Teachers using technology: aspirations and classroom activity

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ABSTRACT

This paper is about teachers using technology in 'ordinary' conditions. It addresses the discrepancies between potentialities of technology and teachers' aspirations with regard to technology use, and between teachers ' expectations and the actual carrying out of technology based lessons in the classroom as well as by unexpected episodes of uncertainty and improvisation that teachers experience when teaching these lessons. Two models are used to make sense of teachers' position and of classroom phenomena. Ruthven and Hennessy's (2002) model helps to understand how teachers connect potentialities of a technology to their pedagogical aspirations, rather than to mathematically meaningful capabilities, and to interpret their classroom activity. Saxe's (1991) model helps to analyse the flow of unexpected circumstances challenging teachers' professional knowledge in technology based lessons and to understand how teachers react to this flow. It also draws attention on the consequences of the introduction of new artifacts in the culture of the classroom. This gives tools for researchers to work in partnership with teachers, as well as for a reorientation of teacher development in technology towards reflective approaches.

Keywords
Digital Technology Integration; Teachers' aspirations; Teachers' Classroom Activity; Emergent Goals; Practitioner Model

This article is about teachers using technology in mathematics teaching/learning. I am interested here by teachers using technology in 'ordinary conditions', that is to say not in the frame of experimental projects. My question is what they really expect of technology and how these expectations impact upon their classroom activity. This question comes from observations we did in a French research group whose name is GUPTEn (Genèses d'Usages Professionnels des Technologies par les Enseignants)[1]. This group worked observing teachers with diverse methodologies and observed a series of gaps. The first gap is between institutional demand and few actual uses by teachers. In some parts of the French curriculum there are strong institutional demands towards technology use, but, as international studies like PISA show, students rarely mention having used technology in the classroom. The second gap is between the potentialities brought by technology and the actual uses by teachers. In some parts of the French curriculum technology use is compulsory. However, uses prepared and carried out by the teachers appear to be deceiving in comparison to the potentialities of technology emphasised by research studies and innovating projects. When our group looked more closely to classroom uses, a third gap appeared. The carrying-out of the lesson in the classroom was often different from what teachers had expected. Very frequently, we observed episodes where teachers seemed to be quite uncertain of how to carry out the lesson and had to improvise.

Some authors explain these gaps by teachers' conservativeness, saying that teachers are reluctant to change especially because using technology would also oblige them to modify their teaching habits and style. In my meaning, these discourses underestimate the constraints that teachers face. Cuban (1989) emphasized the crucial role of these constraints : "*Teachers teach the way they do simply to survive the impossibilities inherent in the workplace*". For me it means that opportunities exist for changing teaching practices, but, constraints make them not many, and one has to consider them carefully, which is a goal of this paper. Another explanation of the gaps would be insufficient teacher education. Certainly teacher education does not contribute efficiently enough to technology integration, but in my view, and from the observation that in France many efforts have been devoted to teacher education in this field, I take for granted that the gap is more qualitative than quantitative.

[1] The web site http://gupten.free.fr presents this research group and its main activities

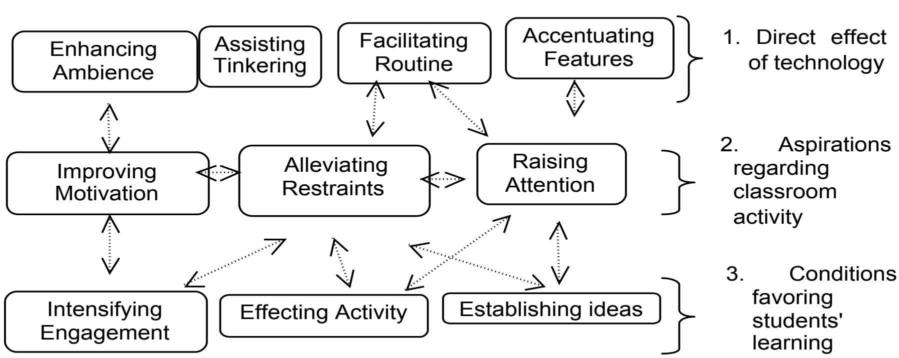
1. HYPOTHESES, FRAMEWORKS, CASE STUDIES AND QUESTIONS

In my view these gaps originate from a poor conceptualisation of teachers' position towards technology and we need to understand better this position. That is what this article wants to contribute to. Studying teachers' expectations relatively to technology and how they impact upon their classroom activity is a means for that. This study is based upon two hypotheses. The first one is of a discrepancy between *potentialities* emphasised by researchers that come from a didactical analysis of software uses and teachers' *expectations* towards supposed effects of technology. Potentialities derive from a cognitive didactical analysis of software uses by researchers, while expectations are marked by teachers' aspirations regarding students' activity.

The second hypothesis is that analysing classroom episodes where teachers meet uncertainty and have to improvise could help to reveal hidden constraints and obstacles. I will use two different frameworks for these two hypotheses. Conceptualising teachers' expectations with regard to technology will be done using Ruthven and Hennessy's (2002) "practitioner model of the use of technology to support mathematics teaching and learning". The framework that I will use to address the complexity and uncertainty of teachers' activity involving classroom use of technology is Saxe's cultural perspective (the four parameters model) that Monaghan (2005) introduced to analyse technology based lessons.

