

HOW CAN TECHNOLOGY SUPPORT EFFECTIVELY FORMATIVE ASSESSMENT PRACTICES? A PRELIMINARY STUDY

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Formative assessment is a process that can inform both teacher and students of their understanding of knowledge at stake. Technology allows to get data, to arrange them and to share them. The FaSMEd project aims to study the effective role of technology within a formative assessment process. This paper presents a preliminary case study allowing to better understand how the teacher processes data from students using technology (i.e., tablets, student response system, IWB) and how he uses them to inform his teaching.

Keywords: formative assessment, low achieving, technology.

INTRODUCTION

This paper reports on an ongoing research we are carrying out within a wider European project, titled FaSMEd (Improving progress for lower achievers through Formative Assessment in Science and Mathematics Education). The preliminary study that is presented here is just a picture of a particular moment at the beginning of the project. Nevertheless, starting from what we observed and analysed, some more information about the influence of this study on the following phases of our work will be provided and justified. The research aim of the FaSMEd project is to investigate the role of technologically enhanced formative assessment methods in raising the attainment levels of low-achieving students. As specified in the shared glossary, formative assessment is a method of teaching where

“[...] evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited.” (Black & Wiliam, 2009, p. 7).

A digital environment which enhances connectivity and feedback can assist teachers in making more timely formative interpretations. The project relies on the hypothesis that creating such a digital environment has the potential of amplifying the quality of the evidence elicited about student achievement (Hattie, 2009). Moreover, both teachers and students have access to detected data for real-time interpretation and further use.

In particular, in this preliminary phase of the project we followed the “school life” of a connected tablet classroom, both directly observing some lessons and indirectly reading reports written by the teachers. We have experienced the deep change of a classroom's reality when tablets enter it, being witness of Walling's words :

“In the emerging world of a tablet classroom the teacher is likely to be a principal learning designer. [...] In an ideal educational environment, of course, teachers would have adequate training prior to being thrown into a tablet classroom. Most often this ideal is not realized, and training is sketchy at best. Consequently, effective teachers draw on both art and science to craft teaching and learning for their students, whether collectively or individually. If we compare effective teachers to jazz musicians, they must be exemplary players, more than merely

technically competent. They know when to follow the score (the curriculum) and when to improvise.” (Walling, 2014, pp. 26-27).

Tablets support, accompany and sometimes replace students' notebooks and the paper and pencil environment. On the technical side, several competences are needed by the teacher to make the lesson develop in a natural way for students. On the didactic side, the usual activities have to be adapted and new activities can be designed and proposed. Moreover, the way of exploiting them in the classroom can change thanks to the possibilities offered by connected classrooms technologies. Nonetheless, the challenges are great. Different studies have highlighted that connected classrooms technologies have increased the complexity of the teacher's role with respect to orchestrating the lesson (Clark-Wilson, 2010, Roschelle & Pea, 2002). As a “conductor-of-performances”, in fact, she has responsibility for choosing and sequencing the material to be performed, interpreting the performance, and guiding it toward its desired forms (Roschelle & Pea, 2002).

In our research, we leave to teachers the responsibility for designing their lessons, being at their disposal for discussion and advice if they wish. Then, we observe and analyse some lessons in order to come back and exchange on them with the involved teachers. This process generates successive cycles of design, observation, analysis and redesign of classroom sequences (Swan, 2014). The resources for the classroom, designed and redesigned through this process, will inform the production of a “toolkit”, that is a set of curriculum materials and methods for teachers to support the development of practice.

In line with the project purposes, we carried out this preliminary study in order to understand which possible formative assessment practices involving technology could be efficiently proposed in classroom. More precisely, we analyse a mathematics lesson in a grade 9 tablet classroom, in which the teacher is testing the student response system provided by the classroom network NetSupport School. We will try to answer the following questions: how does the teacher process data from students using technology (i.e., tablets, NetSupport School, student response system, IWB) and how does he use them to inform his teaching?

