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9. TEACHERS' PRACTICES USING E-EXERCISE BASES IN THEIR CLASROOMS

INTRODUCTION

This chapter examines teachers' uses of specific computational tools: electronic exercise bases (EEBs, see chapter 8). The data come from a project tracking the use of online resources in grade 9 mathematics classes (ages 15-16) in the Paris region. Here the use of EEBs constituted a case of special innovation and should for this reason be distinguished from ordinary classroom situations, where the emphasis is placed on coherence and stability of practices. The stability factor in the use of EEBs is not therefore discussed. Instead we raise questions concerning the way in which these new tools are appropriated by teachers, the different uses in terms of student activity, the changes they bring about in the day-to-day activities of teachers, and, more generally, their impact on the evolution of teachers' overall classroom practices.

The theoretical framework adopted in addressing these questions is the double approach. Special importance is given to concepts drawn from Activity Theory. The activity of the acting subject depends in part on the subject him/herself and his/her conceptions and representations; but it also depends on the situation[1] in which the subject is placed. In terms of the data referred to here, the subject is the teacher, and the situation refers to the particular computational tool used (EEB), though it also takes into account an array of other factors, including the teaching establishment, the social context, and the specific teachers and students involved. Via his/her activities, the subject "transforms the real and transforms himself" (Pastré and Rabardel, 2005). The results of the activity can therefore be divided into two categories: transformations of the real – that is, of the subject's environment – and transformations of the subject him/herself. In order to distinguish these two categories of result, Samurçay and Rabardel (2004) introduce the notions of "productive activity," which refers to changes in the subject's environment, and "constructive activity," which refers to changes in the subject him/herself. In terms of our data, productive activity refers to the effects of the teacher's activity on the students, whilst constructive activity refers to the transformations of the teacher's personal representations and, more particularly, the transformations of his/her teaching practice. Although distinct, productive activity and constructive activity are nonetheless closely connected. More particularly, constructive activity cannot take place without productive activity. Additionally,

F. Vandebrouck (ed.), Mathematics Classrooms: Students' Activities and Teachers' Practices, 185–198.

we should note that productive activity ends when the execution of a task is complete, whereas constructive activity can continue over a longer period. Thus the results of teachers' activities are analyzed both in terms of direct observation of their implementation of student activities (productive activity), and in terms of the transformations of the teachers themselves, in so far as such transformations can be determined (constructive activity).

By analysing both the teacher's productive and constructive activity, we are therefore better able to assess the cognitive and mediative components of his/her practice – even if we cannot describe them in full. We should recall that the results of the activity of the subject (the teacher) have a retroactive effect on the three other components of his/her practice by means of a 'double regulation' that is both 'external' (affecting the institutional and social components of practice) and 'internal' (affecting the personal component of practice). This double regulation functions according to different timeframes (see chapter 2):

– In the short term – that is, limited to an "episode" within a given lesson. From the point of view of the teacher, we define an "episode" as an instance of exchange/dialogue with one or more students or indeed the whole class. We do not discuss this short-term action in detail here. This is because, firstly, the effects of the teacher's activity on students are in this case too limited to be interpreted in terms of learning outcomes. Secondly, the regulations resulting from the teacher's activity take place in real time. The effects of constructive activity on the teacher him/herself seem to be too limited to be consciously recognised and reinvested by the teacher (Rogalski, 2003)
– In the medium term – that is, within the space of a lesson or a lesson sequence (a series of lessons on the same topic). Within this larger timeframe, regulation begins to have an effect on the teaching subject. For example, the teacher might, over the course of the lesson, become aware of persistent difficulties for the students that s/he had not expected; as a result s/he will modify the structure of the lesson in an impromptu manner, going back over certain material and establishing connections with previous topics. From the point of view of the students, the consistencies in the teacher's activity can also allow us to presuppose certain effects on their learning.
– In the long term – that is, in the course of planning, preparations etc. This is the most relevant timescale in terms of the effects on students and the effects of constructive activity on the teacher him/herself. Here we draw on the notion of "geneses of the technology uses" (Abboud-Blanchard & Vandebrouck, 2012) to designate the effects of the teacher's constructive activity. We then attempt to understand, in terms of the five components of the teacher's practices, how the geneses of the EEB uses can be integrated into the global practice of teachers.

