Chapter 6
The Use of Digital Technologies to Enhance Formative Assessment Processes

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Abstract We focus on formative assessment processes carried out, by the teacher and the students, through the use of digital technologies. The research is situated within the European Project FaSMEd, in which a new model connecting the role of technology to classical views on formative assessment is proposed. Through data analysis from teaching experiments in Italian schools using connected classroom technology, we highlight how the specific choices concerning the use of technology and the design of the activities can enable the enactment of formative assessment strategies at the teacher's, the students', and the peers' levels.

Keywords Formative assessment strategies · Connected classroom technologies Making thinking visible · Argumentation · Teaching-learning processes

6.1 Introduction

Digital technology can provide great support both to students and teachers in getting information about students' achievement in real-time. Relying on this hypothesis, the FaSMEd Project, "*Improving progress for lower achievers through Formative Assessment in Science and Mathematics Education*," investigates, by means of design-based research methodology (Cobb et al. 2003), the role of technologically enhanced formative assessment (FA) methods in raising students' attainment levels, with special attention to low achievers (for a detailed presentation of the project, see also Wright et al., in this volume).

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Several studies provide evidence about how new technology can be used as an effective tool in supporting FA processes (Quellmalz et al. 2012). In our design experiments in Italy, we focus in particular on connected classroom technologies that are networked systems of personal computers or handheld devices specifically designed to be used in a classroom for interactive teaching and learning (Irving 2006). Research has shown that connected classroom technology may provide several opportunities for classroom practice: create immersive learning environments that give powerful clues to what students are doing, thinking, and understanding (Roschelle et al. 2004); make students take a more active role in the discussions (Roschelle and Pea 2002); encourage students, through immediate private feedback, to reflect and monitor their own progress (Roschelle et al. 2007); and enable teachers to monitor students' progress and provide appropriate remediation to address student needs (Irving 2006).

Within the FaSMEd Project, we designed mathematical activities and developed a methodology aimed at fostering formative assessment processes by means of connected classroom technology. The overall design relies on two fundamental assumptions: (i) in order to raise students' achievement, FA has to focus not only on cognitive, but also on metacognitive and affective factors; (ii) argumentation practices can be developed as crucial FA tools in the mathematics classroom. The teacher's role is, in particular, envisaged according to a cognitive apprenticeship perspective (Collins et al. 1989; see the theoretical framework section).

In this paper, we highlight how the specific choices concerning the use of technology, the design of the activities and the adopted methodology can foster the enactment of formative assessment strategies at the teacher's, the students', and the peers' levels. We ground our discussion on the analysis of a teaching-learning episode in an Italian grade 5 school. The analysis will be framed by a three-dimensional framework developed within the FaSMEd project. The framework highlights how digital technologies may support formative assessment processes carried out by teachers and students. In particular, we show how students are supported in "making their thinking visible" (Collins et al. 1989) through efficient formative assessment strategies.

6.2 Theoretical Framework

Within the FaSMEd Project, FA is conceived as 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 and Wiliam 2009, p. 7)

In this method, three crucial processes are identified: establishing where learners are in their learning; establishing where learners are going; and establishing how to get there (Wiliam and Thompson 2007). Moreover, Wiliam and Thompson (2007) provide a model for FA in a classroom context as consisting of five key strategies: (A) Clarifying and sharing learning intentions and criteria for success; (B) Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding; (C) Providing feedback that moves learners forward; (D) Activating students as instructional resources for one another; (E) Activating students as the owners of their own learning. Three main agents are involved in these processes: the teacher, the learners, and their peers.

Within FaSMEd, the model by Wiliam and Thompson (2007) has been extended to include the use of technology in FA processes. The result is a three-dimensional model taking into account three main dimensions (Aldon et al. 2017; Cusi et al. 2016): (1) the five FA key-strategies introduced by Wiliam and Thompson (2007); (2) the three main agents that intervene (the teacher, the student, the peers); and (3) the functionalities through which technology can support the three agents in developing the FA strategies (see the chart in Wright et al., in this volume).