1.1 A practitioner model

Figure 1: Ruthven and Hennessy' practitioner model

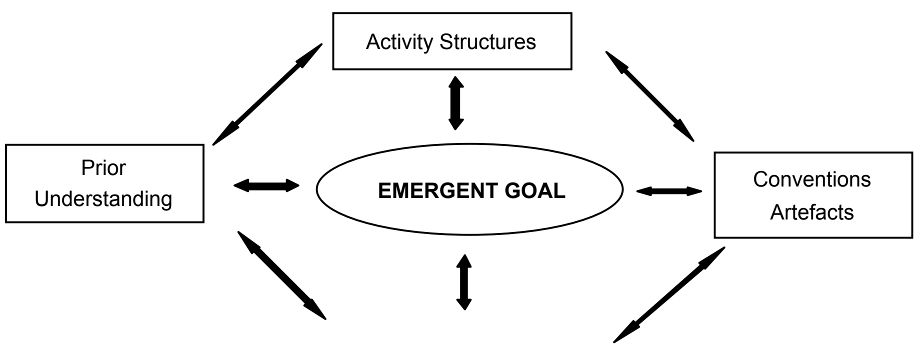


Ruthven and Hennessy built the model outlined in figure 1 from interviews conducted with mathematics teachers in the UK. These were not individual interviews but collective discussions in mathematics departments leaded by the researchers about what is for these teachers a successful use of technology. From the script of the interviews, Ruthven and Hennessy determined ten themes and organized these themes in three levels. The first level is where we find the reasons for success directly following technology use. There is a better ambience because students generally like working in pairs on a computer, it makes experimental approaches possible, routine tasks are facilitated, etc. At the second level we find aspirations regarding classroom activity is the consequences of these effects of technology to the. At the third level, we find teachers' general views regarding conditions favoring students' learning. Teachers consider that students learn better when they engage more, in a more effective activity, and when the ideas are better established.

The links between themes were established by a statistical procedure. Links are between the themes that appear together more often in the same teacher's statements.

1.2 Saxe's cultural perspective (the four parameters model)

Figure 2 : Saxe's four parameters model



Monaghan (2005) proposed to use Saxe's cultural perspective to address the complexity of classroom practises with technology as a whole. My assumption is that Saxe's idea of emergent goal might help to understand what I called above episodes of uncertainty and improvisation: «*Goals are emergent phenomena,* *shifting and taking new forms as individuals use their knowledge and skills alone and in interaction with others to organize their immediate contexts*" (Saxe, 1991).

Monaghan (2004) described the four parameters in the context of technology use (figure 2).

Activity structure:

Monaghan considers here the way teachers organize their classes and prepare students' tasks, and the decisions they take relatively to their role and activity as well as those of the students: he observed that the tasks and cycles of these lessons varied considerably across teachers and, in most cases, varied over time, technology tasks being 'unsafe' as compared to usual tasks.

Conventions – artefacts:

While recognizing that Mathematics teaching involves many cultural artefacts including systems of convention and notations, Monaghan privileges software and written resources in the study of teacher activity in technology-based lessons, considering that the way a software transforms mathematics is an important concern for a teacher and also that the shift towards technology use brings him/her to widely re-evaluate the content of his/her written material as well as the way they use it.

Social interactions:

Monaghan observed a variety of ways in which technology affected social interactions in observed classrooms. Although technology lessons were notable for their diversity, most changes appeared in relationship with specific constraints and did not denote a clear developmental path towards adopting new roles.

Prior understandings: For Monaghan, mathematics teachers' 'prior understandings' of learning and teaching incorporate a range of beliefs and professional knowledge. Beliefs are globally independent of whether or not the lesson uses technology and were not reconsidered. In contrast, teachers' knowledge of their teaching, generally tacit in ordinary lessons, had to be rethought deeply in order to incorporate technology use.

1.3 Case studies and Questions

The two case studies analyzed in this paper come from doctoral theses. The first one is Caliksan-Dedeoglu (2006). It concerns Dynamic geometry (DG) at middle school level. In this context there is a strong institutional demand and many resources

should help the teacher. It is also a context where teachers feel often not easy to teach because of difficulties to maintain student's attention and motivation. The questions are about the discrepancies between potentialities of technology and teachers' expectations, and between teachers' expectations and the actual carrying out of the lessons in the classroom.
The second case study comes from Ozdemir-Erdogan (2006) and deals with spreadsheet use at upper secondary level by non scientific students. The context is a new curriculum where spreadsheet use is compulsory. The questions and hypotheses are about teachers' understanding of this curriculum and the goals emerging in teachers' classroom activity.

2 POTENTIALITIES OF TECHNOLOGY AND TEACHER EXPECTATIONS

In the first case study Caliksan-Dedeoglu studied successive gaps between the potential of Dynamic Geometry as seen by research, by the curriculum, by textbooks and by teachers. She also observed the classroom activity of a panel of teachers.