In the next section, we introduce the data collected and the methodology employed. This is then followed by an overview of the results of our study of teachers' activity in terms of lesson preparation and class proceedings (third section). Finally, the last, fourth, section examines three detailed case studies that supplement the more generalized findings set out in the third section.

DATA COLLECTED AND METHODOLOGY

The data come from two different samples. The first broader sample consists of thirty or so teachers who were involved in the project from 2004-2006. These teachers were observed either directly or indirectly (i.e. via observations of their students' activity). They also filled out questionnaires about their use of EEBs; these questionnaires are especially useful as a supplement to the observations made during lessons. The second smaller sample consists of six teachers whose practices were studied more extensively.

The data collected for each teacher can be organised chronologically in accordance with the timeframes described above – that is, lesson preparation and proceedings (short and medium-term timeframes) and teachers' critical re-viewing of their lesson(s) (medium and long-term timeframes).

As far as concerns lesson preparation, teacher activity is analysed first of all in terms of his/her choice of EEB, lesson content and specific exercises. That is, the initial focus is on the classroom scenario (incorporation of the lesson in a progressive, global learning agenda) and the lesson's learning trajectories, as set out by the class teacher.[2] Such features provide information on the cognitive component of the teachers' practices. However, such details as, for example, the complexity of the tasks set, which are important when studying student activity, are not taken into account here. Indeed, such details are meaningless when examining the activity of several teachers teaching different topics and at different periods in the school year.

The lesson proceedings are analysed by means of the transcripts of the recordings made and the notes taken by the observers. They provide information relative to class management and teacher-student interactions. Particular attention is paid to the way in which different media are used (EEBs, but also hand-outs, the black/whiteboard, exercise books, project notebooks) and to the teacher's interventions. The latter permits a description of the ways in which teachers help students to complete the tasks they have been set using particular resources. This second phase of the study provides access essentially to the mediative component of the teachers' practices, though this may also corroborate and reinforce certain considerations relating to the cognitive components of practices.

Finally, the third observation phase, in which the teacher "learns from," so to speak, his/her classroom experience, is very difficult to observe because it takes place over a protracted period of time. Often the teacher will not give a similar lesson until the following year. Furthermore, the modifications to be made to future lessons are not always made explicit; when they are, it is usually during questionnaires or interviews conducted after the lesson itself. Changes may also

become visible over the course of a sequence of several lessons on the same topic. The information collected here aids understanding of the possible long-term evolution of the cognitive, mediative and personal components of practice. Moreover, it helps us to consider the geneses of EEB uses in relation to the evolutions of all five components of teaching practices.

RESULTS

The results obtained provide information on those features of the cognitive and mediative components of teaching practices that are visible during observation; some features of the other three components were also visible, but to a lesser extent. We will present the various actions carried out by the teachers in chronological order, beginning with lesson preparation, moving onto the proceedings of the lesson itself and ending with subsequent modifications.

Lesson preparation

All of the teachers whose lessons were observed chose a single EEB to be used throughout the year and for all of his/her classes. Some teachers used different digital resources, such as spread sheets or interactive geometry software, but none of them used more than one EEB. The first of the teacher's actions is therefore to select "his"/"her" EEB. In some cases this choice was the same for all the teachers in a given establishment.

The teacher's second action is to choose the type of lesson s/he will give. Lessons using EEBs are nearly always made up of a small number of students working alone or two on a computer, with the teacher offering individual help. EEB-based lessons can even sometimes be supplementary sessions in which students participate on a voluntary basis. The frequency of EEB usage varied considerably from teacher to teacher. In the questionnaires, the majority stated that one EEB-based session per week would be desirable but that, for practical reasons, many of them had actually given fewer than this.