THE CONTEXT OF THE STUDY

In the preliminary study, as well as in the course of the whole project, we intend to maintain those tools teachers have already tested, combined with other supporting tools if necessary. This choice allows teachers to collect and use feedback from students in a way that is, insofar as possible, independent from the teachers' and the students' unfamiliarity with the tools.

In particular, in the observed grade 9 tablet classroom, each student has been equipped and is responsible for a specific tablet, using them for all the subjects. The choice of a personal use of tablets in the classroom encourages the students to appropriate them and allows the teacher to follow more directly the progress of each student.

The leading idea of this study is to get a first insight into the way a teacher can adapt the technological tools available in the classroom for formative assessment, with a particular attention to low achievers. The choice of the observed teacher consists of integrating the use of a student response system offered by NetSupport School : the tablets connecting network he is already exploiting in the classroom.

THEORETICAL FRAMEWORK AND METHODOLOGY

When technology intervenes in the classroom as a learning tool, we can describe the occurring situation referring to the Theory of Didactical Situations (Brousseau, 1997). The teacher creates a *milieu* the student has to cope with, and she modifies it depending on the student-*milieu* interaction.

According to Brousseau, “Within a situation of action, everything that acts on the student or that she acts on is called the ‘*milieu*’” (Brousseau, 1997, p. 9). In our study, we consider the employed technology as a part of the *milieu* that plays a fundamental role in informing the students. Brousseau further specifies the teacher's role, by stating that “Teaching is the devolution to the student of an adidactical, appropriate situation; learning is the student’s adaptation to this situation” (Brousseau, 1997, p. 56). In a complementary way, the institutionalization corresponds to the phase in which the teacher “defines the relationships that can be allowed between the student’s ‘free’ behaviour or production and the cultural or scientific knowledge and the didactical project; she provides a way of ‘reading’ these activities and gives them a status” (Brousseau, 1997, p. 56).

In presence of technology, the role of the teacher evolves as she manages the essential task of orchestrating its use in the classroom. Indeed, each student working with a particular technology develops her own schemes of use with respect to it, through a process that is called instrumental genesis (Rabardel, 1995). At the same time, each student shapes the technology in the so-called instrumentation. For each student, the technology from a simple artefact becomes an instrument through this double movement from the artefact to the user and from the user to the artefact, but the time for the instrumental genesis can be very different from student to student. In the context of a tablet classroom, where each student is appropriating her own tablet, the orchestration of all the different schemes of use developed and of all the instrumental genesis occurred at different levels is a crucial task for the teacher. With this concern, Trouche (2004) speaks about “instrumental orchestration” to indicate didactic configurations and exploitation modes of these configurations. In the observed tablet classroom, this framework is particularly suitable to describe the arrangement of the technological environment and the teacher's exploitation of it. The teacher networks all the tablets in the classroom, so that each tablet can communicate with the central system. He acts directly on NetSupport School to communicate with all the students. He uses the IWB as a common screen to collect all the data sent by the students. In this particular environment, he exploits a NetSupport School functionality that works as a student response system. So he sends to each student a question, taping and hiding the correct answer; then he gets an elaboration of the set of answers taped by each student on her own tablet, compared with the correct one (so they appear in red or green). The particular orchestration chosen by the teacher provides him with data that can potentially inform his teaching and produce other modes of exploiting the arranged didactic configuration, perhaps decided on the spot, during the lesson. It is interesting also to notice that the teacher in this technological environment wants to maintain a written mark of the work done during the lesson. Instrumental orchestration is then combined with the use of paper and pencil as illustrated in Figure 1.