The third dimension (functionalities of technology) is the new one integrated to the previous model. More specifically, we subdivide the functionalities of technology in three main categories, according to the different uses of technology for FA within our project:

(1) *Sending and displaying*, when technology is used for sending questions and answers, messages, files, or displaying and sharing students' worksheets or screens to the whole class.
(2) *Processing and analyzing*, when technology supports the processing and the analysis of the data collected during the lessons, such as the statistics of students' answers to polls or questionnaires, the feedback given directly by the technology to the students, the tracking of students' learning paths.
(3) *Providing an interactive environment*, when technology enables the creation of an interactive environment within which students can work individually or collaboratively on a task or a learning environment where mathematical/scientific content can be explored.

In FaSMEd, a main goal was studying the exploitation of new technologies in order to raise students' achievement. As stressed by the European Commission Report on low achievement in mathematics and science, "low achievement is associated with a range of factors that are not only cognitive in nature" (European Commission n.d, p. 27). In particular, research has highlighted the role played by metacognition (Schoenfeld 1992) in fostering students' achievement in mathematics. The importance of focusing on the metacognitive dimension, in particular when working with low-achievers, is stressed by Gersten et al. (2009, quoted in Scherer et al. 2016), who identify the selection and sequencing of instructional examples and the students' verbalization of their own strategies as fruitful components that support students who face difficulties in mathematics. However, research has also shown the impact of affective factors (McLeod 1992) in students' achievement, as documented, for example, by Fadlelmula et al., who declare that "if mathematics educators want to enhance students' mathematics achievement, they may need to consider motivational factors along with learning strategies, rather than considering each factor in isolation" (2015, p. 1372).

In our study, we planned and developed classroom activities with the aim of fostering students' development of ongoing reflections on the teaching-learning processes at both a metacognitive and affective level. More specifically, we planned activities with a strong focus on students' sharing of the thinking processes with the teacher and their classmates, supporting them in making thinking visible (Collins et al. 1989).

Cognitive apprenticeship theory proposes a model of instruction that incorporates some key aspects of the apprenticeship of practical professions. Collins et al. (1989), in particular, identified specific teaching methods that should be designed to give students the opportunity to observe, engage in, and invent or discover expert strategies in context:

(1) *modeling*, which requires an expert (the teacher or a classmate) to carry out a task externalizing his/her internal processes;
(2) *coaching*, that is the expert's observation of students while they are facing a task, in order to give them stimuli, supports, feedbacks;
(3) *scaffolding*, which refers to the support the expert gives to students in carrying out a task;
(4) *fading*, which refers to the gradual removal of the support to enable students to autonomously complete the task;
(5) *articulation*, which involves those methods aimed at getting students to articulate their knowledge, reasoning, or problem-solving processes to become able to consciously control their own strategies;
(6) *reflection*, aimed at making students compare their own problem-solving processes with those of an expert (the teacher or another student).

These categories can be subdivided into two groups: the first group (modelling, coaching, scaffolding, and fading) refers to the methods mainly aimed at fostering students' development of specific competencies through processes of observation and guided practice; the second group (articulation and reflection) includes methods aimed at making students reflect on experts' approaches and learn how to consciously control their own strategies.

Another crucial assumption concerns the central role of argumentation. Mathematical argumentation is conceived as "the discourse or rhetorical means (not necessarily mathematical) used by an individual or a group to convince others that a statement is true or false" (Stylianides et al. 2016, p. 316). The argumentation process encompasses ascertaining (when the individual removes his or her own doubts about the truth or falsity of a statement) and persuading (when the individual or the group remove the doubts of others about the truth or falsity of a statement) (Harel and Sowder 2007). The concept of argumentation was widely studied by scholars in the last decades, with an emphasis that can be traced back to two different kinds of sources. The first one relies on the possible links between argumentation and proving processes (Durand-Guerrier et al. 2012). The second source of interest for argumentation relies on the growing consensus on the importance of classroom discourse as a source of mathematical learning (Sfard 2001; Yackel 2004). Argumentation as a social activity was studied by many scholars, starting from Krummheuer (1995). More recently, some researchers have addressed the role of the teacher in managing argumentation in the classroom, discussing the double role of the teacher in giving arguments and in dealing with the arguments provided by the students, towards the creation of a "collective" argumentation (Conner et al. 2014). Although research did not explicitly address the possible connection between argumentation and formative assessment, in our research we argue that argumentation practices may support formative assessment processes.