2.1 Successive gaps between views about Dynamic Geometry

Dynamic geometry in research studies

Caliksan-Dedeoglu looked for the potentialities that didactic research studies attribute to Dynamic Geometry, but also for the conditions that researchers find important in order that DG really contribute to learning.

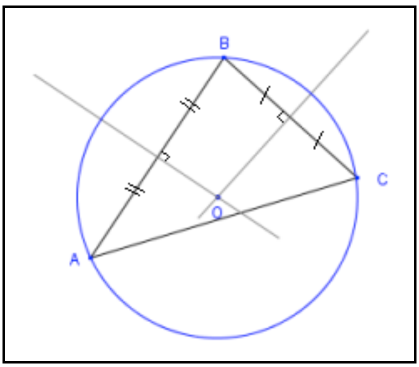
She found that the construction and creation tools can help students to draw quickly accurate figures and that the dragging tool is appropriate to distinguish between a drawing and a figure (Laborde 1994) and to explore invariant properties.

She also noticed that these features are considered in interaction. A good example of interaction is the case of robust and soft constructions (Healey 2000).

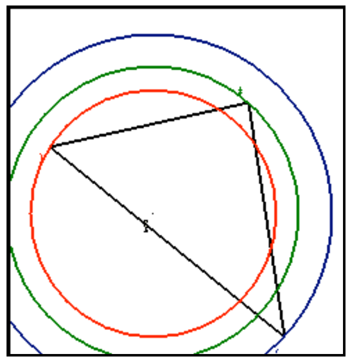
A robust construction (figure 3, left) is the dynamic equivalent of a mathematical geometrical construction. For instance, constructing the circumcircle of a given triangle *ABC*, the students classically construct O at the intersection of two perpendicular bisectors, for instance of *A* and B and of B and C. It is a robust construction because it resist to a change in the position of the given points. More generally, in a robust construction activity, dragging gives evidence of a valid construction.

In a soft construction, (figure 3, right) students drag free points to obtain a given configuration. For instance, to obtain the circumcircle of a given triangle *ABC*, students create a free point O and three circles centred in O, passing respectively by *A*, B and C. They move O in order that the first two circles overlap. Then they move O carefully in order that the two circles continue to overlap, until the three circle overlap. This is a soft construction because it does not resist to a change in the position of the given points. When a student or the teacher moves a vertex of the triangle, the three circles disjoin. In a soft construction dragging helps to explore constructions and can play a role in the proof process: "*dragging tools enable students to examine their constructions, both to identify relationships which remain invariant and to impose further relationships visually*" (Healey 2000).

Figure 3: Constructing the circumcircle of a triangle



A robust construction



A soft construction

Another important idea that we found in research studies is how classroom activities should be organized. For instance Falcade R., Laborde C., and Mariotti (2007) used Dynamic Geometry to develop students' understanding of functions and they insist on three types of uses. One is in the computer lab, students working in pairs on a task, the second is individual writing, possibly using the computer to check some functioning and the third is classroom discussion where a video projector can be used. In their view, it is important that these three types of uses are coordinated, the individual writing fostering a reflection on computer activity, and the classroom discussion helping to give a mathematical meaning to the observations.

2.2 *Dynamic geometry in Textbooks*

Caliksan-Dedeoglu made a comprehensive study of textbooks for the middle school with regard to Dynamic geometry and she found first a discrepancy with the curriculum. While the curriculum says that DG can be used for most tasks as well as paper/pencil, only 5% of the geometric tasks tasks involved Dynamic Geometry. And also there were some subjects like 3D geometry that the curriculum specially emphasised as interesting for the use of Dynamic geometry software and for which textbooks did not mention its use. This is for us an indication that integrating DG, as recommended by the curriculum is not so easy because textbooks authors find difficulties to propose tasks that the teachers could really put into operation.

These were also clear discrepancies between Dynamic Geometry in Textbooks and in research. First, tasks in textbooks separated construction and dragging. Task for creating constructions were typically reproducing a paper pencil figure. Tasks involving dragging objects typically aimed to recognize invariant properties. And also there was emphasize on measure in invariant properties, for instance invariance of ratios in the theorems of the parallels.

Then textbooks separated two types of uses. Textbooks considered mainly two types of work, one in a computer room, students working alone or in pair on a computer and following a worksheet, and the other in an ordinary classroom with a computer hooked to a video projector and activated by the teacher. As a difference with research, textbooks did not insist on coordination between these types of uses.

Because textbooks influence teachers' practices, but also are influenced by what is possible in teachers' practice, it was an indication that there could be a distance between these practices and what research studies found necessary for a successful use of DG. Actually, the computer room is seen as an environment for student autonomous work, while the computer hooked to a video projector and activated by the teacher is seen as a tool for the teacher to illustrate a lesson without necessary connection between those uses.

2.3 *Classroom observation*

As said above, Caliksan-Dedeoglu also observed teachers. She had difficulties to find teachers using dynamic geometry and accepting that a phD student observe their classroom. She found nevertheless a panel of five teachers in three schools that were not ordinary teachers in the sense of randomly chosen teachers, but rather experienced teachers with some contact with groups of research and action. Two teachers in this panel developed uses in computers labs, what we called above GD Environment for student autonomous work and three used systematically a computer hooked to a video projector that they operated themselves.