After the initial sessions in which the EEB was rapidly explored, all of the teachers produced what we will later refer to as "work plans" – that is, a structured sequence of exercises chosen from the EEB. Most often the work plan was the same for all the students. However, some inclination to adapt it to different students' needs was observed. For example, in a remedial session following a test, the students were given exercises addressing the mistakes they had made in the test. Or again, in the same establishment, several teachers grouped together and decided that each would offer a workshop on a different topic; their students were then redistributed, each being sent to the session that best corresponded to his/her needs. When work plans were used, many teachers inserted some personal remarks at the beginning. The work plans were quite precise and generally too long to be completed in a single session.

The exercises set by teachers always related to topics that had either already been studied or else were currently being studied. Their format and title were

similar to those of traditional exercises. No exercises introducing new topics were used. Furthermore, the teachers' goals for the sessions were always limited: the aim was to work on a specific topic or to revise specific concepts. Exercises drawing on several concepts at the same time were only very rarely used, with the exception, now and again, of a few exercises at the end of the work plan, intended for the strongest students. Additionally, teachers in their first year of using the EEB preferred to use simple exercises featuring a single problem to solve and closed-ended questions; they then expanded their repertoire of exercises in subsequent years. Various mathematical topics were covered in the sessions, from geometry and factorisation to functions and statistics. The topics were always chosen in relation to the class's overall progress.

Lesson proceedings

All of the teachers observed structured their lessons in the same way – in three sections of very different length: first, a very short start-up phase; second, the bulk of the lesson, or what we call the "cruise" phase; and, finally, a very short, even barely existent closing phase. We structure our findings on lesson proceedings around these three phases.

The start-up phase

In the start-up phase the teacher mostly addresses the whole class, giving practical instructions regarding the distribution of students among the workstations and how to access the exercises.

For example: "*Sit down, ideally one of you at each desk (...) When you've opened the session, I want you to pay close attention to the instructions I've given you. I've written these at the beginning of the session (...) I want you to call me when you're ready to start. I want to see some good work (...). And don't forget to show your working out for worksheets one and two (...)*."

In this example the instructions also deal with the way in which the tasks are to be completed and the arrangements for addressing the teacher. This initial phase is always very short; it may even be missed out completely once the teacher and the students have got used to the equipment and the initial lesson set-up has become "routine." On the other hand, when the technology is used for the first time extensive practical instructions will be needed.

The "cruise" phase

In all the lessons we studied, this phase made up close to the entirety of the lesson, with the teacher no longer addressing the whole class and instead speaking almost exclusively with one or two students at a time. Likewise, there is no collective review of the answers on the blackboard. These two features demonstrate important departures from traditional exercise-based lessons. A further difference is that the students cannot wait for a collective answer review because they know there will not be one. Indeed, the observations made in these lessons show that the students were "active." They also interacted with the software by, for example,

reading the "help" box that accompanied the exercise or providing an answer and viewing its evaluation.

Amongst the various kinds of assistance supplied by the teachers, we can distinguish "mathematical" help (which can be procedural or constructive; see chapter 2) and "instrumental" help. We also see, though rarely, certain teacher interventions relating to the students' application to their work; where such interventions took place, there aim was to encourage, praise or push the student. Instrumental help concerns the handling of the exercise database; at times it is difficult to distinguish this from mathematical help. We noted that, in all the lessons observed, instrumental help was often initiated by the students. Most of the mathematical help provided by the teacher was procedural: s/he helps to resolve the difficulties encountered in the exercises and checks the students' work. However, individual assistance can be constructive. For example, if a student is making a persistent mistake, the teacher will re-explain a particular concept they have studied and its relation to the exercise. There are thus various types of teacher interventions, each adapted to a specific case. This means that the teacher is often required to assess diverse situations rapidly so as to respond accordingly.

