# TECHNOLOGY AND MATHEMATICS TEACHING PRACTICES: ABOUT IN-SERVICE AND PRE-SERVICE TEACHERS

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*Abstract: This article examines the practices of in-service and pre-service teachers in technology based lessons by exploring three dimensions: the students' tasks, the students groups' management and the discourse of the teacher. Regularities emerging from two case studies about in-service teachers are compared to results of a larger study about pre-service teachers. The article shows that what characterize teachers' practices in technology environments is not the same in the two populations of teachers and thus suggests some propositions for the design of training strategies seeking to improve the practices of novice teachers.*

Key-words: technology, teaching practices, ordinary teachers, pre-service teachers

## INTRODUCTION

For the last decade constraints and difficulties encountered by mathematics teachers integrating technologies has been an ongoing issue. Indeed the contrast between the technological development and the weakness of the integration of computer technologies in classrooms despite the abundance of governmental funding, questions necessarily researchers (Artigue, 2000), (Ruthven, 2007). Some researches have considered the role of teachers in the classroom use of technology throughout a holistic approach examining thus the influence of key factors on their activity (Monaghan, 2004); others have investigated teachers' ideas about their own experience of successful classroom use of computer-based tools and resources (Ruthven & Hennessy, 2002); others have shown discrepancies and variability in the ways teachers use technology in their mathematics classrooms (Kendal & Stacey, 2002). Research about student teachers' practices and their determinants in technological environment is nevertheless rather rare. It stresses particularly the problems that student teachers have to overcome such as their lack of familiarity and confidence with technology or their need to make explicit the connections between technological and paper-and-pencil work (O'Reilly, 2006). Furthermore, it stresses the growing awareness that technology-based lessons require extra time for planning and for teaching.

In this paper, I want to contribute to the research on issues related to teaching practices in technology environments and issues related to teacher education in these environments. I will do so by relying on the results of three research projects that I have carried out in the last four years. I will firstly present two case studies about teachers' practices in technology-based lessons taken from the two first researches. Secondly, I will highlight regularities that emerge from these studies. I will finally try to cross these findings with results of a third research about pre-service mathematics teachers using computer technologies and conclude by issues about teacher education arising from this synthetic view on the three studies.

## CASE-STUDIES

The two case studies that I am presenting here have been carried out in two researches: the first one on the characterization of the practices of 'ordinary' teachers using dynamic geometry (Abboud-Blanchard, 2008); the second one on the analysis of the activity of volunteer teachers using exercise-bases (Artigue *et al.*, 2006). In these two studies the main issue is to characterize teacher's activity in a technology-based lesson according to three polarities in complete interaction: the tasks proposed for students’ learning (cognitive pole), the management of the students' groups (pragmatic pole), and the discourse and the interaction with students (relational pole).

### Framework and Method

These studies use methods and concepts developed within the general framework of the two-fold approach which combines both a didactical and an ergonomical perspective in analysing the factors that determine the teacher's activity as well as that of students prompted by the teacher in class (Robert & Rogalski, 2005). Within this framework, analyzing lessons takes into consideration the fact that there are two main types of channels used by the teacher in classroom management: the organization of tasks prescribed to students (cognitive-epistemological dimension) and the direct interactions through verbal communication (mediative-interactive dimension). Furthermore, the authors (*ibid*) differentiate task from activity: task is what is to be carried out; activity is what a person develops when realising the task.

For each of the two case-studies I will first report on the *a priori* analysis of the students' tasks and what they are supposed to undertake in terms of initiative and use of knowledge already acquired and actually needed to execute the tasks. Secondly, I will present the lesson in progress, that is to say, what really happened in the classroom by underlining the teacher's aids and by studying the features of his/her discourse. The teacher intervenes often to provide assistance to the students sometimes modifying their activities. Robert (2007) defined two types of aids, depending on whether they modify the activities scheduled or they add something to the students’ action. The first, "procedural help", deals with the prescribed tasks by modifying activities with regard to those planned from the presentation of the task. It corresponds to indications that the teacher supplies to the students before or during their work. The second, "constructive help", adds something between the strict activity of the student and the (expected) construction of the knowledge that could result from this activity. The analysis of the teacher's discourse provides more information about how he/she contributes to model students' activities. This analysis has been undertaken by using a methodology constructed by Paries (2004) who adapted tools used in psychology, notably the functions of scaffolding defined by Bruner (1983) who regarded interaction as the major form of assistance provided by adults for cognitive development. Thus, Paries studied the role of discourse in the mediation of cognitive development and defined functions of the mathematics teacher's discourse by specifying the manner in which he/she intervenes gradually in details in the students' work. Paries distinguishes two groups of functions:

- The “cognitive functions” linked to the task, to the realisation of the task and to the mathematical content. These functions are: introduction of a task or dividing a task into sub-tasks, assessment, justification and structuring.

- The “functions of enrolment” apparently independent from the task, at least in their formulation, but can have an impact on its realisation. They allow the teacher to maintain communication. These functions are: engagement, mobilization of the student's attention and encouragement.

**William's case**

William has volunteered to participate in a government project to use exercise-bases with his grade 10 students (first year of the upper secondary level - aged 15/16 years). I chose to present here this study because William's case could be considered as representative of those of the other teachers engaged in the project.

He is a regular user of technology in both his personal and professional activities. He sees the use of exercises-bases in the classroom as facilitator without neither change in the approach of mathematics contents nor change in teaching practices: this software is just an additional mean that will be added to (and not replace) usual practices.

*Students' tasks*

The observed session is a training one and it took place in the computer room; students were assigned by groups of two to a computer. William's discourse was recorded; a remote cordless microphone was attached to the teacher. An observer was present in the classroom. William has chosen in the exercise-base a module of exercises-generator concerning two tasks: (1) To find the reduced equation of a straight line. The straight line is drawn on the screen with two of its points A and B in an orthonormal cartesian system; students have to find the values of $m$ and $p$ in the equation $y = mx + p$. (2) To solve systems of two linear equations (first degree equations with two unknowns)

In both cases, students must make their calculations on paper and give the two numbers solutions to the software that validates them in terms of true / false.

These two tasks are similar to paper-and-pencil tasks; the only difference is that each student can train at his/her own pace.

*The development of the lesson and the teacher's help*

During the lesson William tries to check up the work of every group of students with some regularity, and even when he moves at the request of a student, he quickly control the work of other students along his path. Despite this, students put a lot more time than what William had planned (half an hour per task). This gap between the planned and actual time resolution leads William to ask students to move to the second set of exercises, although a few students have still some difficulties with the first exercises.

Among the interactions with students, I note only four collective ones which concern particularly the management of the session; the rest are individual (per group to a computer) interactions. Some aids are related to the handling of the software: they consist primarily to explain how to switch from one exercise to another or to resolve a technical problem. They are usually brief, local, and allow the student to continue the resolution. The individual help concern mostly mathematical resolution; they are of various kinds and are often procedural help: - controlling the resolution and calculations; - validating an answer or helping find the error (often at the request of students); - structuring the resolution or asking students to do it.

The frequency and variety of these mathematics aids show that the execution of the mathematical tasks seems to require a strong mobilization of the teacher.

To sum up, I notice that William, who is at ease in a technology environment, succeeds in providing students effective aids for handling computers and exercise-bases software. The class gives the impression of "functioning" in a satisfactory manner, all students work and progress. Nevertheless, the teacher is highly mobilized on the mathematical level; the majority of students cannot progress in the resolution without his help. So, despite an "illusion" of autonomy of students, the presence of the teacher seems indispensable.

*The functions of discourse*

I will not detail here the study of the teacher's discourse, because of the restricted length of this paper; I will rather give some significant percentages of the functions of discourse. I note first a small percentage (9%) of the functions of enrolment. Everything indicates that students are "supported" by the technology environment and work without needing to be constantly motivated by the teacher. The function of structuring occupies 21% of the total, because when helping students, William first begins by helping them bring "order" in their calculations. This is also due to the desire that students work more quickly because the time doesn't progress as William has planned (see above). The function of assessment occupies a high percentage (47%) because the software provides validation only in terms of true/false for the solution given by the student. The students are therefore responsible for the control of calculations but they seek constantly the teacher's help for this assessment. This requires the teacher to take over the function of accompanying the resolution and control of progress, and interpretation of the results not validated.