6.3 Methodology and Research Question

In line with the perspective introduced in the previous section, we planned activities with a strong argumentative component and we searched for a technological tool that allows the students to share their productions, and the teacher to easily collect the students' opinions and reflections during or at the end of an activity. The activities were carried out in a connected classroom environment, in which students were using tablets connected with the teacher's laptop. Specifically, we chose a software (IDM-TClass) which enables the teacher to monitor students' work, to show (to one or more students) the teacher's screen and also the students' screens, to distribute documents to students and to collect documents from the students' tablets, and to create instant polls and immediately show their results to the teacher's laptop, which can be connected to a wider screen by means of a data projector or an interactive whiteboard.

The experimental phase involved 19 teachers from three different clusters of schools (primary and lower secondary schools) located in the North-West of Italy. In order to foster collaborative work and argumentation, students are asked to work in pairs or small groups (of three) on the same tablet.

The use of connected classroom technologies has been integrated within a set of activities on relations and functions, and their different representations (symbolic representation, tables, graphs). We adapted activities from the ArAl project (Cusi et al. 2011) and from The Mathematics Assessment Program, designed and developed by the MARS Shell Center team at the University of Nottingham (http://map.mathshell.org/materials/lessons.php). Specifically, we prepared a set of worksheets aimed at supporting the students in the verbalization and representation of the relations introduced within the lesson, enabling them to compare and discuss their answers, and making them reflect at both the cognitive and metacognitive levels. The worksheets, which have been designed to be sent to the students' tablets or to be displayed on the interactive whiteboard (IWB) or through the data projector, can be divided into four main categories:

(1) *Problem worksheets*, introducing a problem and asking one or more questions;
(2) *Helping worksheets*, aimed at supporting students, who have difficulties with the Problem worksheets;
(3) *Poll worksheets*, prompting a poll between proposed options;
(4) *Discussion worksheets*, prompting a focused discussion.

In this paper, we show how our specific choices concerning the use of technology and the design of the activities promoted the development of FA processes. More specifically, we address the following question:

> In what ways could focusing on "making thinking visible", through the support provided by connected classroom technologies, enable the activation of FA strategies?

During the design experiments, all lessons were video-recorded. Aligned with design-based research methodology (Cobb et al. 2003), one researcher (one of the authors) was always in the class as both an observer and a participant; she supported the teacher in the use of the technology and in the management of the class discussion. When we use this term *class discussion*, we refer to the idea of mathematical discussion developed by Bartolini Bussi: "Mathematical Discussion is a polyphony of articulated voices on a mathematical object (e.g., a concept, a problem, a procedure, a structure, an idea or a belief about mathematics), that is one of the motives of the teaching-learning activity … A form of mathematical discussion is the scientific debate that is introduced and orchestrated by the teacher on a common mathematical object in order to achieve a shared conclusion about the object that is debated upon (e.g., a solution of a problem)" (1996, pp. 16–17).

The video-recordings of the lessons have been examined to identify meaningful episodes to be transcribed, which were chosen as "selected aspects of the envisioned learning and of the means of supporting it as paradigm cases of a broader class of phenomena" (Cobb et al. 2003, p. 10). Other collected data were field notes from the observers, teachers' interviews after sets of lessons, questionnaires posed to students at the end of the activities, and interviews with groups of students.

In the following, we analyze an episode from a class discussion developed in primary school, referring both to the FaSMEd three-dimensional framework and to the cognitive apprenticeship methods.

6.4 Analysis of an Episode from a Classroom Discussion

The episode is taken from a classroom discussion carried out in grade 5. The discussion is focused on a problem worksheet called *Match the story* (Fig. 6.1), from a sequence of lessons on time-distance graphs, which we called *Tommaso's walk*. The students have previously worked on two sequences of lessons (about 16 hours) on functions and graphs, set within the context of early algebra. The lessons involve interpreting, comparing and discussing different representations (verbal, symbolic, graphical) of relations between variables and are adapted from