DG= Environment for student autonomous work

Anne was one of the teachers that developed uses in computers labs. She taught at 7th grade and she was positive towards technology. Especially, she saw advantage in GD use like speed and accuracy of drawings by students, avoiding mistakes by not confusing words for instance perpendicular bisector ('médiatrice' in French) and median in a triangle. To her, dragging was a means for students to experience an invariant property.

Figure 4: Anne's instructions for students

Create a triangle A B C
Create a free point O
Create three circles centred in O passing by A, B, C
What can you say of these circles?
Create the perpendicular bisector of segment AB.
Put O on this line
What do you observe?
...
Write instructions to construct the circumcircle of a triangle

Figure 4 presents a task that Anne proposed in her 7th grade class. The objective was to introduce students to the topic of the circumcircle of a triangle and more precisely that they understand the position of the circumcenter and find a paper pencil construction..

Students had to create a triangle *A B C*, a free point *O* and three circles centred in *O* passing by A, *B*, *C*, they had then to observe that the circles are different, because point *O* is randomly positioned. Then Anne did not ask her students to find experimentally some position where two or three circles could be the same, like in a soft construction strategy. In contrast she directly asked to draw the perpendicular bisector of segment *AB*, to drag *O* on this line and to observe that the two circles passing by *A* and *B* are the same. At the end, she did not ask for a hard construction and to verify by dragging, but to write a program of construction from the guided tasks they did before.

In our understanding, Anne transformed a problem of soft construction into a series of construction-observation tasks that should lead students to a paper pencil construction. She separated creating and dragging objects, thus loosing the challenging aspects of the problem.

The observation showed that students actually had much difficulty when operating the software, not understanding for instance that the three circles had to be named and how. Anne tried to help them individually, but there was much disturbance: the task was prepared for just half of a 50mn session, and few students could actually make sense of the observation.

DG= a tool for the teacher to illustrate a lesson

I now contrast Anne with another teacher, Bruno who had systematically developed the use of DG as a tool to illustrate a lesson. He was also positive towards technology and particularly stressed that technology helps to visualize dynamically and allows easy construction and easy measurements. He said that he preferred to use a computer hooked to a video projector because he tried before to use GD in a computer room and found that it was much work for him and little gain for the students. He said he would have needed worksheets to strictly guide students. He taught nearly all geometry lessons with DG and video projector**,** operating the computer and showing various configurations. His students had to answer questions and to copy the configurations on paper.

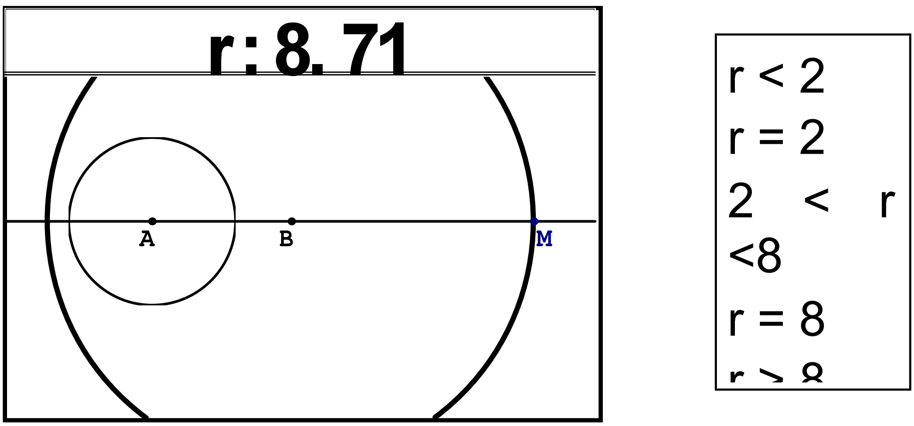
A typical situation was a lesson about the triangle inequality for an 8th grade class. The triangle inequality is the theorem stating that for any triangle, the length of a given side must be less than or equal to the sum of the other two sides but greater than or equal to the difference between the two sides. Note that only the first inequality is mentioned by the curriculum at this level.

Starting the lesson, Bruno presented the goal with the following question:

Consider a triangle ABC, with AB= 5cm, AC= 3cm. What can be the length of BC?

In a first phase, students had to try do draw a triangle on their paper. Bruno's intention was that students guess an adequate measure for the distance BC and use the standard compass procedure for drawing a triangle of given sides. Then five phases followed. Theses phases were supported by a GD figure animated by the teacher. In this figure, *A* and B were two fixed points with a distance of five. M is a free point on the line (*AB*). A fixed circle centered in *A* and of radius 3, and a circle centered in *A*, passing by M were also drawn. The teacher animated the second circle by dragging M and the radius was displayed in the form r =.... (figure 5). Bruno's idea was that the students would easily connect this figure with the standard compass procedure activated in the first phase.