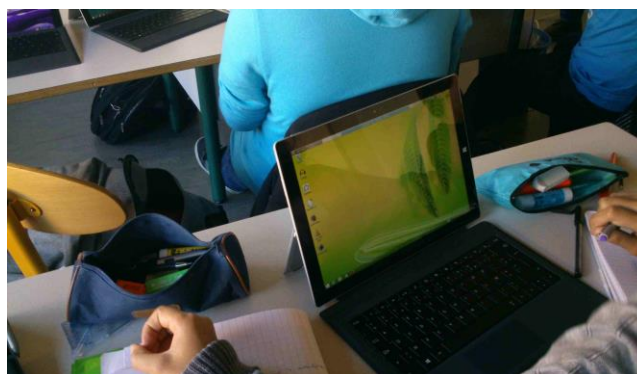


Figure 1. Instrumental orchestration combined with the use of paper and pencil.

The feedback coming from technology is useful for both the student and the teacher. The student can use it to improve her performance in front of questions or to change her strategy in the

resolution of a problem. Nonetheless, the feedback has to be problematic, sometimes negative or doubting. This surely entails a moment of difficulty for the student, but the way in which she manages it can actually inform herself and the teacher about her understanding of the involved piece of knowledge. The teacher, in turn, can use this feedback to have a class overview, to identify what are the problematic notions and which students have more difficulties with a particular concept, and then to adapt his didactic strategy. It is in conditions like this that assessment becomes “formative” and can efficiently contribute to the students’ learning. Observing a lesson, thus, we are interested in those moments in which the teacher collects data and draws on them for deciding his didactic technique. Starting from what he plans before the lesson, all these local variations contribute to shape his actual practice in the classroom.

For the case presented in this paper, we have attended a one-hour lesson as observers in the classroom, without participating to the lesson design and implementation. The collected data at our disposal encompass the audio recording of the whole sequence, some short videos and pictures.

In the next paragraph, part of these data are analysed, according to the theoretical framework that is described above. More precisely, we have selected two specific moments in which teacher and students communicate via tablet. The teacher poses a question through NetSupport School and asks the students to send him their answers. The first question deals with the result of a given problem. The second one is related to an argument proposed by a student, who is in difficulty during this lesson.

DATA ANALYSIS

The teacher proposes two geometrical problems that require to determine the length of a chord, given the radius of the circle and the angle subtended at the centre by the chord. In the first case, the radius is 3 cm long and the angle is 60° wide. Each student works on her own tablet, but she can discuss with her schoolmates. The teacher recalls all the possible supports students can draw upon to solve the problem:

- 1 Teacher: You have many possibilities: you can draw the figures by hand in real dimensions, you can do some calculation [...] you can also draw the figure in real dimensions with GeoGebra if you want. Do whatever you want. I give you, it's 27, at 32 I want that there are some answers [...] that everyone has an answer to propose, right or wrong it doesn't matter, but by 5 minutes I want everyone to have an answer to propose with a written argumentation.

With his words, the teacher devolves the problem to the students. He makes them cope with a *milieu* that encompasses their geometrical knowledge, the given geometrical problem and the tools they dispose of. He leaves them complete freedom in choosing their resolution strategy (“Do whatever you want”), but he specifies that a justification is needed (“with a written argumentation”) and not simply the answer. We find really interesting his clarification about the allowed answers: “right or wrong, it doesn't matter”. He encourages the students to make their proposal and to defend it. Then, the students work alone or in pairs on the task. There can be interaction with the tablet if they draw and explore the figure with GeoGebra. So, the teacher a priori permits the work on tablet and in paper and pencil as well, as the students prefer. This is another important element of orchestration that is explicitly declared in classroom. However, actually, few students open GeoGebra. They generally prefer to work on their notebooks (Fig. 2).