We will now provide a few examples of different types of teacher intervention. They are all taken from the "cruise" phase and are specific to the use of EEBs. The assistance offered is usually a mixture of the mathematical and the instrumental.

Example 1: "*Yes? What is it you don't understand? Right, where's the question, first of all? I didn't see your answer just now. What does this value represent? Go back ...*" The teacher has to understand which exercise the student is working on, which is all the more difficult because many EEBs set the exercises in a random order, which means that the question asked at any one time can differ from one session to another. In the case of a set of questions proposed in sequence, the teacher has to grasp the student's whole chain of reasoning.

Example 2: "*They sometimes offer you some comments on your answer; you should always click 'yes.' It's not enough just to read the 'well done,' you need to read the rest as well (...) You don't have to read and copy out everything ...*" Here the same teacher adapts his/her advice to the specific student and the specific exercise and encourages the student to interact directly with the EEB.

Example 3: "*You will all need at the very least your exercise book and a pen or pencil. Because you won't be able to do everything in your heads. Some of the exercises you can do mentally, but at times you're going to need to do some working out on paper.*" Here the teacher repeatedly encourages the students not to neglect pen and paper when working out their answers.

Example 4: "*So you did the calculations, you gave all the answers ... did you get them right? OK, then move on to this one. I recommend you go to 'information' and read exactly what they want you to do.*" In this single intervention the teacher performs three actions: s/he finds out what the student had done before s/he came over, s/he advises the student to move on with the exercises and, aware of the difficulties of the following exercise, s/he asks the student to read the information.

These examples show that the EEB is an action tool for the teacher, who finds him/herself playing a dual role: s/he is both mediator between the student and the

software, explaining how to use the EEB, and monitor, checking whether the questions have been answered correctly. These two roles are not in themselves new for the teacher, since they have to be adopted whenever a new instrument is introduced, be it "traditional" (e.g. protractors in the grade 5/6 – age 11-12) or technological (e.g. a new model of calculator). The difference is that the teacher must now simultaneously keep in mind not only the kind of mathematics the EEB proposes and the automatic structure and sequencing of the exercises, but also the means of assessment and the kind of help that is to be provided. Depending on the teacher, these functions are more or less close to his/her usual practice and thereby more or less easy to perform. For example, a teacher who usually monitors students' work individually will have less difficulty conducting EEB sessions than a teacher who adopts a more collective approach, mostly teaching from the front of the classroom.

Furthermore, the teacher's interventions are always adapted to the work of a specific student, without making generalizations on the basis of the rest of the class. It is as if the task of collective correction has been taken over by the computer, with the teacher instead providing personalized comments for each student. It may be that work with EEBs provides opportunities for the furnishing of "meta" information (Rogalski, 1997). Again, the extent to which this opportunity is exploited or not depends on the individual teacher.

In the next section, we will examine a case study (the case of Diane) to see how a teacher, given the specificities of working with EEBs, adapts his/her interventions and fulfils the new roles required to manage the lesson's "cruise" phase.

The closing phase

The closing phase is very short. In most cases it begins when the bell rings to indicate the end of the lesson. The teacher announces the lesson is over and asks the students to switch off their computers. Sometimes s/he will try to gauge how far the students have advanced with the exercises because each of them is likely to be at a different stage in the work plan; this will only rarely be followed by some further comments.

Example: "*I want you to write down the last results you've got and then close everything down as usual....OK?... Who managed to get to the last exercise? Charlène, you did, didn't you? Aurélia, you were more or less there. Marianne?*"

There is thus no summing-up and very little in common with traditional lessons. On these points teachers are divided. Some do not mind ending the lesson in this way. First, as we said above, these lessons aim at the consolidation of existing knowledge; the teachers do not therefore feel the need to do a collective summing-up of the mathematical topics being practised. Second, the students and the teacher feel that they have "worked hard" in so far as they have made use of new technology and met institutional requirements; but this work ends the machines are switched off. Meanwhile for other teachers this lack of conclusion at the end of class marks a break with their usual practice and can generate frustration. In the previous example we can see how the teacher tries at the last minute to glean as

much information as possible as to where exactly the individual students have got to in their work.