In addition to these results on the functions of discourse, I note that the functions succeed in a similar order with each group of students. Indeed when the teacher comes to see a group: he assesses or takes a stock of the situation of resolution, sometimes he structures it, and then he gives a sub-task to the students to execute until he comes back. This phenomenon of repeating the same succession of action in each group with aid substantially similar implies a strong mobilization of the teacher which is 'non-economic' in terms of classroom management.

**Anna's case**

Anna is an 'ordinary' teacher not engaged in any innovation or research project. She has an episodic use of technological tools with her students that one wouldn't qualify as significant use. I present here her case because she corresponds to what we, in the research project, consider to be an average teacher representative of ordinary teachers. The lesson studied here is about space geometry in a grade 9 class (fourth year of middle school - aged 14/15 years). It takes place in the computer room with the use of dynamic geometry software; students are assigned by groups of two or three to a computer. The lesson observation was videotaped. The camera was at a rear corner of the classroom. A remote cordless microphone was attached to the teacher. No observer was present in the classroom. The topic is the section of a pyramid by a plane parallel to the basis, and Anna uses a ready-to-use session designed by the software developers.

*Students' tasks*

The figure downloaded by the students is a given cube ABCDEFGH in which they have drawn in a previous session: I, middle of [EF] and J, middle of [AB] and have also found the lengths JC and JD. First, the students have to draw the section of the pyramid IJCD by a plane passing by M, the middle of [IJ], and parallel to the basis JCD, getting thus two points N (middle of [IC]) and Q (middle of [ID]). This technological-task (t-task) is entirely guided by a set of manipulation commands and students only need to follow the instructions given in the worksheet provided by Anna. Secondly, they have to examine, with the software commands, the triangles JCD and MNQ. The aim here is that students get to see MNQ as the 1/2 reduction of JCD. Once done, tasks that follow are mathematical-tasks (m-tasks): to calculate the areas of triangles MNQ and JCD, to calculate the volume of IMNQ and IJCD to compare these two volumes. These m-tasks are complex and require a certain number of adjustments such as taking initiatives (to construct a height in a triangle in order to calculate its area) or operating a change of frames (when comparing the two volumes) that consists in introducing the comparison of two numbers in a geometrical frame. Therefore, t-tasks are designed to be simple, guided and quickly executed in order to get a stronger focus from the students on m-tasks. The latter are more complex and require time to be carried out.

*The development of the lesson and the teacher's help*

Globally, I note that students are often in an autonomy-mode and for very long moments. When she is present, Anna divides the task into sub-tasks to be immediately executed by students, in a bid to allow them to pursue quickly their work. The teacher's collective interactions are rare and mostly concern the management of the session.

The assistance of the teacher consists almost exclusively in procedural help, simplifying the students' activities. The division of tasks into simple sub-tasks is clear: sometimes Anna nearly dictates the work to do and at times she even takes herself the mouse to accomplish some sub-tasks. Often, when the teacher is interacting with a group, students only follow her instructions, or even finish a sentence that she begins. I might here underline that the teacher stays with every group a very short time and thus her assistance allows the students to pursue their work on their own. One can wonder if dividing the task is some how a way for Anna to be efficient. Still, Anna did not succeed to meet her objective; students were too slow in the construction of the section of the pyramid. She had prepared simple t-tasks in order to help the students to start quickly the mathematical activity. Perceiving during the lesson that these tasks took more of time than expected, she tried to accelerate their execution by doing the work herself or by coaching students step by step in the execution.

