THE TEACHER'S USE OF ICT TOOLS IN THE CLASSROOM AFTER A SEMIOTIC MEDIATION APPROACH

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The issue of the teacher's role in exploiting the potentialities of ICT tools in classroom is more and more raising the interest of our community. We approach this issue from the Semiotic Mediation perspective, which assigns a crucial importance to the teacher in using ICT tools in the classroom. In the report we describe a Teaching Sequence centred on the use of the tool Casyopée and inspired by the Theory of Semiotic Mediation. Then we focus on the teachers' use of the tool with respect to the orchestration of collective activities and present an on-going analysis of her actions.

INTRODUCTION

Recent research points out a wide-spread sense of dissatisfaction with the degree of integration of technological tools in mathematic classrooms. Kynigos et al. observe that so far one did not succeed to exploit the ICT potential suggested by research in the 80s and the 90s and denounce that "the changes promised by the case study experiences have not really been noticed beyond the empirical evidence given by the studies themselves" (Kynigos et al. 2007, p.1332).

The acknowledgement of the existing gap between the research results on the use of technology in the mathematical learning and the little use of these technologies in the real classroom led recently to reconsider the importance of the teacher in a technology-rich learning environment, and to investigate ways of supporting teachers to use technological tools.

Those "teacher-centred" studies have been developed from different perspective and address different aspects, for instance: teacher education (Wilson, 2005), teachers' ideals and aspirations regarding the use of ICT (Ruthven, 2007), teacher's role in exploiting the potentialities of ICT tools in the classroom.

With that respect, as Trouche underlines, most studies refer to the importance of teachers' guide or assistance to students' activities with the technology (Trouche, 2005). Trouche himself emphasizes the need of taking into account the teacher's actions with ICT. For that purpose he introduces the notion of "instrumental orchestration", that is the intentional systematic organization of both artefacts and humans (students, teachers…) of a learning environment for guiding the instrumental geneses for students (ibidem, p.126).

Within this approach the teacher is taken into account insofar as a guide for the constitution of mathematical instruments.

As we will argue in the next section, guiding the constitution of mathematical instruments does not exhaust the teacher's possible use of ICT. In fact ICT tools can be used by the teacher (a) for developing shared meanings having an explicit formulation, de-contextualized with respect to the ICT tool itself and its actual, recognizable and acceptable in respect to mathematicians' community, and (b) for fostering students' consciousness-raising of those meanings. The Theory of Semiotic Mediation (Bartolini Bussi and Mariotti, 2008) takes charge of that dimension.

In this report, we present an analysis of the teacher's use of an ICT tool within the frame of the Theory of Semiotic Mediation. More precisely we focus on the teacher's promotion and management of collective discussions. But a systematic discussion of the role of the teacher or a classification of her possible actions is out of the goals of the present paper. The context is a teaching sequence, inspired by the Theory of Semiotic Mediation, and centred on the use of the tool Casyopée. Both the teaching sequence and the tool are presented in the next sections, after recalling some basic assumptions of the Theory of Semiotic Mediation.

THE THEORY OF SEMIOTIC MEDIATION

Assuming a Vygotskijan perspective Bartolini Bussi and Mariotti put into evidence that the use of an artefact for accomplishing a (mathematical) task in a social context may lead to the production of signs, which, on the one hand, are related to the actual use of the artefact (the so called **artefact-signs**), and, on the other one, may be related to the (mathematical) knowledge relevant to the use of the artefact and to the task. As obvious, this knowledge is expressed through a shared system of signs, the mathematical signs. The complex of relationships among use of the artefact, accomplishment of the task, artefact-signs and mathematical signs, is called the **semiotic potential** of the artefact with respect to the given task.

Hence, in a mathematics class context, when using an artefact for accomplishing a task, students can be led to produce signs which can be put in relationship with mathematical signs. But, as the authors clearly state, the construction of such relationship is not a spontaneous process for students. On the contrary it should be assumed as an explicit educational aim by the teacher. In fact the teacher can intentionally orient her/his own action towards the promotion of the evolution of signs expressing the relationship between the artefact and tasks into signs expressing the relationship between the artefact and knowledge.

