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7.2 How a street lamp, paper folding and GeoGebra can contribute to teachers’ professional development

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Abstract: Professional development of the mathematics teacher is explored through activities addressed to students and proposed to teachers in order to discuss them from different points of view: mathematical, educational and technological. The activities belong to a wide research project carried out in Italy and Australia bounded to teachers. The data collected from the research were discussed during the workshop, analyzing the shared praxiologies emerged.

Introduction

The activities proposed to the teachers belong to an international research project, named "Problem Solving with GeoGebra", which involves two different countries, Australia and Italy (and in Italy University of Torino, Valle d’Aosta, Barì). The aim of the project is to engage in-service secondary school teachers in professional development based on best practices in mathematics with GeoGebra. The activities are in the spirit of the methodology of "Mathematics Laboratory" (UMI, 2003). The teachers are observed during the project and data are analysed according to "the Meta-Didactical Transposition" framework (Arzarello et al., 2012).

This research project is connected to a national teachers' education programme, named PLS (Piano Lauree Scientifiche), born in 2004 from the collaboration among the Ministry of Education, the National Conference of Headmasters of Science and Technology University Faculties, and Confindustria, with the aim of promoting the cooperation between school teachers and university teachers in education, working together to design didactical activities, and of orienting students towards scientific choices at University.

Rationale of the workshop

The current Italian paradigm for the research in Mathematics Education is “Research for innovation” (Arzarello et Bartolini Bussi, 1998), integrated with the new paradigm of Meta-Didactical Transposition (Arzarello et al., 2014; Aldon et al., 2013). The first paradigm is based on teaching experiments in classroom that involve teachers in every phase of the research, with different roles: teacher-researchers (working with the group of researchers), teacher-trainers (doing education programmes for teachers) and teachers (involved in teacher programmes as learners, and working in class as teachers). Sometimes the same teachers may have different roles in different phases of the project: for example, a teacher-researcher can be also teacher-trainer during the process of professional development in the education programme for teachers. The second paradigm is the theoretical background to the design phase and the teacher education phase, when the cooperation and collaboration between teachers and researchers is particularly meaningful. The theoretical framework for data analysis is based on the Meta-Didactical Transposition, an innovative model elaborated in 2012 by the research group of Torino and Modena and presented in the National Seminar of Mathematics Education (http://www.seminarioioida.unimo.it/mat12.php).

In this model the teachers are observed during their training process in order to check whether the traditional methodologies are transformed in order to give space to laboratorial activities, using technologies.
The Meta-Didactical Transposition model is based on the Anthropological Theory of Mathematics Education (Chevallard, 1999) but it refers to the specific context of teachers' training (considering the actions of researchers, teacher-researchers, teacher-trainers and teachers) and focuses mainly on the "meta" aspects, which are related to the reflection on the process of formation itself. Two are the communities involved in the formation process: the community of the researchers (who organizes and directs the activities) and the community of teachers (who are in training). Each of these communities has got its own praxeologies. The praxeologies are declined through two main aspects (García et al., 2006): the "knowledge" (the praxis) which includes a family of similar problems to be studied, as well as the techniques available to solve them and the "knowledge" (the logos) that is the "discourses" that describe, explain and justify the techniques that are used. The "knowledge level" can be further decomposed in two components: Technologies and Theories.

A praxeology consists in a Task, a Technique, and a more or less structured Argument that justifies or frames the Technique for that Task. The MDT model considers the meta-didactical praxeologies, which consist of the tasks, techniques, and justifying discourses that develop during the process of teacher education.

Meta-Didactical Transposition considers the mechanism in which the praxeologies of the researchers’ community are transposed to the community of teachers, and how this implementation transforms the professionalism of teachers. In that way, we can observe a shift from the "savoirsavant" to the mathematical and pedagogical knowledge necessary for teaching (Arzarello et al., 2014; Arzarello et al., 2013; Akih et al., 2013).

The purpose of the "Problem solving with GeoGebra" project is to transform the teachers' praxeologies in new praxeologies, which are the fusion of the praxeologies of the two communities involved, becoming at the end the shared praxeologies. The "broker" (mediator) is the person who belongs to more than one community and is able to create new connections between them and opens new possibilities for the construction of meanings (Rasmussen et al., 2009). The role of the broker (the teacher-trainers in our project) is fundamental for the creation of the shared praxeologies.

The synergetic interaction between the two communities (the researchers' community and the teachers' community) can be declined through different phases. In the design phase we can see the university researchers working together with the teacher-researchers and the teacher-trainers in order to construct the project and the activities, involving both poor materials and technological tools, such as GeoGebra. The use of a Dynamic Geometry Software (DGS) has the power to mediate the construction of knowledge transferring the manipulation of the poor materials in the dynamic sketch, and favouring the exploration and the conceptualisation. The research phase concerns all the research aspects related to the international project with Australia. The main actors are the researchers, they define the framework of the research itself and the main aspects to analyse.

The dissemination phase, which is deeply connected to the others, concerns the education of in-service secondary school teachers in the national programme PLS. In this phase the actors involved are: the teachers and the teacher-trainers (the same involved in the design phase, as teacher-researchers). Teacher-trainers are the "brokers" between the two communities. The teachers are involved in two different ways: the first one concerns their professional development in a blended modality (exchanging ideas, results and practices during face-to-face meetings and through an on-line platform) and constructing a community of practice (Wenger, 1998). The second one concerns the teaching experiment in their classroom.

In the data analysis phase, teacher-trainers, teacher-researchers and university researchers are involved in recognizing the introduction of shared praxeologies between the two communities, thanks to the action of the brokers.