*The functions of discourse*

As in William's case I only give here some significant percentages of the functions of discourse. I first observe that the functions of enrolment have a low percentage (7%) which might be explained by the fact that the mobilization of the students' attention and the engagement in tasks is supported by the technology-environment itself. I notice also that structuring accounts for an important rate among cognitive functions (28%). As stated above, Anna is aware of the slow execution of the tasks and tries, by this mean, to accelerate the pace. As for the cognitive function of the introduction of sub-tasks, the high percentage (21%) is coherent with the analysis of the m-tasks. These tasks are complex, need adjustments, and on top of that, students' work progresses slowly. Assessment stands at 35% and corresponds to interactions with groups of students and not to collective interactions. Actually, after the start (collective phase), the class splits into several 'mini-classes' (groups of two or three students per computer) which function separately and to which the teacher talks independently from the remainder of the class. Besides, certain functions of the discourse apparently succeeded in these 'mini-classes' in this same order: assessment, structuring and introduction of a sub-task.

## Regularities emerging from the two case-studies

Despite of the different contexts and profiles of the two teachers and also the different nature of the software used, a number of regularities emerge from the two studies, I want to emphasize these in this section. I will do so in order to highlight what actually is characteristic of a technology-based lesson led by in-service teachers. I will also illustrate continuities between these findings and those of some researches mentioned above, to suggest that a number of results may be more widely transferable.

On the cognitive level, in the two cases the exercises chosen by the teachers, in technology environment, are similar to the ones that would be proposed in pencil-and-paper environment; the resolution of mathematics tasks is identical to what could be proposed in non-technology environment. This result is close to what Kendal and Stacey (*ibid*) underline about CAS (Computer Algebra Systems).the mathematical knowledge and skills stay globally within the range of those expected in non-technological environment. Indeed, the teacher has, on the cognitive level, a practically similar activity as in a non-technology environment. In the open environment of dynamic geometry we see that Anna has chosen a ready-to-use sequence where all the questions of the exercise except one, are feasible in a pencil-and-paper environment. In the environment of exercise-bases, William has also chosen training exercises used in pencil-and-paper environment. The content of the interventions of the two teachers when it comes to mathematical tasks is therefore identical to what they would have said or done in non-technology environments since there is no reference to the specificity of technology environment in these interventions. This can be traced to some indications provided by Ruthven and Hennessy (2002) about teachers who initially view technology through the lens of their established practice, and employ it accordingly. This fact certainly favours the connection of these sessions with the rest of learning process and helps to explain why for these teachers this connection is not perceived as problematic.

On the pragmatic and relational levels, firstly I note that the work in computer room generally entails that students must be in groups of two or three per machine. Consequently, there is a 'class split' in several 'mini-classes' working relatively independently, and a quasi disappearance of collective phases except the collective time management. The teacher is not able, in certain cases, to generalize the supply of certain indications given only to some students whereas they could be useful to all the others. Artigue *et al.* (ibid) encountered the same features notably the fact that individual interactions substitute for collective interactions and that institutionalisation phases are nonexistent because of the different 'trajectories' of students. Besides it, for each of the mini-classes, the teacher adapts to what students are doing and to their current reasoning, whereas in pencil-and-paper lessons, it is more often that the students have to adjust themselves to the teacher's project (Abboud-Blanchard & Paries, 2008). This appears to be an important element of the management of a technology-based lesson which differentiates it from a non-technology one. Moreover, the analysis of the interactions showed similarities in the successions of the functions of the discourse among the mini-classes. Secondly, as to the aid provided to students, I observe that the teacher focuses on local mathematical aid without decontextualization. There is a clear majority of cognitive functions of the discourse that operate as help, but mainly procedural help. This type of support is partly motivated by the teacher's concern about the progress of the students' work, in order to have all the tasks prepared for the session completed. This echoes a strong trend of teaching practices in the computer room underscored by several researches (Monaghan, 2004). Other characteristics seem to be related to specificities of the environment and enhance the previous difficulties. Indeed, not all the students handle the software with ease, thus the teacher has to provide technical help which is not common in a mathematics course. Thirdly, in individual interventions that predominate, the rate of interventions of enrolment is much weaker than what is generally observed in non-technology class sessions (Paries, 2004). The functions of enrolment are rarely present in the discourse of the teacher; they seem to be taken in charge by the software. The teacher has also to 'share' with the computer certain functions of enrolment, which disturbs the usual management of the class.