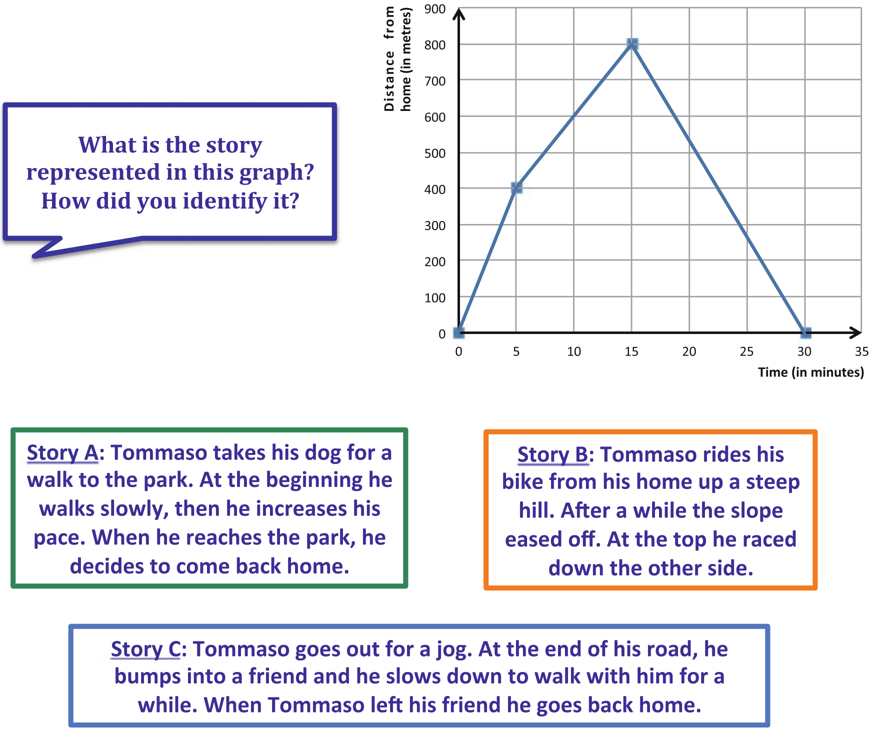


Fig. 6.1 The problem worksheet *Match the story*

two activities from the ArAl Project: "The archaeologist Giancarlo" and "La festa di Primavera." (All sequences of lessons can be found at https://microsites.ncl.ac.uk/fasmedtoolkit/category/partner/university-of-turin/.)

Tommaso's walk is our adaptation of the activity ***Interpreting distance-time graphs*** developed within the Mathematics Assessment Program. This activity was chosen to be adapted and implemented by all the partners involved in FaSMEd. In tune with the results of the TIMSS seven-nation comparative study (Hiebert et al. 2003), the common aim was to adopt approaches which preserve the complexity of concepts and methods, rather than simplifying them. Accordingly, the activities are designed and implemented with the aim of fostering the students' construction of meaning through formative assessment. Before facing the Tommaso's walk sequence, students are introduced to time-distance graphs by an experience with a motion sensor, which produced the distance-time graph of their movement along a straight line. Subsequently, they face the interpretation of a given time-distance graph according to a given story (referring to the walk of a boy, Tommaso) and focus, in particular on the meaning of ascending/descending lines and horizontal lines within a time-distance graph, and on the distinction between the concepts of "distance from home" and "distance that was walked through."

Match the story (Fig. 6.1) is the 6th worksheet of the sequence and is aimed at making students: (a) consolidate their competencies in the interpretation of a time-distance graph; (b) interpret the slope of the graph as an indication of the speed; (c) consolidate their competencies in recognizing complete justifications of given answers. The sequence then develops through matching between different graphs and the corresponding stories and finishes with the construction of graphs associated with specific stories. (The complete sequences of the designed worksheets can be found at https://microsites.ncl.ac.uk/fasmedtoolkit/2016/11/16/time-distance-graphs-idm-tclass/.)

After working on the interpretation of time-distance graphs for two lessons (about 4 hours), students are given the *Match the story* worksheet. The worksheet requires students to identify which story corresponds to a given graph among three proposed stories. To solve the task and identify the correct story (C), students have to interpret the slope of a line, within a time-distance graph, as an indicator of the speed. Stories B and A were designed as containing typical mistakes with this kind of task. Story B presents the typical mistake of interpreting time-distance graphs as drawings (in this case, the drawing of a hill). An interesting aspect is related to the main reason why this choice is not correct: story B implies that the distance from home should increase, while the last section of the graph represents a "return to home." Story A and story C are very similar. Identifying the correct story requires the student to observe that the graph represents, through the changing of the slope from the first to the second section, a decreasing of the speed.