Activity of the workshop and discussion

The workshop was mainly focused on the "Streetlamp problem", an open ended problem designed in order to give students a meaningful situation for reasoning, arguing, discussing and proving.

In the design phase we chose (as researchers) an item of OECD tests involving geometry and we tried to transform it from a closed problem, with a unique expected answer, to an open ended one.

This is the item we started from: "The city council has decided to place a streetlamp in a small triangular park so that the whole park is lit. Where should the streetlamp be placed?"

Changing the formulation of the problem, according to our project, we gave more space to the exploration phase with GeoGebra, more space to different solution and more space to discussing, arguing, justifying and proving. This is the new text: "The city council has decided to build a small triangular pedestrian area planned by the previous administration, the registered project foresees only one street lamp as illumination for the whole area. Can you help the technician, who will have to deal with the installation, to find the exact point where the street lamp should be placed? Now open the file GeoGebra Lampion.ggb. You will find the area to be lit. Together with your group find a
solution to the problem, giving reasons for your choices. In your opinion does the position depend on the shape of the pedestrian area? What happens if the triangle changes? Answer and give reasons for your answers?"

The problem is related to the exploration of a contextualized situation that leads to the discovery of geometrical properties. The aim of the problem is to have a meaningful problem, powerful in engaging students into a specific context and stimulate their problem-solving competences, not to have a real-life problem. This problem is characterized by the openness that allows students to do maths and to build a piece of knowledge finding solutions by themselves, exploring, arguing and giving the reason of their choices. The power of open-ended problems is that the solution depends not only on the problem itself, but also on the interpretation of the problem that students have, on the constraints they fix, on the assumption they make.

The activity has been designed for grade 7 to 11, but it is enough open to be used at different grades or educational contexts, and to be solved with several strategies. The participants to the workshop were asked to identify which was the suitable position to place a lamp to enlighten the square, exploring the problem with poor materials and then to think about representing the situation with GeoGebra, finding a suitable solution and give reason for their choices as they were students (first level, the student side). Then, they were asked to think about their students (second level, the professional side). The problem was also discussed under other different levels: the technological point of view (thinking about potentialities and limits of technology and instruments) and the (meta)didactical transposition level (thinking about the activity and the mathematical concepts involved and about the praxeologies). The activity offered several points of discussion in the workshop regarding the use of poor materials (like paper folding, a torch, ...) and the different use of software and their strong and weak points.

During the workshop participants worked in small groups, as students in a classroom, using in each one a different triangle, a torch and then GeoGebra. Some teachers, during the exploration phase, tried to find the best triangular shape to fit a given circle (in order to waste the minimum amount of light) instead of looking for the best point to put the lamp in.

The discussion was so rich that there was not enough time to discuss all the points the participants were asked to reflect on. We mainly focused on the problem, the materials and the technology.

While discussing about the aims of the problem, some participants underlined that this problem seems to be not a real problem, according to Paul Drijvers’ (2013) meaning, but it represents a very good problem for discussion and arguing. The added value of the problem stands in the use the teacher makes of it. The discussion went on trying to contextualize in real life the problem and some participants suggested to make clear the measure of the square’s edges in order to create a real-life situation.

Some cultural differences emerged during the discussion by some Polish and Czech sharers: in their country the flowerbeds are not pedestrian, so they had some difficulties to understand which whose the pedestrian area to enlighten. This made us to discuss about the cultural context and its importance when posing a problem.

The importance of poor materials such as paper folding, paper triangles and the torch has been underlined during the discussion, furthermore some participants argued that this kind of materials are instead very "rich" because allow students to experience mathematical concepts with their bodies.

Since we did not have many computers, participants used a little technology, but pointed out that the dynamic geometry software are useful in the process of generalization and abstraction, but they focused their attention to the problem, not to the students.

Data analysis

The data collected during the project have been analysed in order to check if the brokering had been performed and to recognize the shared praxeologies arose by the interaction between the two communities.

We analysed the behaviour of the teachers during the training meetings and we noticed that while they were solving the problem as if they were students, simultaneously they were thinking with the "mind of the teachers", imagining how their students would have solved the same problem and reflecting about the possible processes of the students.

During the workshop we showed some excerpts from the professional development of teachers in contact with the community of researchers, you can find an example in the image below.

This is an example of how praxeologies of teachers can change through the brokering of the teachers-researchers. On the left we have the starting point of the teacher about teamwork and the use of GeoGebra. In the middle we can see what he said to his students during the teaching experiment. At the end, on the right side we can see the final point of view the teacher wrote in the relation about his work. So we can notice that there is a development in
the professionalism of the teacher, thanks to the brokering of the teacher-researchers and teacher-trainers during the educational activity.

Among the praxeologies of the researchers we chose to analyse the Design of a task for the teachers and we declined it under the four elements identified in didactic transposition theory (Chevallard, 1999):

Task: designing the activity for teachers and students;

Technique: finding a problem considered linked to the topics of Curriculum; opening a close-ended problem, adapting it to the aims of the project, the methodology to induce, the use of GeoGebra, and the institutional constrictions;

Technology: institutional (the new curriculum), from research about exploring, conjecturing, arguing, proving, the use of mathematics laboratory and use of GeoGebra;

Theory: research elements such as: open problem, conjecturing and arguing, mathematics laboratory, meta-didactical transposition, communities of inquiry, with the related literature as background.

This praxeology can become a shared praxeology when teachers, during the educational course, designed tasks for their own students.

REFERENCES