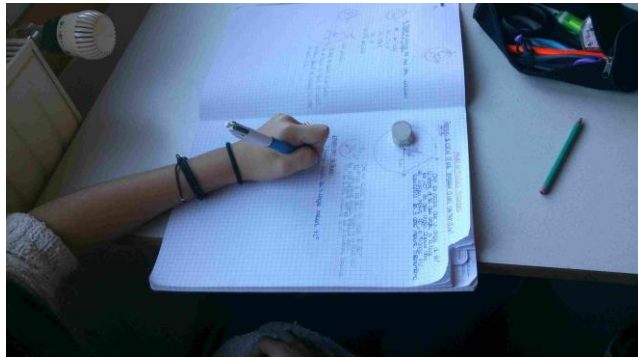
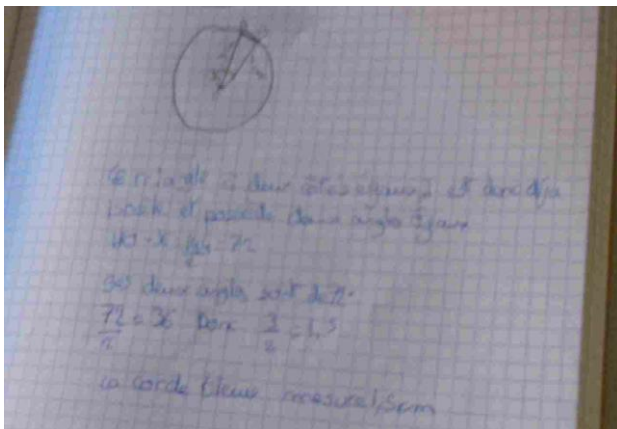


Figure 2. A student's research on her notebook.

After a while, the teacher asks to each student to submit the obtained result. The answers are compared by the system with the correct answer, taped and hidden by the teacher. In this moment, all the students interact with the tablet, and the classroom attention focuses on the common grid that collects all the answers available at the IWB. We clearly see that the students use the tablet mainly as a mean of communication. One of the answers appears in red, even though the student swears to have taped 3, that is the correct answer. The teacher reviews the exercise on the IWB, asking the students' participation for giving reason of all the steps. This first problem has been useful for the teacher to introduce the task to the students and also to test the student response system.

Afterwards, he invites the students to focus on the second problem. The *milieu* changes with the adding of the first problem now solved and of the second given problem. The geometrical situation is similar to the first problem, the radius of the circle is 3 cm long, but this time the angle at the centre is 36° wide. The task is the same: finding the length of the chord. The teacher's suggestion is to exploit what they know about the right-angled triangle (i.e., the relation between leg and hypotenuse, in terms of sine and cosine) and to try and obtain a right-angled triangle in the figure. Following another reasoning a student, we will call Student1) finishes very fast and proposes his resolution to the teacher (see Fig. 3). It is a wrong argument, but the teacher shows it to the classroom in order to discuss about it.



The triangle has two equal sides then it is isosceles and has two equal angles.

$$180^\circ - 36 = 144 / 2 = 72$$

Its two angles are 72° wide

$$72 / 2 = 36 \text{ then } 3 / 2 = 1.5$$

The blue cord is 1.5 cm long. [1]

Figure 3. Student1's solution (translation on the right).

- 2 Teacher: I highlight Student1's remark, on which we stop two minutes to discuss. Let's simply note it, we are not going to discuss about it, let's simply note it without reasoning and we are going to further answer it. So, note Student1's proposal. He proposed something that would be so practical! [...] So, he said this [angle at the centre] is 36, so those two [angles at the base] are 72. 36 is the half of 72, so AB is the half of 3.

- 3 Students: Uh!
- 4 Teacher: [...] Student2, is your conclusion different from that of Student1 or did you get to the same result? Did you conclude, didn't you?
- 5 Student2: Yes.
- 6 Teacher: So, I'm going to take Student1, then you will tell me the way you concluded.
- 7 Student2: It isn't right.
- 8 Teacher: I don't know. If it isn't right you will tell me why it isn't right. The other two angles of the triangle are 72 wide, 36 is the half of 72, then AB is the half of OB.
- 9 Student3: But how do you know it is the half? You don't see it there!
- 10 Teacher: I agree with you, this is a question we should ask to Student1. Nonetheless, what I ask you with respect to this is what is the mathematical notion that [...] Student1 presupposes, when he does so. What mathematical property is he using? What is he using in mathematics? [...] I'm going to ask you the question on the tablet, you will answer on the tablet.