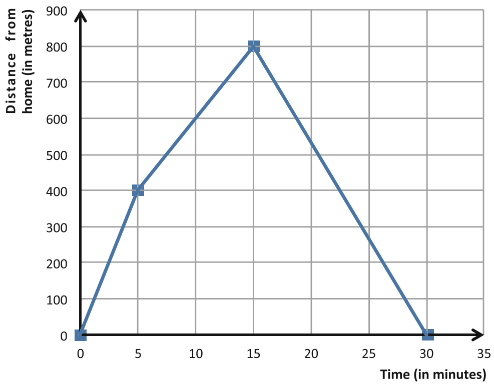
At the beginning of the lesson, the worksheet is sent from the teacher's laptop to the students' tablets. Students work in pairs or small groups of three to solve it. To support the students who face difficulties, two helping worksheets were designed. The first one (Fig. 6.2) provides students with a given table to collect the distances from home next to the corresponding times (0, 5, 15 min). This helping worksheet also proposes guiding questions to make students observe that the same distance (400 m) was walked in different periods of times, highlighting when Tommaso was quicker.

During the working group activity, the teacher can send the *helping worksheets* to the pairs/groups of students who face some difficulties. Receiving the *helping worksheets* represents therefore feedback for the students, because they become aware that their answer should be improved, and at the same time, they receive support to face the task. So, sending helping worksheets is a means to foster the activation of FA strategy C (*Providing feedback that moves learners forward*).

After facing the task and answering the questions, the pairs/groups send back their written productions to the teacher. When all groups send back their answers, the teacher groups the written answers and shows some of them on the IWB to set up a class discussion, activating FA strategy B (*Engineering effective classroom discussions that elicit evidence of student understanding*). Specifically, four answers are projected on the IWB.

The discussion starts focusing on Carlo and Elsa's answer, which is projected on the interactive whiteboard:

What is the story represented in this graph? How did you identify it?



<u>Story A</u>: Tommaso takes his dog for a walk to the park. At the beginning he walks slowly, then he increases his pace. When he reaches the park, he decides to come back home.

<u>Story B</u>: Tommaso rides his bike from his home up a steep hill. After a while the slope eased off. At the top he raced down the other side.

<u>Story C</u>: Tommaso goes out for a jog. At the end of his road, he bumps into a friend and he slows down to walk with him for a while. When Tommaso left his friend he goes back home.

<u>Help to identify the story</u>:

Collect, in the following table, the information provided by the graph:

Time	Distance from home
0 minutes	
5 minutes	
15 minutes	

Answer the following questions:

- What is the distance that Tommaso has walked through during the first 5 minutes?
- What is the distance that Tommaso has walked through in the period of time from 5 minutes to 15 minutes?
- Which is the period of time (among those analysed in the previous answers) during which Tommaso walks quickly?
- What is, therefore, the story represented in the graph?

Fig. 6.2 The helping worksheet for the *Match the story* task

In our opinion, (the story) B is not right because a sensor cannot measure the height. (The story) C is not correct because the graph tells that Tommaso initially walks slowly, then more rapidly; however, the story tells the contrary. The story A tells something that, probably, is possible.

After the teacher reads the text, Carlo and Elsa immediately declare that they realized they made a mistake. Carlo says that, however, the justification they gave to discard story B is right. The teacher and the researcher help the students notice that the argument they propose ("a sensor cannot measure the height") is not the correct one because a motion sensor could also be used to study the motion of a person walking on a hill, even if in the classroom this was not experienced. The discussion then focuses on the reasons why story B could not be accepted, and Sabrina asks to speak:

(347) Sabrina: Because [the story] B, practically, … I see a sort of drawing that looks like a hill…so I describe it as I see it and not…

(348) Researcher: So you are saying: "The story B…the graph resembles a hill… this fact could lead me to make a mistake".

Sabrina highlights that the reference to the hill in story B could make the students think that the graph represents the same hill that Tommaso is climbing, which is a typical mistake in this kind of activity. The researcher's strategy can be referred to the *articulation* and *reflection* categories of cognitive apprenticeship methods. In fact, by revoicing Sabrina's observation to make it more explicit for the other students, the researcher focuses the discussion on the possible mistake, thus providing students with tools to monitor their future work. In this way, Sabrina's contribution to the discussion is exploited as a resource for her classmates, and *FA strategy D* is activated.