Proposed modifications

In the interviews conducted after the lessons, some of the teachers offered immediate reflections on their activity in the classroom and proposed some short-term modifications.

For example, in one of the lessons the teacher met with the following difficulty: for many students it is not evident that "divide by three" means the same thing as "multiply by 1/3." However, the particular setup of the software means that it is not possible to divide by three. In the interview the teacher explained that she had not anticipated this problem because she had never encountered it when setting traditional exercise work.

More generally, the teachers found it hard to integrate the EEB lessons into their overall teaching agenda. Indeed, given that they are conducted in a classroom other than the one usually used and make use of a special technological resource, these lessons can seem marginal. This is even more so in the case of sessions tailored to students' individual needs. To offset this problem, some teachers take exercises similar to those encountered in the EEB and insert them into their class tests or ask students to perform them in front of the class during the next (non-EEB) lesson. Likewise, the students are asked to work with EEBs as part of their homework, for example when revising for tests.

After the first year of experimentation, almost all of the teachers wanted to continue in the following year. They envisaged some adjustments in terms of:

- their work plans ("construct lesson plans"; "make shorter and more targeted lesson plans")
- the overall structure of the timetable ("get started from the first day of term so as to get into good habits and normalize the use of EEBs"; "try working as a team, rotating the students"; "arrange for 'maths help sessions' to coincide with those of other colleagues so the students can choose whether to work with computers or not").

Following the second year of experimentation the teachers generally envisaged reinforcing the use of EEBs ("*more regular use*") or integrating their use of EEBs in full-class sessions by using a video projector ("*use also in class*"; "*greater use in class*") or extending their use "*at home and in the library*" or indeed adapting their use of EEBs to the needs of different students ("*increased use to deal with weak points*"). We also observed the beginnings of a teamwork initiative; an example of this will be given in the following section where we discuss the case of Flora.

EVOLUTION OF TEACHERS' ACTIVITY: THREE CASE STUDIES

We now turn to the question of long-term evolutions in teaching practice as seen in three case studies. Where possible, these evolutions are interpreted in terms of constructive activity. The interpretations are particularly difficult because, firstly, the evolutions are closely linked to the personal component of teaching practices, for which the data are not always sufficient. Secondly, the long periods of observation needed to detect such evolutions are not always possible. We will present the cases of three teachers who were part of the sample taken at the end of our study.

Michel

Michel teaches in a *lycée professionel* (vocational college, ages 15-18). We collected data on the classroom proceedings of five of his lessons given within a two-year period.

Over the course of the lessons Michel enriched the work plans he used with the target age 15-16 (first year of *lycée*) section of the EEB Paraschool[3] with supplementary study sessions and exercises taken from the target age 14-15 [final year of French *collège*] section. In this way he increased the bank of exercises proposed to students so as to facilitate the transition between the two levels. Indeed, Michel was conscious of the difficulties previously encountered by his students and tried to overcome these by setting exercises from the age 14-15 section, which he began to consult in his second year of teaching with Paraschool. We can say that the modification in his use of the EEB was guided by the cognitive component of his habitual teaching practice.