The teacher chooses the production of a student and rewrites it on the IWB, in order to share it with the whole classroom. He specifies that his intention is not to judge Student1's proposal ("Let's simply note it without reasoning", line 2) but to discuss about it. His choice is particularly interesting because Student1's proposal and solution are wrong, even if the reasoning begins correctly with the calculation of the angles width. Discussing about a classmate's proposal can be an effective technique to foster formative assessment in the classroom. Every student has the possibility to compare his production with the presented one and the teacher can be informed by the other students' reaction. In our case, the fact that several students react with an exclamation of surprise (line 3) to Student1's wrong solution informs the teacher about the direction he must give to his intervention. Orchestrating the works of different students is his explicit intention (line 4-8). Even though a student, probably a high achiever, notices that there is something wrong with the proposed solution (line 9), the teacher quickly admits to agree with him ("I agree with you, this is a question we should ask to Student1", line 10), but he goes on discussing Student1's argument. In particular, he wants to focus students' attention on the mathematical property that is behind Student1's proposal. His aim indeed is not simply to lead the students to reject the proposal. He wants to be sure that the students get to understand the mathematical reason why it has to be rejected. Then, he poses the question via tablet.

- 11 Teacher: What I am interested in is knowing, to be able to compare then with the computer, orally is there anybody that can tell me what is the name of the property 36 is the half of 72, then AB is the half of OB? What is it?
- 12 Student4: Thales[2].
- 13 Teacher: It recalls Thales. What is behind Thales? Student2?
- 14 Student2: 1 over 2.
- 15 Teacher: Yes, it is the equal ratios. And these questions of equal ratios, when we make this kind of work...
- 16 Student5: Cosine.
- 17 Teacher: No, it is not the cosine.
- 18 Student6: Proportionality.

- 19 Teacher: It is the proportionality. Raise the hand up those who have answered, honestly, to have a feedback, those who have found that it was the proportionality. Ok, did you tape it or not?
- 20 Student7: Yes.
- 21 Teacher: And you don't appear...
- 22 Student8: The same for me.
- 23 Teacher: You wrote proportionality (in French *proportionnalité*). How many “n” did you tape? It can be linked to this.

While the students are sending their answers and the system is elaborating them, the teacher asks the students to share their ideas with him. This will allow him to make a comparison with the collected data (line 11). Such a comparison between oral answers and taped answers reveals essential for the teacher when, in the end, the right name of the property comes out (line 18). The correct answers in the common grid appear to be less than expected (line 19). The quick oral survey the teacher has carried out helps him in interpreting the data and in understanding what problem could have occurred (line 23). In particular, he realises that part of the wrong answers he sees in the common grid are not due to a mathematical misunderstanding or a conceptual error. They are probably due to an error in taping the good answer.

DISCUSSION

The preliminary study we conducted aims to identify elements for an efficient formative assessment practice with the support of technology. Observing the teachers' usual employ of technology in the classroom can enable us to support them more effectively in developing and adapting their formative assessment practices and to interpret possible changes in their usual techniques.

The case discussed above is an example of a way of using a student response system to support the teacher's formative assessment practice in classroom. For the observed teacher, it is a first test of the possibilities offered by the a connected classroom technology. From a global perspective, we can observe that the teacher tries to integrate technology in his usual practices, but not in an exclusive way. We can also detect some moments in which technology could help but it is not exploited. For example, if every student had worked on her tablet, Student1 could have shared his screen with the schoolmates in order to explain his reasoning. Thus, the teacher could have extended the *milieu* including the students' tablet productions. The analysis and the *a posteriori* discussion with the teacher concerning this lesson allow us to highlight the possible modifications of the *milieu*, in order to improve what has been done and to try what has not been done yet.