Figure 5: Bruno's screen and blackboard

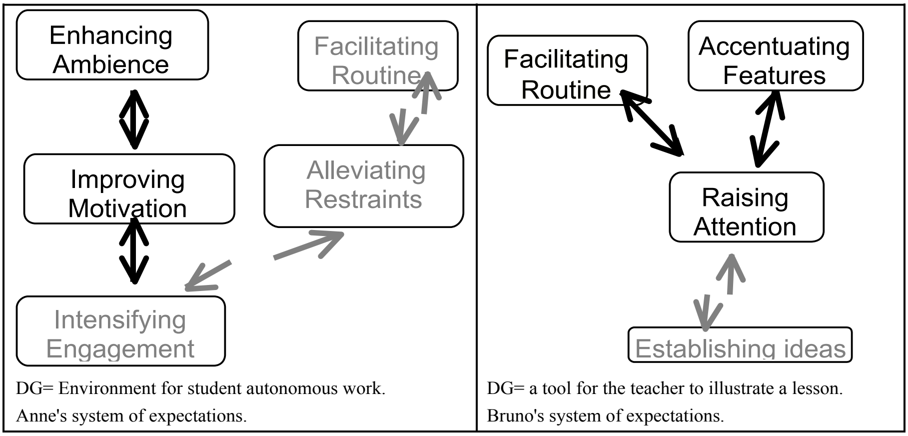


In each of the five phases, the teacher considered a specific configuration: the circles were successively separated externally, tangent internally, secant in two points, tangent internally and separated internally. After discussing each configuration with the students, the teacher wrote a condition relatively to r on the blackboard. In a last concluding phase, he tried to make students pass from the condition 2<r<8 to a statement involving the measures of the sides, that is to say the triangle inequality. He did this by raising the students' attention on the numbers 2 and 8 (respectively the difference and the sum of 5 and 3) rather than by considering the relationship between the radius of the circles and the distance of the center in a generic configuration.

Caliksan-Dedeoglu's observation showed that the visualisation did not really make sense for the students. They did not understand the relationship between the problem and the GD figure. In the first phase they had used the compass, but they did not see the relationship with the circle drawn and animated by the teacher. They did not understand the role of the free point M and of the variable r. They saw that the different cases correspond to $r<2$, $r=2$, $2<r<8$, $r=8$, $r>8$ but they did not put these facts in relationship with properties of the lengths of the triangle. In an interview after the classroom session, Bruno said that he was disappointed: students should have found themselves the triangle inequality after observing the configurations.

2.4 *Teachers' expectations versus actual carrying out*

Figure 6: a summary of the analysis



The figure 6 summaries the above analysis of the two different types of use that we pointed out in the textbooks' analysis and that we observed respectively in Anne's and Bruno's classrooms. For each teacher, from their declarations, we retain in Ruthven and Hennessy's model the themes that he (she) privileges, and the links between them. In Anne's case (left), she insisted that students would work better in the computer lab, and then that their motivation, which was one of her great concern, would improve. Easy construction would also help students to go faster in the task. The two lines of themes would converge towards intensified engagement. Really for Anne, student's engagement in the task is condition for learning. For Bruno (right), DG helps to facilitate constructions and to put the focus on relevant features of the situation. It should help students to be attentive and to make clear the relevant ideas of the situation. As we can see, the two systems realize nearly a partition of Ruthven and Hennessy's model. I take this as an evidence of two distinct systems of expectations underlying the two types of uses. This is clearly different as compared to research where different types of uses are articulated.

The two systems connect the anticipation by the teachers of effects of technology uses to deep personal aspirations regarding students' access to knowledge. For Anne, students' engagement in tasks is a condition for conceptualising, whereas Bruno privileges a good visualization of math properties in order to retain the main ideas. These personal aspirations are clearly related to the context: as said above, at middle school level in France, teaching conditions can be difficult, a situation that teachers often explain by students lacking in motivation and concentration. Teachers' use of technology seems to be driven by these context related aspirations rather than by the didactical potentialities evidenced by research on cognitive aspects of technology use.

In the figure 6, the broken arrows pointing to themes written in grey reflect phenomena observed in the classroom: in some cases expectations of the teachers were not fulfilled. Anne's students experienced difficulties with the software. Routine was not really facilitated. Then for Anne there was a danger that students did not fully engage in the task. That is why she devoted most of her time and energy to help individually students in their constructions. In Bruno's case, the link between "Raising attention" and "Establishing ideas" did not work. That is why, like so many teachers in the same circumstances, Bruno finally obtained the statements he needed by what Brousseau (1997, p.25) named "a Topaze effect". This means that the systems of expectations that I outlined can explain both how teachers prepare a lesson with technology, but also how they carry out the lesson, including the way they face unexpected circumstances. Using the second model outlined in section one, the next section will consider in more depth how a teacher in another context encounters and manages these unexpected situations.

3 EMERGING GOALS IN TEACHERS' CLASSROOM ACTIVITY

The context for the second case study is the French curriculum for upper secondary non-scientific classes existing since the year 2000. It is intended for students more attracted by literature and arts than science, and who generally experienced difficulties in mathematics. It aims to strengthen mathematical basic knowledge by favouring modelling, interpreting and criticizing varied information. It recommends involving "*mathematics use visible in society*" that is to say graphs, tables, percentages… It "*systematically proposes to put all the items into operation on a spreadsheet*". It does not recommend the study of the spreadsheet for itself, but as means for exploring and solving problems.