According to the Theory of Semiotic Mediation, the evolution of students' personal signs towards the desired mathematical signs is fostered by iteration of **didactic cycles** (Fig.1) encompassing the following semiotic activities:

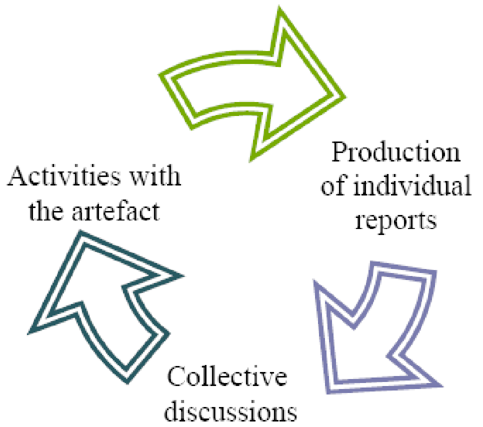

Fig. 1. Didactical Cycle

- activities with the artefact for accomplishing given tasks: students work in pair or small groups and are asked to produce common solutions. That entails the production of shared signs;
- students' individual production of reports on the class activity which entails personal and delayed rethinking about the activity with the artefact and individual production of signs;
- classroom collective discussion orchestrated by the teacher

The action of the teacher is crucial at each step of the didactic cycle. In fact the teacher has to design tasks which could favour the unfolding of the semiotic potential of the artefact, observe students' activity with the artefact, collect and analyse students' written solutions and home reports in particular posing attention to the signs which emerge in the solution, then, basing on her analysis of students written productions, she has to design and manage the classroom discussion in a way to foster the evolution towards the desired mathematical signs.

The Theory of Semiotic Mediation offers not only a frame for designing teaching interventions based on the use of ICT, but also a lens through which semiotic processes, which take place in the classroom, can be analysed (for a more exhaustive view, see Bartolini Bussi and Mariotti, 2008).

CASYOPÉE

Casyopée (Lagrange and Gelis 2008) is constituted by two main environments which can "communicate" and "interact" between them: an Algebraic Environment and a Dynamic Geometry Environment (though the designers' objective was not to develop a complete CAS or a complete DGE). Possible interactions between the two environments are supported through a third environment, the so called "Geometric Calculation". Without entering the details of Casyopée functioning, we can illustrate it through the following example.

If one has two variable geometrical objects in the DGE linked through a functional relationship (e.g. the side of a square and the square itself), Casyopée supports the user in associating algebraic variables to the geometrical variables and building an algebraic expression for the function (e.g. the function linking the measure of the length of the side, as independent variable, and the measure of the area of the square, as dependent variable). The generated algebraic variables and functions can be exported in the Algebraic Environment, and then explored and manipulated.

DESCRIPTION OF THE TEACHING EXPERIMENT

The Theory of Semiotic Mediation shaped both the design and the analysis of the teaching experiment carried out. In this chapter, we briefly describe the design.

Educational Goals of the designed teaching sequence.

The design of the teaching intervention started from the analysis of the semiotic potential of the tools of Casyopée. That analysis led us to identify two main educational goals: fostering the evolution of students' personal signs towards

1. the mathematical signs of function as co-variation and thus consolidate (or enrich) the meanings of function they have already appropriated, that entails also the notions of variable, domain of a variables…;

2. the mathematical meanings related to the processes characterizing the algebraic modelling of geometrical situation.

Description of the teaching sequence

According to our planning the whole teaching sequence is composed of 7 sessions which could be realized over 11 school hours.

The whole teaching sequence is structured in didactical cycles: activities with Casyopée alternate with class discussions, and at the end of each session students are required to produce reports on the class activity for homework.

The familiarization session is designed as a set of tasks and aims at providing students with an overview of Cayopée features and guiding students to observe and reflect upon the "effects" of their interaction with the tool itself, e.g.:

> Could you choose a variable acceptable by Casyopée and click on the "validate" button? Describe how the window "Geometric Calculation" change did after clicking on the button. Which new button appeared?

Besides familiarization, the designed activities with Casyopée consist of coping with "complex" optimization problems formulated in a geometrical setting and posed in generic terms, e.g.:

> Given a triangle, what is the maximum value of the area of a rectangle inscribed in the triangle? Find a rectangle whose area has the maximum possible value.

The aim is to elaborate on those problems so to reveal and unravel the complexity and put into evidence step by step the specific mathematical meanings at stake.

The diagram (Fig. 2) depicts the structure of the teaching sequence: the cyclic nature of the process, which develops in spirals, is rendered through the boxing of the cycles themselves.

Implementation and data collection

With some differences, the teaching sequence was implemented in 4 different classes (3 different teachers): two 13 grade classes and a 12 grade class of two Scientific High Schools, and a 13 grade class of Technical School with Scientific Curriculum.

Different kinds of data were collected: students' written productions; screen, audio and video recordings, and Casyopée log files. The analysis presented below is based on the verbatim transcription of the video recordings of the classroom discussions.