Other changes Michel made suggest an evolution in the mediative component of his practice. For example, over the course of the lessons he perfected a new format for the dialogues he conducted with individual students as he walked around the classroom: he would systematically ask them to go back over their thinking to check they have understood. We see this taking place in the following dialogue: "*Yes? What is it you don't understand? Right, where's the question, first of all? I didn't see your answer just now. What does this value represent? Go back …*" Michel also devised a special strategy for addressing the whole class. When he first started using the EEB, he used a function that blocked all the computers and stopped the activity of all the students whenever he needed to give an explanation to a group of students or even to just one student. However, these explanations had no relevance to the activity of students who had advanced at a different rate and were at a different point in the work plan. After several lessons he began instead to give his explanations to groups of students on the board, leaving the rest of the class to continue working at their computers. In this way the explanations on the board remained visible to any other students who might need them. Here it seems that the evolutions in Michel's EEB activity resulted from constructive activity, which had an influence on the mediative component of his practice. Certainly we

can see a learning curve in Michel's method of dialogue with students and his way of managing blackboard use in relation to the autonomous activity of his students.

Flora

Flora teaches in a *lycée d'enseignement général* [ages 15-18 and giving access to higher education]. We observed two of her exercise-based lessons, given to a group of fifteen students aged 15-16 using the EEB Euler.[4] In addition to watching Flora's classes, we also conducted an interview in which she described the changes she had made during the year and her plans for the following year.

An initial evolution in Flora's activity seems to have been the desire to integrate the EEB into her overall teaching agenda; in other words, she thought to establish connections between her traditional classroom lessons and her EEB-based lessons. For example, she noticed during an EEB session that the students frequently struggled with linear functions; she therefore decided to adapt next year's traditional classroom session so as better to deal with this topic. In addition, she aimed at a regular use of the EEB even in her traditional classroom sessions. More generally, Flora envisaged restructuring her annual lesson plan so as to begin with, for example, lessons on how to use the EEBs. Flora's progressive integration of the EEB indicates a change in the cognitive and mediative components of her practice that in turn testifies to the presence of constructive activity.

We also detected some localized evolutions in the proceedings of Flora's EEB lessons, though Flora did not seem to notice these herself. For example, her addresses to students during the second lesson we observed aimed to clarify, simplify or develop the methods used to arrive at the answer. She appeared to tailor the help she provided to each student, improving the methods of struggling students and enriching the stock of possible methods in the case of more confident students. Yet in the interview she did not seem to be aware of this "differentiation" in the help she offered. It would therefore appear that this is a stable feature of the mediative component of Flora's practice, common to all her exercise-based lessons.

Finally, Flora helped to create a community of EEB users in her establishment. At the end of the experiment she persuaded two of her colleagues to work with her as a team during special tutoring sessions (i.e. individual help sessions), which are all timetabled at the same time in her establishment. The teachers began to think collectively about how to combine the teaching of topics with the use of EEBs. They also thought of possible ways to link up the EEB-based special tutoring sessions, which are attended by only the weakest students, with their regular, whole-class lessons. For example, they might ask a student from the special tutoring session to come up to the front during an ordinary lesson and explain what they had covered in the tutoring session. What we have here is an evolution in the institutional, social and personal components of Flora's teaching practice. We can therefore affirm the presence of constructive activity. Flora developed, in

particular, an inclination towards teamwork and she now participates in other projects aiming to integrate new technology in teaching.[5]

Diane

Diane had been interested in educational ICT for many years. Prior to our project she had already participated in experiments on the use of spread sheets and interactive geometry software in secondary schools. The evolutions we observed therefore stretch over a very long period, and it would seem that they too can be interpreted in terms of constructive activity. The EEB used this time was Mathenpoche.[6]

The first long-term evolution observed in Diane's practice relates to the use of paper and pencil. During the early experiments with spread sheets, she handed out a sheet for the students to fill in and stick in their exercise books. When observing her lessons, we noticed that the students had a technology's exercises book that they used throughout the lesson. Diane also gave precise instructions on what the students should write down in theses books – for example, the answer to an exercise plus each stage in their working out. Additionally, many of her addresses to the students during the lessons concerned the use of pencil and paper. This goes hand in hand with her idea (expressed in a questionnaire prior to the experiment) of "keeping track" of the students' computer-based activity so that they would have notes to refer to when working independently.