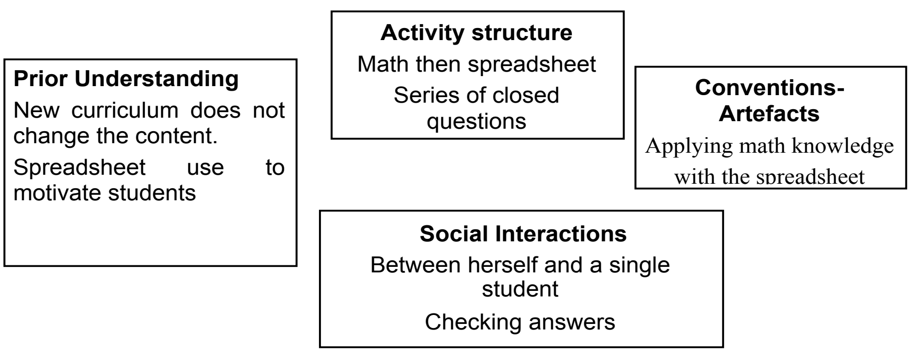
Ozdemir-Erdogan focused on lessons about linear and exponential sequences. In the curriculum, this topic derives from the focus on "visible mathematics". Students are supposed to study "types of progression" from examples of situations without the mathematical apparatus of sequences, but with the help of the spreadsheet. As a difference with other courses where most teachers ignore curricular recommendation about technology, spreadsheet's use cannot be avoided because of the national evaluation –the baccalaureate- whose texts are written in order that candidates could not succeed without spreadsheet knowledge.

3.1 *The case of Charlotte*

Among the teachers that Ozdemir-Erdogan observed in these classes we selected one - Charlotte . She was a very experienced teacher, she taught these classes for 30 years, and she had to adapt her teaching to the new curriculum although she thought that technology would not give great help. That ensured that difficulties would not come from poor classroom preparation and management. Actually Charlotte is representative of a majority of teachers who teach these classes because of the curriculum's demands rather than because they like technology. This section presents Charlotte's profile using Saxe's four parameters and then reports on fragments of a classroom session identifying emergent goals.

3.2 *Charlotte's profile*

Figure 7: Charlotte's four parameters



This is how we can see Charlotte with the help of the four parameters model

Activity Structures:

Charlotte devoted three weeks to sequences which is not much with regard to the curriculum's demands. Charlotte's structure was simple: the notion of sequence was presented to the students the first week, then arithmetical sequences the second and geometrical sequences the third. This structure is not consistent with the curriculum, since the study of situations and the notion of progression should be privileged.

The course was two hours per week, one in whole class and one in half class. Teachers had to decide how to use them. Charlotte taught the whole class in an ordinary classroom and the half class in a computer room. In both classes, whole class sessions were devoted to the presentation of the mathematical content and half class sessions to "applications" with the spreadsheet. Charlotte's students worked individually following a worksheet.

Conventions – artefacts:

We consider here the spreadsheet whose use is compulsory in this course and the written material that teachers prepared for the students. In the whole class hour Charlotte's students had to work on paper-pencil. In half-class it was clear that they had to work on the spreadsheet: Charlotte's worksheets were really specific about this use, referring to cells and formulas.

Social Interactions:

Charlotte's interactions with students were similar in the computer and in the ordinary room. These interactions were very frequent and generally between herself and a single student.

Prior Understandings:

In Charlotte's view, technology was introduced in this course in order that students learn about spreadsheets. For her, beside the use of technology, the mathematical content was not different from the previous curriculum. She thought that technology does not bring a very concrete contribution, but has a positive effect on the behaviour of her students that she considered weak and not interested in mathematics.

3.3 *Fragments of a lesson*

Figure 8: an example of a task for the first lesson about sequences

Sabine has just been born. Her grandmother opens a credit account for her, makes a first 100 € deposit and decides to make each year a new deposit of the same amount plus the double of Sabine's age.

a. Starting with u0 = 100, compute by hand the money that Sabine's grandmother will deposit on the account
   at year 1 : u1 =… at year2 : u2 =…
   at year 3: u3 =… at year 4: u4 =…

	A	B	C
1	ans	versement	total
2	0	100	
3	1	=	
4	2		
5	3		

b. Which of the following formulas should we write in cell B3 and fill down to obtain the values of the sequence?
   (1) = B2 + 2*A3 (2) = B2 +2 (3) = B2+ 2*A3

The figure 8 presents an example of a task proposed by Charlotte for the first lesson about sequences. Question a. gave priority to the mathematical notion of sequence and notation, and privileged by hand calculation in the understanding of the situation. In question b., a table and three formulas were provided, and students had only to "press buttons" to complete the electronic sheet. The first formula, although congruent to the definition, does not work, because of the filling down functioning. The second formula is recursive, and then not congruent to the definition, and it works. The third formula corrects the first by way of an absolute reference (B2) to the initial deposit.