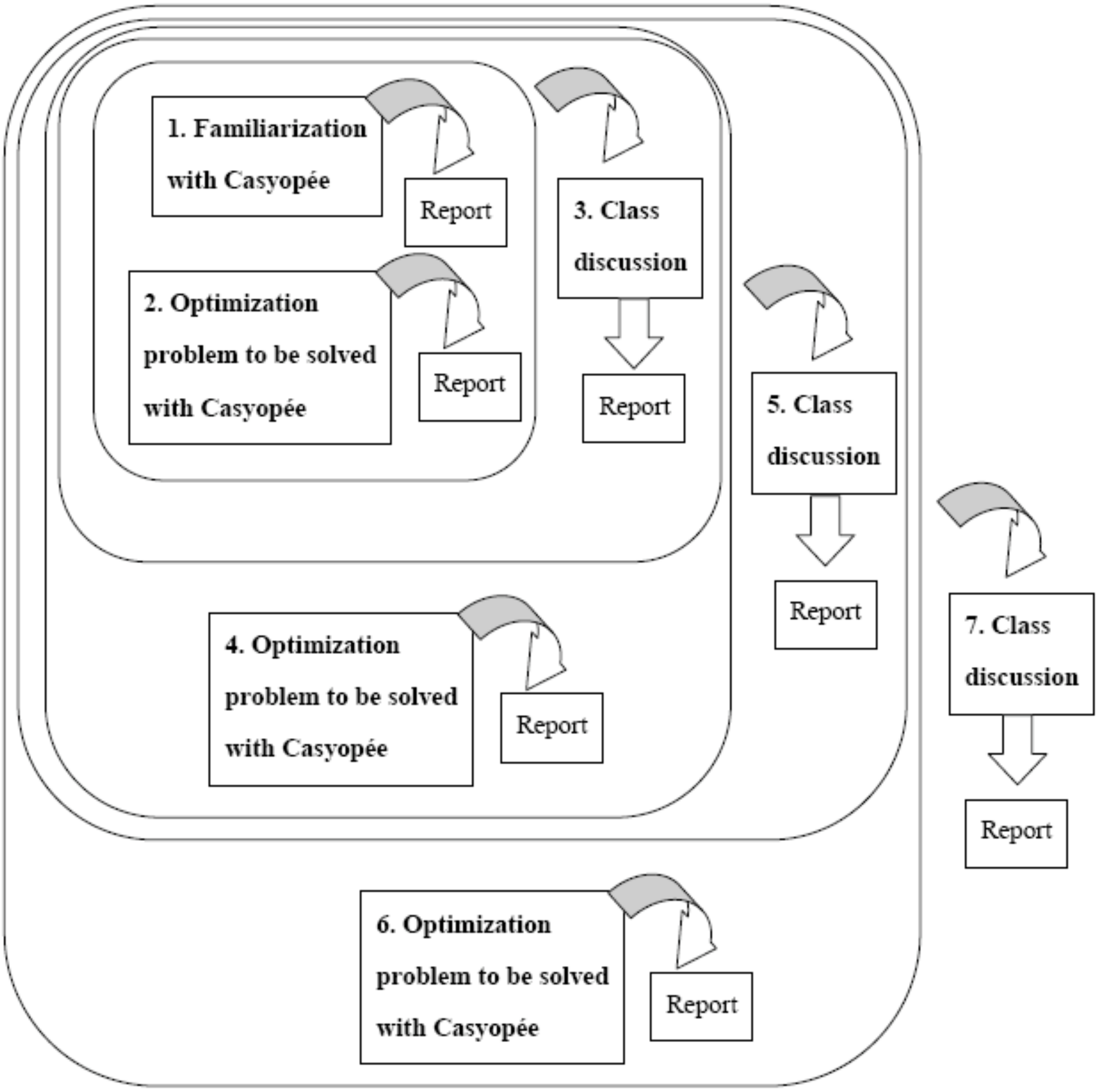

Fig. 2. Outline of the Teaching S

ANALYSIS OF THE TEACHER'S ACTIONS

According to the theory of Semiotic Mediation, the teacher's action should aim at promoting the evolution of students' personal signs towards mathematical signs. Such evolution can be described in terms of *semiotic chains*, or chains of signification to use Walkerdine's terminology, that is:

> "particular chain of relations of signification, in which the external reference is suppressed and yet held there by its place in a gradually shifting signifying chain." (Walkerdine, 1990, p.121).

The following excerpt is drawn from the transcript of the class discussion held in the 5th session. It shows an example of how artefacts signs are produced in relation to the use of the artefact, and how they may evolve during the discussion. We first go quickly through the excerpt showing the evolution of signs, then we will analyse how the teacher contributes to this evolution.