The second evolution we observed in Diane's practice relates to her desire, like that of Flora, to integrate the EEBs into her overall teaching agenda. This can be seen particularly in the questions she set for class tests. At the beginning of the experiment she systematically included in paper and pencil tests exercises taken from one of the EEB sessions and presented as a screenshot. Later on she changed this slightly, instead using exercises that were similar to those from the EEB sessions, but that she had adapted for the test. In both cases she asked the students not simply to write their answer but also to show every stage in their working out; in this way the students recognised the importance of her instructions to take notes during EEB lessons. We can therefore observe that the effective integration of EEBs into Diane's classroom work brought about, first and foremost, an evolution in the cognitive component of her practice.

Bearing in mind these two evolutions, it is clear that Diane was working in the long-term towards the inclusion of the EEB in her global teaching agenda. As in the case of Flora, this corresponded to a progressive integration of the EEB into her teaching practice. Her actions regarding the use of pencil and paper are typical of the sort of strategies we have seen employed by a number of teachers. Indeed, the aim of Diane's various actions was to "oblige" students to keep a written record of their work at the computer; afterwards they were required to employ a similar technique in class tests. If the students are conscientious and use their notes to revise the exercises they have done in class, this may well have a positive effect on their marks.

A third evolution relates to the important role that Diane accorded to the EEB in the last few lessons we observed. Indeed Diane more so than other teachers, seemed to "fade into the background" during EEB classes, her aim being to train the students to work independently with the computers and with as little assistance as possible. In her view, the teacher's role is to help the students to acquire a sound method that will allow them to deal with the exercises independently. Moreover, we noticed that when Diane did monitor or assist the students, she generally concerned herself very little with evaluation. This shows, again, that Diane was willing to delegate part of her usual activity to the EEB. In this case she allowed the software to do the evaluating for her. This contrasts with other teachers, such as Michel, who attributed more importance to the function of evaluating students' work. We should emphasise here that Diane had a thorough understanding of the EEB she was using. This meant that she could, in the course of her explanations, refer students to the appropriate help sections provided by the software. This allowed her to encourage the students as much as possible in developing their autonomy. Certainly, the effort to develop student autonomy is one of the strong points of the personal component of Diane's teaching practice. We can therefore assert the presence of constructive activity in Diane's practices: she acquired a thorough knowledge of how to use the EEB and this because the EEB was the best means of achieving her teaching objectives.

Finally we should note that, thanks to her thorough knowledge of the EEB, Diane's interventions during the lesson sometimes succeeded in promoting the construction of mathematical knowledge (constructively oriented assistance) and not simply the execution of the task in hand (procedurally oriented assistance, see chapter 2). In the final lesson we observed, for example, she explained that the concepts of images and pre-images often pose problems for students because they tend to mix them up or else do not understand how they relate to whether a point is positioned on or off the curve. Diane thus helped the students to distance themselves from the specific EEB tasks they worked on and to think back over their mathematical knowledge. This can be seen in the following conversation she had with a student:

Diane: "*When you draw a curve, what are the coordinates of point M on the curve?*
Student: *M.*
Diane: *No. When you have a curve, what do you do to find the position of M? If I ask you to draw the curve* x^2*, what do you do first? You make the table of values, and then? You've got the x values, now you need to find the y values, in other words the* x^2 *values. Then once you've got your table of values, how do you move onto the curve? ...*"

It is clear that the use of the EEB brought about changes and privileged new types of interactions with the students. Could we see this as an evolution in the mediative component of Diane's practice?

CONCLUSIONS

Let us recall that one of the conclusions of the study of students working with EEBs (chapter 8) was the primordial importance of the role played by the teacher. This was true across all class levels. Without the mathematical assistance of the teacher, it is unlikely that students would be able to complete the exercises proposed. We can therefore appreciate the importance of the present chapter in which we have looked at the practice of teachers using EEBs and addressed the underlying question of the effects of EEBs on students' progress in mathematics. We have also asked more specific questions relating to teachers' appropriation of this new tool, its possible uses in terms of student activity, and the changes it brings about in teachers' daily activities and the evolutions of their global practices more generally. We have made several important findings.