This is how the students carried out the task: they launched directly the spreadsheet, entered the values in each cell; one hundred and two in cell B2, one hundred and four in cell B3, etc.. Going to question b. they tried formula (1) that did not work. Without reflecting more they tried formula (2). Then they passed to the next question without trying formula (3). Looking at the students' screens, Charlotte was first satisfied to see the right numbers in the cells, and then she became aware that students did not enter a formula and she seemed quite surprised. She then devoted a number of individual interactions with the students to prompt them to enter formulas and fill down the sheet.

This was the first emergent goal: *making the students use the spreadsheet as a calculation tool*.

She was again surprised that students did not try the third formula and she also prompted them individually for that. This was the second emergent goal: *making the students try formula* (3).

Figure 9: Managing the first emergent goal. Two interactions

Interaction 1
Student 1: Am I right ?
Charlotte: Yes…
…And.. how do you proceed?
Student 1: I calculate
Charlotte: no, you must not calculate, the spreadsheet must calculate!
Student 1: but it is quicker than with the computer
Charlotte: but go until 200 years like that?
Student 1: but this poor girl will never be 200 years old!

Interaction 2
Charlotte: what happens to you…? No, no, do not make like that.
Student 2: me?
Charlotte: one should not type each time the calculation.
Student 2: but why not?
Charlotte: it is necessary that…
I want to be able... Take your formula and fill down.

The figure 9 displays two examples of interactions showing how Charlotte encountered and managed the first goal. The first interaction shows that teacher and student have different views of the task and of the spreadsheet. For Charlotte it was important to use the spreadsheet as a calculation tool, because, although she did not quite believe in the contribution of technology, she was aware of teaching a mathematics course and not just a course "about arranging data in columns". In the students' view the spreadsheet was not fundamentally a calculation tool. It was difficult for them to enter formulas and easy to calculate mentally the values. Some of them devoted a lot of time to neatly format the data and the columns using colours.

As can be seen in the second interaction, after trying with student 1 to give reasons for using the spreadsheet, Charlotte gave up and exercised her authority on student 2.

Figure 10: Managing the second emergent goal.

Interaction 3
Charlotte: Did you choose between the three formulas?
Student: Yes this one (She shows the second formula on her screen).
Charlotte: Did you try the third one? (with absolute reference)
Student: No, I did not.
Charlotte: Then please try.
Student: But, after that I will have to do it again!

Then Charlotte shows the student how to use a third column for the third formula.

Figure 10 shows an example of interaction relatively to the use of the third formula (second emerging goal). It helps to understand why students did not try this third formula. Because the second formula gave the data they expected, they were satisfied. They feared that the third formula would not work and then that their previous work would be destroyed. This is very consistent with common social behaviour with regard to technological tools. If one finds a way to reach a goal for instance with his (her) mobile phone, he (she) will generally not continue to seek for another way. He (she) will prefer to keep strictly to the way he (she) found. In contrast the task proposed in the text was about comparing different ways to reach the same goal.

3.4 *Parameters and emergent goals*

This is how the emergence and the management of goals can be seen under the influence of parameters (figure 11).

Activity Structures:

Charlotte's students worked individually following a worksheet. This did not favour reflection that would be necessary to compare the three formulas and make sense of these.

Conventions - artefacts:

The students understood that in the computer lab they had to use the computer, that is why they directly launched the spreadsheet not understanding that the text asked first a paper pencil task and then a comparison with the spreadsheet.

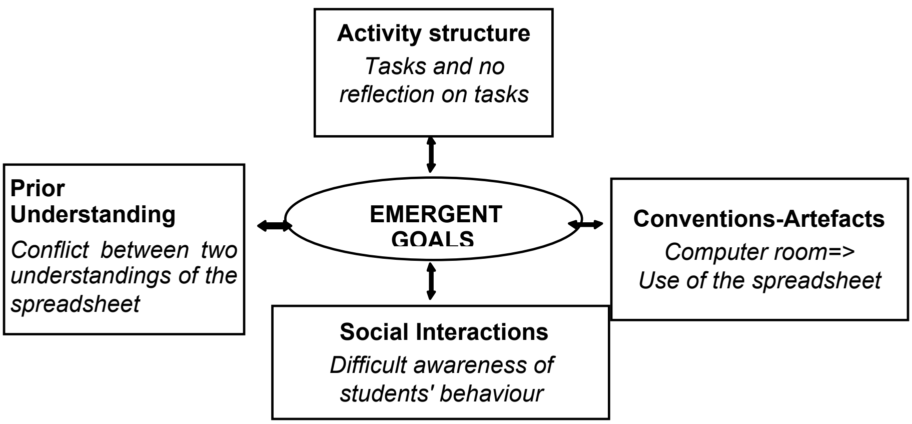
Social Interactions:

Charlotte's scheme of interactions with a single student made difficult for her to become aware of their behaviour. She was first satisfied to see the right values in the cells, before understanding that they had been entered one by one in the spreadsheet.