1. Teacher A: "Which are the main points to approach this kind of problem? Which kind of problem did we deal with? […] What is an important thing you should do now? To see the general aspects and apply them for solving possible more problems with or without the software, […] the software guided you proposing specific points to focus on.[…]"

2. Cor: "[…] First of all we had to choose the triangle by giving coordinates"

[Students recall the steps to represent the geometrical situation within Casyopée DGE]

5. Luc: "But you have to choose a mobile point, first […]"

6. Teacher A: "Does everybody agree?[…]How would you label this first part? […]"

7. Students: "Setting up"

8. Teacher A: "Luc has just highlighted something […] do you see anything similar between the two problems?"

9. Sam: "One has always to take a free point which varies, in this case, the areas considered […]"

10. Teacher A: "Then we have a figure which is…"

11. Students: "Mobile."

12. Teacher A: "Mobile, dynamical. Let us pass to the second phase. Andrea, which is the next phase? […]"

13. And: "The observation of the figure would let us see… we need to study that figure and observe what the shift of the variable causes…"

14. Teacher A: "Ok, then? Everybody did that, isn't it?"

15. Sil: "We computed the area of the triangle and of the parallelogram, we summed them, and by shifting the mobile point one observed as [the sum of the areas] varied […]"

Focusing on students' signs, one can notice:

- Elements of a collectively constructed *semiotic chain*, in which a connection is established between artefact signs ("mobile point") and mathematical signs ("variable"). The elements of this semiotic chain are: "movable point" (item 5), "free point" (item 9), "variable" (item 13), and "movable point" (item 15). It is worth noticing the two directions: from the artefact sign (“mobile point”) to the mathematical sign (“variable”) and vice versa. That semiotic chain shows: (a) students’ recognition that geometrical objects can be considered (can be treated, can act) as variables, and (b) the enrichment of students’ meanings of variable to include meanings related to “movement”.

- Elements of a collectively constructed *semiotic chain,* in which the meaning of function as a relation of co-variation of two variables emerges. The elements of this semiotic chain are: “a free point which varies […] the areas” (item 9), “the shift of the variable causes” (item 13), “by shifting the movable point, one observed as [the sum of the areas] varied” (item 15).

Analysis of the Teachers’ orchestration of the discussion.

We reconsider the excerpt previously analysed form the point of view of the signs produced and used by students. Here we focus on how the teacher’s actions fuel the discussion, foster the production of artefacts signs in relation to the use of the artefact, and create the conditions for their evolution during the discussion.

1. Teacher A: “Which are <u>the main points to approach</u> this kind of problem? Which <u>kind of problem</u> did we deal with? […] What is an important thing you should do now? <u>To see the general aspects</u> and apply them for solving possible more problems with or <u>without the software</u>, […] <u>the software guided you proposing specific points to focus on</u>.[…]”

The teacher starts the discussion by making explicit its objectives: to arrive at a shared and de-contextualized formulation of the different mathematical notions at stake (“to see the general aspects and apply them for solving possible more problems with or without the software”).

In order to do that, the teacher asks students to recall the problem dealt with in the previous section and to report on the solutions they produced. She explicitly orients the discussion towards the specification of the main phases of the solution of the problem, asking students to look for similarities between the two problems addressed so far and between the strategies enacted to solve them.

While asking students to do that, the teacher suggests to refer to (or to remind) the use of the DDA. The suggestion to explicitly refer to the use of Casyopée facilitates the production and use of artefact-signs and the unfolding of the semiotic potential.

5. Luc: “But you have to <u>choose a mobile point</u>, first […]”

…

8. Teacher A: “<u>Luc has just highlighted something</u> […] do <u>you see anything similar between the two problems</u>?”

9. Sam: “One has always to take a <u>free point</u> <u>which varies</u>, in this case, <u>the areas</u> considered […]”

Following the teacher’s request, students collectively report on their work with Casyopée. That leads to the production of the artefact sign “mobile point” (out of the others) (item 5). The sign “mobile point” is clearly related to the task and the use of Casyopée for accomplishing it. At the same time it may be related to the mathematical knowledge at stake: the notion of variable. There are several possibilities for the subsequent development of the discussion: one could orient the discussion towards the distinction between mobile and variable, towards the specification of other variable elements, discussion towards the distinction between algebraic or numerical variable and geometrical variable, towards the recognition of the aspects of co-variation between the variable elements of the geometrical figure, towards the distinction between independent and dependent variable.