Firstly, the teacher's productive activity is determined by the circumstances pertaining to the use of EEBs in class. Indeed, we have seen that a number of features relative to the organisation of the lesson tend to be adopted fairly quickly. These include a relatively long and rigid work plan, a smaller class size, work on topics that either have already been studied or are currently being studied, student-teacher interactions that is chiefly one-to-one, the absence of a summing-up addressed to the whole class at the end of the lesson, and limited use of the black/whiteboard. These features, which are both cognitive and mediative, seem to be linked both to the short- or medium-term "external" regulations of the teacher's EEB-related activity and, especially, to the significant constraints associated with the use of EEBs in class.

Secondly, the circumstances of the use of EEBs during lessons determine a teacher's geneses of the EEBs uses. In particular, teacher's activity will unavoidably, if progressively, acquire certain specificities. Thus we have the insistence that students keep a written record of their work and the linking up of EEB-based lessons with the ordinary (traditional classroom) lessons and class tests. These evolutions seem chiefly to affect the cognitive and personal components of teachers' practice. They are the result of constructive activity ("internal" regulations, chapter 1) but can accompany (as in the case of Flora) a desire for professional development. Nonetheless, these evolutions all have their limits. We can see this, notably, in the teachers' work plans, where, even after extended use of the EEB, crossovers between different mathematical topics still tend to be avoided.

Furthermore, the disparities between teachers and the different evolutions in their activity can testify to more complex geneses of uses that are linked to the teacher him/herself. These seem to be more directly linked to the mediative and personal components of practice. However, to detect geneses of this kind would require study over a much longer period of time. It is hard to say whether Diane's relinquishment of a part of her evaluation work to the EEB was really a matter of professional development or rather a helpful adjustment when integrating the EEB into the mediative and personal components of her practice. Flora's tailoring of the assistance she offered based on the needs of individual students did not seem to be conscious and so could be a pre-existing feature of her practice. We might also ask

ourselves whether Michel's methods for helping students during EEB sessions (a very specific use of the blackboard and a particular dialogue format when discussing students' work with them) really evolved because of his use of the EEB or is rather a reflection of the mediative component of his pre-existing practices.

Lastly, another conclusion of the study of students working with EEBs (chapter 8) was that students must adopt a reflexive attitude in order for their work to be profitable. Whereas we might say that such an attitude is always desirable in learners, it is actually shown to be necessary when working with EEBs. Attempts by teachers to develop this reflexive attitude in their students would therefore appear to be beneficial. According to our observations, teachers actually do this, more or less consciously and in harmony with the different components of their practices. Thus, Michel felt that he should make available a written explanation that his students will be able to use "*where necessary*." Meanwhile Flora, when helping students with a given exercise, altered her assistance, more or less consciously, to meet the needs of different students. Finally, Diane worked on developing her students' independent learning skills by, for example, leaving them to evaluate their own work with the help of the EEB. Drawing on these three examples we can thus see that, in spite of various disparities resulting from the mediative component of these teachers' practice, all of them seem to have paid attention to the development of a reflexive attitude in their students.

NOTES

1 The use here of the term 'situation' is the same as in chapter 1.

2 The precise methodology at this stage is the same as that laid out in chapter two and is consistent throughout the book. In particular, we attempt to analyse the complexity of the tasks required to complete a given set of exercises, bearing in mind the help offered by computer technology. An analysis of the difficulty of applying knowledge to specific maths problems is important in gauging the quality of students' mathematical activity.

3 http://www.paraschool.com/

4 http://euler.ac-versailles.fr/

5 http://www.edumatics.eu.

6 http://mathenpoche.sesamath.net

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