The episode continues with the researcher challenging the students with the aim of making them focus on a fundamental part of story B, which assures them that the story cannot be associated with the graph:

(349) Researcher: There is also another reason why B is not right… Let's look at the graph for a while. Let's see if you can find it looking at the graph. Why is B not right?

Many pupils raise their hands.

(350) Researcher: A lot of hands have been raised. Who can start? Giacomo…

(351) Giacomo: The story C: "Tommaso went … When Tommaso left his friend, he walked back home". And you cannot find it over there (*pointing to story B written at the whiteboard*)…

Voices.

(352) Researcher: Wait (*speaking to the other students*). Maybe I understood what Giacomo wants to say. He says: here we can read "he walked home" (*pointing to this sentence in story C*). Here you can read "he goes back" (*indicating the sentence*

in story A). Here (*indicating story B*) you cannot find it. …Why is it not correct that "he goes back home" is not written in this story? (*speaking to Giacomo*)

Giacomo remains silent.

(353) Researcher (*speaking to Giacomo*): Why do you say that it is not correct that here we cannot find the sentence "he goes back home"?
(354) Giacomo: Because, over there, we can find that it [the line], then, goes down (*he indicates the graph on the IWB*).
(355) Researcher: You say: here, the graph is going down (*moving her finger along the descending part of the graph, from the point (15,800) to the point (30,0)*), it goes down toward the horizontal axis. What does it tell us?

Giacomo remains silent.

(356) Researcher: What is Tommaso doing?
(357) Giacomo: He is going back…
(358) Teacher: Good!

In this excerpt, it is possible to observe the activation of several categories of cognitive apprenticeship methods by the researcher. On one side, her interventions can be interpreted within the *articulation* and *reflection* categories, because she revoices two interventions by Giacomo to make them more explicit for the other students (lines 353 and 355):

line 351, when he stresses that, differently from the stories A and C, the story B does not include the fact that, at the end, Tommaso goes back home, and

line 354, when, asked to explain why it is so important that the story includes the fact that Tommaso goes back home (line 353), he focuses on the descending line of the graph.

At the same time, the researcher poses to Giacomo specific questions to support him not only in making explicit his reasoning, but also in refining and consolidating it, carrying out a *scaffolding* process through the questions: "Why is it not correct that "he goes back home" is not written in this story?" (line 352); "Why do you say that it is not correct that here we cannot find the sentence "he goes back home"?" (line 353); "What does it tell us?" (line 355); and "What is Tommaso doing"? (line 356).

The combination of *articulation* and *reflection* interventions and of *scaffolding* strategies also enables Giacomo to carry out the task posed by the researcher (lines 355–357). This observation puts the approach of the researcher in the *modeling* category of cognitive apprenticeship methods, that is, the researcher proposes Giacomo answer those questions that guide an expert in the solution of the task. In this way Giacomo becomes a model of reasoning for his classmates. For these reasons, this excerpt can be considered an example of an effective activation of *FA strategies D and E*. Giacomo, in fact, thanks to the support provided by the researcher, is activated as the owner of his learning (FA *strategy E*). At the same time, the interventions aimed at making Giacomo's ideas more explicit enable him to become an instructional resource for the other students (FA *strategy D*).

The discussion continues then as follows:

(359) Researcher: Let's listen to other observations.
(360) Teacher: Did you listen to what Giacomo said? …I don't know. Someone, in my opinion, was lost.
(361) Carlo: Can I explain it?
(362) Researcher: Carlo is going to explain what Giacomo said.
(363) Carlo (*speaking to his classmates*): Because Giacomo said that, in the answers A and C, these two stories explain that, at the end, … A tells that he goes back, C tells that he goes home … while C doesn't tell this thing. And, if we look at the graph, … the line …it goes down …it goes down at a certain moment. It approaches the horizontal axis, which is the home, it is right…but B doesn't specify it.
(364) Teacher: Instead of "It doesn't specify"…
(365) Researcher: Is it only that B doesn't specify this? It tells something that contradicts…

Livio, Adriana, Ambra raise their hands. Ambra is asked to speak.