Certainly, the teacher’s intervention is needed both to drive the attention of the class towards the sign introduced by Luc and to orient the discussion. The teacher is aware of that and intentionally emphasizes Luc’s contribution to the discussion (item 8). At one time, she requires to generalize so to foster a de-contextualization from the specific problems faced and strategies enacted, and to provide the possibilities for the evolution of personal signs to initiate.

After the teacher’s intervention, Sam (item 9) echoes Luc’s words. But she uses the sign “free point” instead of “mobile point”, and introduces the consideration of other variable elements (“areas”) also emphasizing the existence of a link between them (“free point which varies […] the areas”). Those are the first elements of the two semiotic chains described in the previous section.

10. Teacher A: “Then we have a <u>figure</u> which is…”

11. Students: “<u>Mobile</u>.”

12. Teacher A: “<u>Mobile, dynamical</u>. Let us pass to the second phase. Andrea, which is the next phase? […]”

13. And: “The <u>observation of the figure</u> would let us see… we need to study that <u>figure and observe what the shift of the variable causes</u>…”

Sam’s contribution (item 9) ends with the reference to variable areas. That could prematurely move the discussion towards the consideration of algebraic or numerical aspects, without giving time to elaborate on variable and variation in the geometric setting. In order to contrast this risk, the teacher introduces the term “figure” (item 10) which has the effect of keeping students’ attention still on the geometrical objects. In addition the teacher fuels the discussion echoing students and, thus, emphasizing the reference to the dynamical aspects (item 12), which nurtures the construction of the semiotic chains on variation and co-variation.

And, whose intervention is stimulated by the teacher, echoes the use of the sign “figure” and makes explicit exactly the co-variation between the geometrical objects in focus. She also introduces the sign “variable” so establishing a connection between the artefact sign “mobile point” and the sign “variable”.

We are not claiming that the evolution towards the target mathematical signs is completed: a shared and de-contextualized formulation of the different mathematical notions at stake is not reached yet, as witnessed by Sil's words (item 15), who still makes reference to the use of the artefact in her speech.

14. Teacher A: "Ok, then? Everybody did that, isn't it?"

15. Sil: "We computed the area of the triangle and of the parallelogram, we summed them, and by shifting the mobile point one observed as [the sum of the areas] varied […]"

The above analysis puts into evidence a number of interventions of the teachers who succeeds in exploiting the semiotic potential of Casyopée, and thus in making the class progress towards the achievement of the designed educational goals.

One can find also episodes in which the teacher' action is not so efficient. The following excerpt is drawn from a discussion held in another class and orchestrated by a different teacher, and it shows an episode in which the teacher does not succeed to exploit the potentialities of the students' interventions. Chi countered the sign "variable" with the sign "variable point" so offering the possibility to dwell on the relationship between not measurable geometrical variables and measurable geometrical variables. The specification of this distinction was considered a key aspect of algebraic modeling, and as such highly pertinent to the designed educational goals. The teacher does not seize the occasion and does not take any action to fuel the discussion on that, she was probably aiming at orienting the discussion along a different direction.

184. Chi: "we put CD as <u>variable</u>, and not by chance CD, in fact we used a fixed point, C, and a <u>variable point</u> on the segment, D"

185. Teacher B**:** "well, the underpinning idea is to link numbers, and, […] having observed a link between the position of the point D and […] the area of the rectangle […] a link is established between a geometrical world and an algebraic world"

That witnesses the difficulty of mobilizing strategies to foster the evolution of students' signs. One has to constantly keep the finger on the pulse of the discussion and of its possible development. In fact the evolution of students' signs depends on extemporary stimuli asking for a number of decisions on the spot.

CONCLUSIONS

The analysis carried out in the paper confirms the crucial role of the teacher in technology-rich learning environments. In particular, such role may (and should from our perspective) go beyond that of assistant or guide for students' instrumental genesis process. In fact through her interventions the teacher promotes and guides the development of the class discussion, so to foster the production and the evolution of students' signs towards the target mathematical signs, and to facilitate students' consciousness-raising of the mathematical meanings at stake.

Certainly we are aware that the analysis presented is still at a phenomenological level. There is an emerging need for elaborating a more specific model for analysing the teacher' semiotic actions. But there is not only the need of developing tools for finer analysis. We showed an episode witnessing the difficulty of mobilizing strategies to foster the evolution of students' signs. Currently, the Theory of Semiotic Mediation does not equally support analysis and planning. Due to the richness of a class discussion and the number of extemporary stimuli which could emerge, one cannot foresee the exact development of the discussion. That makes the teacher's role still more crucial. Nevertheless there is the need of an effort for elaborating more specific theoretical tools for supporting the a-priori design of classroom discussion. All this is also relevant to the more generic issue of teacher's formation.

NOTES

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