Prior Understandings:

There is a conflict between two understandings of the spreadsheet; students' understanding is related to a social view of technological tools whereas the teacher understands the spreadsheet as a calculation tool. Charlotte seemed to be not aware of social representations of tools possibly conflicting with mathematical uses.

Figure 11: Charlotte's parameters and emergent goals



3.5 *Discussion*

Other observations confirmed that Charlotte's tendency to act on an exposition/application activity format and a teacher/student individual interaction scheme, already existing before the curriculum change, had been reinforced by the spreadsheet and consequently application was replaced by narrow spreadsheet tasks. Maybe we could say that the observation of goals comes from the fact that Charlotte is particularly weak, falling into every pitfall of technology use. It is not the case, since Ozdemir-Erdogan observed another teacher, very experienced in the classroom use of technology, volunteer to teach this course after the curriculum change, with a much better understanding of the curriculum and an innovative classroom management. The observation of a similar session showed that this teacher encountered similar emerging goals and that, although she reacted better, this reaction was not always consistent (Lagrange, Erdogan 2009).

This idea of emergent goals was means to give account of teachers' uncertainty in classroom use of technology. It brings further to think about what these teachers have in common with the New Guinea Oksapmin from which Saxe built the model. This should be that both had to deal with a new artefact involving deep cultural representations. In the Vygotskian perspective, Saxe was interested by the impact of culture upon cognition and he chose the Oksapmin people because in their case there was a conflict of cultures: these people have a traditional way of counting, using parts of the body as representation of numbers; some of them trade in the modern way, but their traditional way does not permit them the calculations that this trade requires. This comparison brings to consider cultural systems involved in classroom use of technology. Students saw the spreadsheet as a means to neatly display data. It is consistent with the social representations of technological tools. People are generally not aware of the real power of the computer, which is the possibility of doing controlled automatic calculation on a data set, even when they used spreadsheet features based on this capability. In contrast, Charlotte saw the spreadsheet as a mathematical tool. She was disconcerted because she was not conscious of the existence of other representations.

4 CONCLUSION AND PERSPECTIVES

Combined with classroom observations, the two models helped to make sense of teachers' position and of classroom phenomena. Ruthven and Hennessy's model helped to understand that teachers connect potentialities of a technology to their pedagogical aspirations, rather than to mathematically meaningful capabilities. The observation of two teachers using dynamic geometry showed what happens when the connection does not work: the teacher tries to re-establish the connection. In the first observation the teacher Anne expected that technology would help students to work alone on a task, but it did not work because of insufficient instrumental genesis. Then she tried to re-establish the connection by becoming a technical assistant. This explain why teachers teaching in a computer room devote much time to technical scaffolding when they expected that technology would help their students to work alone and that they could act as a catalyst for mathematical thinking. In the second observation the teacher Bruno expected that after the students had their attention raised thanks to technology, it would be easy for them to make sense of the situation mathematically. Again here it did not work because students did not understand the teacher's action on the computer and the teacher had to rely on a "Topaze effect".

I also noted that these teachers had different expectations directing them towards different uses of technology, one in a computer room, the other on a computer he operated himself, and that in both cases, their expectations were connected to their teaching context.

Saxe's model was chosen to analyse classroom episodes where teachers meet uncertainty and have to improvise. The notion of emergent goals was central to analyse the flow of unexpected circumstances challenging teachers' professional knowledge. The four parameters helped to understand how teachers react to this flow. Saxe's model also drew our attention to how cultural representations of a technological tool can differ between the teacher and the student, making it difficult for teachers to anticipate and understand what students do with the tool.

The upshot of the two analyses is that teachers' views of technology are influenced by general expectations and necessarily diverge from cognitive views privileged by research. It is then important that research broaden its range of concerns to include teachers' expectations and context. It is also important that research take into account the impact of cultural views associated to computer artefacts upon classroom phenomena, which is another way for broadening the range of concerns to consider the diversity of social representations relative to technological tools.

This is consistent with Fuglestad, Healy, Kynigos & Monaghan 's (2009) idea that the complexity of technology use is linked to the fact that tools are a constituent part of culture; hence the introduction of new artifacts necessarily involves the establishment of new cultural practices. The need to involve teachers as partners in research studies about technology is then increasingly evident, the focus of the partnership being on the design of learning activities and/or on the design of the digital tools themselves both resources playing the role of "boundary objects". As a tool to understand teachers' position towards technology, the two models we used are valuable for researchers working in these partnerships: learning activities and digital tools could be appreciated for their didactical relevance as well as for their adaptation to a context and for the way they can be incorporated into teaching practices.

Reciprocally, ways are to be found in order that teachers come to re-think their expectations, considering the actual support that technology is able to bring. Whilst strategies based on the transmission of "good practices" taking little care of the complexity of the integration fail to engage teachers, reflecting upon actual more or less unsatisfactory classroom activities might help them to identify possible evolutions (Emprin 2007). As a tool for teachers to clarify their beliefs, knowledge and decisions, as well as to learn to deal with shifting goals in the classroom, the two models we used here could facilitate a strategic shift towards reflectivity in teacher professional development about technology.

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