivity regarding user's actions;
4. Intervention: this dimension regards the change of parameters and other changes that depend from the knowledge of mathematics and experience with the program.

Besides, the data gathered in this research allowed us to identify the conceptual difficulties presented by teachers, in order to propose the means to overcome them through a strategy employing GeoGebra. However, the possibilities of generalization of these statements should be the focus of further and deeper investigations.

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