(366) Ambra: It tells that …that it goes down to the other side. It [the graph] seems a hill, so it goes down to the other side. But …
(367) Noé: It is a graph, not a hill!
(368) Researcher: Noé says: "it is a graph, not a hill".
(369) Noé: Because…
(370) Researcher: Then, if Tommaso went down to the other side, …?
(371) Ambra: He wouldn't come…
(372) Arturo: He wouldn't be at home.
(373) Valeria: Yes! … and, in C, you can read "he goes back home".
(374) Researcher: He (*indicating Arturo*) says: "he wouldn't be at home".

In the subsequent part of the discussion the pupils are guided to observe that, if story B were the correct one, the last part of the graph should be an ascending line.

In this third excerpt, the teacher and the researcher act together in order to foster a sharing of the ideas expressed by Giacomo in the previous excerpt. The technique they adopt is to ask other students to revoice Giacomo's interventions (lines 360 and 362). This approach could be, again, located within the *articulation* and *reflection* categories of cognitive apprenticeship methods. The effectiveness of this approach is evident when Carlo asks to explain his classmate's observation (line 361), activating himself both as *owner of his learning* (strategy E) and as *an instructional resource for the other students* (strategy D).

The subsequent interventions by the teacher and the researcher aim at supporting Carlo and the other students in the correct interpretation of the graph and in the identification of the reasons why story B should be discarded. The interventions in lines 364, 365, 370 can be therefore referred to as the *modeling* and *scaffolding* categories of cognitive apprenticeship methods. Thanks to these interventions, other students take the responsibility of their own learning (*strategy E*), as Ambra (line 366), Noé (lines 367), Arturo's (line 372) and Valeria's (line 373) interventions testify.

6.5 Conclusions

In this paper, we argued that the *sending* and *displaying* functionality of connected classroom technologies and the focus on making students' thinking visible could foster the activation of FA strategies. As a first remark, we stress the role played by technology in supporting the different phases of this lesson and the subsequent activation of *FA strategies*: the worksheets are *sent* by the teacher to the students and vice versa (fostering, in case of helping worksheets, the activation of *FA strategy C*); then the students' written answers are *displayed* on the IWB, enabling the teacher to carry out a class discussion during which different feedback is provided (*FA strategy B and C*); and the students read carefully, discuss and compare their classmates' answers. In this way, students are activated both as owners of their learning (*FA strategy E*) and as resources for their peers (*FA strategy D*).

As a second remark, our analysis shows relevant interrelations between:

(a) the activation of *articulation* and *reflection* categories of cognitive apprenticeship methods and the activation of *FA strategies C* (*Providing feedback that moves learners forward*), *D* (*Activating students as instructional resources for one another*), *and E* (*Activating students as the owners of their own learning*);
(b) the activation of *modeling* and *scaffolding* categories of cognitive apprenticeship methods and the activation of *FA strategy E* (*Activating students as the owners of their own learning*), because students are guided to "act as experts" in facing the tasks. As a result, students' ideas are made more explicit, enabling them to become instructional resources for their classmates (*strategy D*).

Moreover, the combination of the different teacher's interventions delineates specific ways of managing class discussions, so they support an effective activation of *FA strategy B* (*Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding*).

The analysis we developed highlights also how argumentation, besides being part of the mathematical task at issue (students are required to justify their answers), turns into a means to enhance formative assessment. It is possible to distinguish two main argumentative moments that characterize the structure of the lessons we carry out during our design experiments: first when pairs/groups of students are asked to accompany their answers with an explanation of their plausibility; and second, a collective moment, when the class, under the guidance of the teacher, examines some selected group answers. When, during the collective argumentative moment, students explicitly state the reasons behind their answers, they are led to become owner of their learning (*FA strategy E*); when the classmates intervene and explain why the answer at issue doesn't hold and should be modified, they become resources for their classmates (*FA strategy D*); moreover, the teacher and classmates give feedback on the proposed argumentation and, in this way, clarify what are the learning objectives (*FA strategy A*), that is to say what are the relevant features an argumentation should have. The role of argumentation in formative assessment activities and the connection between argumentation and FA strategies is an issue that we are planning to study in depth.

We are also developing an analysis of teacher's interventions in relation to the goal of providing specific feedback to students. In particular, we are going to integrate the analysis presented in this paper with the analysis on the strategies of feedback to focus on the intentionality behind the teacher's interventions.

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