Thus, the teacher's role in technology based-lessons seems to be essential according to the pragmatic and the relational poles. Indeed in the two case studies students' tasks were enough guided, one could *a priori* expect to see the teachers a bit observers ( rather than actors) of their students' learning. The analysis shows that this is not the case; teachers are very present and very engaged in the students' work.

## ISSUES ABOUT TEACHER EDUCATION

As member of a research team investigating the uses of technology by pre-service teachers, I studied the professional dissertations made by these teachers in which they report about technology-based lessons that they prepared and carried out in their classes (Abboud-Blanchard & Lagrange, 2006). The data come then only from what the teachers themselves reported and not from class observations.

The main result that I want to highlight in this paper is the focus of these dissertations on the preparation of students' mathematical tasks, while the teacher's activity is overlooked. Aspects of the teacher's role are very rarely questioned; they are rather mentioned as “events” in the body of the reports and in the conclusions. Indeed, the learning activities are often document-based, students being assigned tasks based on a written document that teachers deliver at the beginning of the session. In such classroom documents, tasks are organised as a series of subject-based questions, with instructions on how to use the software. Furthermore, in the development of lessons reported in the dissertations, it seems that the teacher has a marginal role in the technology-based lessons carried out and reported by pre-service teachers. For example, at the beginning of a typical lesson, the pre-service teacher provides guidance to the students on manipulating the software and makes sure that they understand the assignment. Then the students work on their own in the computer room and the teacher’s activity is limited to individual help to manipulate the software. My hypothesis is that the teacher’s marginal intervention can be explained – at least partially - by the prescriptive nature of the tasks. Another reason may be that pre-service teachers transfer part of their role to the computer, a kind of ‘joint partnership’.

### Comparing results about pre-service and in-service teachers

My aim in this section isn't to make a detailed comparison of the two first case studies and the study of pre-service teachers. A direct comparison wouldn't be relevant notably because of the differences of the methodologies used. I'm rather presenting here a synthetic approach of the three studies focusing on the results relative to the three poles developed above: cognitive, pragmatic and relational.

In the studies on the activity of in-service teachers I showed that the cognitive pole isn't what seems to be problematic for these teachers in technology-based lessons. What differentiate the teacher's activity in these lessons with the same in non-technology ones are mainly the management of students (pragmatic pole) and the interactions with students (relational pole). Thus what makes a technology-based lesson 'works' with experienced teachers seems likely more related to the pragmatic and relational poles than to the cognitive one. Whereas the study of the practices of pre-service teachers shows on the one hand that they focus on the cognitive pole and they neglect the two other poles, and on the other hand that they report their non satisfaction of how technology-based lessons took place. Moreover, when we ask pre-service teachers about their experiences of technology-based lessons they most frequently reflect on difficulties related to time management of the session and also to preparation work to set up the tasks of students. They also underline that the teacher is no longer the only holder of knowledge. However such reflections tend to remain at a general level and do not seem to provoke pre-service teachers into making propositions for a more suitable integration of technologies in mathematics teaching. This also reveals that despite of their increasing awareness of the specificity of technology environments in preparation work and class work; it does not necessarily lead to a wider reflection about real integration of technology in their practices.

Can we take advantage of this awareness to develop an approach of teacher education programs? During discussions within the WG12 of CERME 5 (Carillo *et al.*, 2007) it seems that there was a consensus among participants on the fact that awareness is necessary for reflection and on promoting reflection as a means of professional development. Seeking to improve the practices of novice teachers, this last pattern can be used for the design of training strategies such as the analysis of video episodes of experienced teachers using technologies with a special focus on the role of the teacher and his/her interactions with the students. Such analysis would help pre-service teachers to bridge between a focus on the preparation of students' mathematical tasks and another on their own activity during the lesson in order to help them overcome the state of didactic tinkering and go further to a successful integration of technologies in mathematics teaching and learning.

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