We visited again the tablet classroom two months later and we could observe a remarkable evolution in the teacher's appropriation of the connected classrooms technologies and in his didactic practices with them, especially with respect to formative assessment. We attended one lesson about the introduction of probability and the teacher reported on the following two lessons we could not attend. In a first a-didactic phase, the teacher proposes to the students to play a game : betting on the difference of two dices with 6 faces. The students work in small groups for exploring the problem. Each component of the group works on her tablet, aiming to get a shared conclusion : on which result they would bet and why. In a second phase, the teacher collects one production for each group by making tablet screen shots. He shows the different proposals at the IWB, discussing and commenting them with the classroom. The tablets are blocked during this central phase of the lesson, since the teacher wants to have the complete attention of the students (see Figure 4).



Figure 4. Tablets are blocked during discussion to catch students' attention.

In the last phase, the teacher gets to the institutionalization of the definition of probability, starting from students' productions available at the IWB (see Figure 5, as an example) : this allows him to validate students' work, in a perspective of formative assessment within the learning process. Connected classrooms technologies play a relevant role in the way the teacher orchestrates the classroom and guides the lesson. NetSupport School permits him to collect in real-time the students' work, to foster discussion and debate in the classroom and to use such data for constructing the lesson notes at the whiteboard.

② Méthode des combinaisons:
 Toutes les combinaisons possibles:
 C'est la méthode des combinaisons.
 Il y a 21 combinaisons.

Avec ce modèle en pair: e sur 0 } cela ne correspond pas à la méthode des tests: il y a un problème.

Les tirages qui ne sont pas des doubles ont 2 combinaisons possibles.

Il y a 36 combinaisons possibles.
 6x6

dé 1 \ dé 2	1	2	3	4	5	6
1	0	1	2	3	4	5
2	1	0	1	2	3	4
3	2	1	0	1	2	3
4	3	2	1	0	1	2
5	4	3	2	1	0	1
6	5	4	3	2	1	0

Le 1 apparaît: $\frac{10}{36}$ fois
 Le 0 $\frac{6}{36}$
 2 $\frac{8}{36} \approx 0,2222 \dots$
 3 $\frac{6}{36}$
 4 $\frac{6}{36}$
 5 $\frac{2}{36}$

La probabilité d'apparition du 1 est $\frac{10}{36}$, environ 0,277.

2) Combinations method:

All the possible combinations

S1's proposal: There are 21 combinations (list).

With this model we bet on 0; this does not correspond with the tests method [before, throwing the dices 100 times students have found that 1 is the most frequent result]; there is a problem.

The throws that are not double have two possible combinations.

S2's proposal: There are 36 combinations (table).

1 appears : 10/36 times ...

The probability of appearance of 1 is 10/36, about 0,277.

Figure 5. Lesson notes at the IWB using the students' productions as a base (translation on the right).

Technology allows the teacher to enrich the students' milieu by sharing the different proposals and ideas produced by the students in the a-didactic phase.

FINAL REMARKS

The analysis of these examples gives us some precious indications about how teachers can process data from students using technology and consequently how they can use them to inform their teaching. Comparing the probability learning sequence with the geometry one already shows a modification in the teacher's practices and the essential support of technology. The new

orchestration skills of the teacher allow him to modify the students' *milieu* and to enrich it through data collection, discussion and lesson notes constructed on the students' proposals.

The results of our preliminary analysis have been useful to develop case studies and to analyse them more deeply in the frame of the FaSMEd project. As a result, we conceive formative assessment as a process that requires time, but in the same time the way teachers decide to exploit data for modifying their teaching evolves over time. So, in our case studies, we are planning to visit and observe classrooms in different moments of the school year.

We will build our presentation for the conference on both these preliminary experiments and the first results of different case studies that will be at our disposal.

NOTES

1. Our translation of:

Le triangle a deux côtés égaux, et donc déjà isocèle et possède deux angles égaux. / $180-36=144/2=72$.
Ses deux angles mesurent 72° . / $72/2=36$ donc $3/2=1,5$. / La corde bleue mesure 1,5 cm.

2. The students refers to the Intercept Theorem (also known as Thales' Theorem) concerning the ratios of the line segments that are created if two intersecting lines are intercepted by a pair of parallels (and, by extension, the ratios of the sides of similar triangles).

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