CASE STUDY 1

REPORT OF THE ACTIVITIES – Scuola Primaria "Giacomo Matteotti"

This part consists of 6 sections:

1) Contextual information: the school context, teacher demographic, class demographic;
2) Report and analysis of three lessons;
3) Teacher's perception: interview after a series of lessons, final interview on classroom teaching;
4) Pupils' perception: q-sorting and interviews with two groups of students;

1. Contextual information

School name	**Scuola Primaria "Giacomo Matteotti"** - Istituto Comprensivo di Vinovo
Subject	Mathematics
Activities used	Our adaptation of the activity "*Interpreting Distance-Time Graphs*", from the Mathematics Assessment Project. The worksheets, on which the documented lessons are focused, are 1 - 1A – 2 - 2A – 3 – 4 - 4A – 5 – 6 – 6A.
Technology/tools used	The networked classroom technology IDM-TClass.

1.1 School Context - Scuola Primaria "Giacomo Matteotti"

School Roll (number of pupils)	About 150
Staff Roll (number of teaching staff)	13
Geographical location (urban/rural, etc.)	Rural
Relationship to other schools (e.g. cluster/Feeder/Part of a group of schools)	Scuola Primaria "Giacomo Matteotti" is part of a cluster of 4 schools

Age range	6-10
Single or mixed gender	Mixed gender
Ethnicity	Few students are not Italians
Mixed ability or selected (could include Special Educational Needs)	Mixed ability classes
Socio-economic intake (with local contextual indicators, e.g. UK Free School Meals)	Medium socio-economic level
How the school is judged to be performing in local context	The school performs at a medium-high level in the National standardised tests and also in other tests, proposed within the Regional Project "AVIMES" (Autovalutazione d'Istituto per il Miglioramento dell'Efficacia della Scuola - Institute Autoevaluation for Improving School Efficiency, http://www.avimes.it), which is focused on research, innovation and professional development in the field of school self-evaluation.
Past experience of using formative assessment	A team of teachers of the cluster of schools is involved in a Regional Project focused on FA, the project "AVIMES".
Past experience of using technologies/tools	The teachers do not have almost any experience in the use of technologies during the mathematics lessons.
Previous experience of working within other research projects	Some of the teachers were involved also in small research projects focused on innovation in the teaching of Mathematics.

1.2 Teacher demographic (Daniela Vittone – Teacher DV)*

Subject area (science or mathematics)	Mathematics
Role (e.g. Head of Department/Teacher, etc.)	Teacher
Gender	Female
Age range (under 20; 21-30; 31-	51-60

40; 41-50; 51-60; over 60)	

* Other information on Daniela's teaching experience can be found in the paragraph "Final interview on the classroom teaching".

1.3 Class demographic

Class	**5A from Scuola Primaria "Giacomo Matteotti"**
Age range	9-10 (grade 5)
Number of students in the class	27
Gender split within class (male/female)	11 males; 16 females
Ethnicity	In the class, no students are from foreign countries.
Mixed ability or ability set	Mixed ability
Any relevant contextual information	Two teachers works with the class 5A. The teacher DV teaches Mathematics, Science and Arts. As teacher DV also stated in the final interview on her teaching experience, this class has always worked well together. Before the beginning of the teaching experiments, we asked teacher DV to prepare a synthetic presentation of the pairs/groups of students that were going to work on the same tablet: 1) Carlo and Elsa: Their performances are usually at a medium level. Carlo is excellent and Elsa is good in applying known procedures. They are rather well intuitive, but not so good in constructing argumentations. 2) Claudia and Anna Their performances are usually at a high level. Claudia is excellent in applying procedures, but she is insecure when she has to face situations that are not well known. Anna is more intuitive and she has more spirit of initiative. Both these students are sometimes able to construct argumentations.

	3) Vincenzo and Mirco Their performances are usually at a medium-high level. These students often participate, speaking a lot and showing their interest. Sometimes they are insecure, but also able to propose productive interventions (especially Mirco). Both the students are able to construct argumentations. 4) Livio and Giacomo Their performances are usually at a low level. Their concentration, their capability of interpreting a given task, their use of data and information are often inadequate. Livio is sufficiently self-confidence in performing calculations, he is able to repeat known procedures, but he is not intuitive. Giacomo understands and is sufficiently intuitive only during collective activities and when the communication is at a verbal level. He is not able to autonomously face activities that have been already discussed together. They both are not able to construct proper arguments about their choices. 5) Arturo, Luca and Elisabetta Their performances are usually at a high level. These three students are very intuitive and display good logical skills. However, they rarely contribute to the classroom discussions. They are able to analyze, reflect and construct argumentations to justify their choices. 6) Anita, Gregorio and Veronica Their performances are usually at a low-medium level. Anita is very insecure, especially in front of something new. If she is calm, she is good in applying known procedures and she rather well faces situations that she has already experimented. She seems to be not so intuitive and, sometimes, she displays inadequate logical skills, but it could be due to her insecurity. Sometimes she is able to construct argumentations to support her choices. Veronica arrived in the class in May 2015. She seems to be sufficiently intuitive. However, serious familiar problems prevent her from making the most of her potential. Gregorio has a learning disability (a mild retardation). If enough time is given to him, he is able to concentrate, to construct good logical reasoning and to propose interesting answers to the questions that are posed to him.

	7) Emilia and Carlotta Their performances are usually at a medium level. Emilia is becoming more self-confident, but she rarely intervenes during class discussions. She usually choose to face situations trying to recall those situations that she has extensively experimented. Carlotta is enough self-confident in performing calculations and in applying known procedures, but she is not vey intuitive. Both the students are not so good in constructing argumentations. 8) Rita and Lavinia Their performances are usually at a medium level. Rita is gifted: she has good logical skills and she is intuitive, but she often does not listen to the teacher or to the class discussions and, usually, she does not participate. Sometimes, especially when she has to face new situations, she becomes more interested. She is not collaborative with her classmates. Lavinia is fair in applying known procedures. She is insecure, even if she has logical skills. Both the students are not able to revise what they have done and to construct argumentations. 9) Stefano and Sabrina Their performances are usually at a medium-high level. Both these students are shy and insecure. Sabrina is intuitive and she has good logical skills, but she is always worried, especially when she interacts with adults. When she works in a group, she is often passive, because of her insecurity. She is able to construct argumentations. Stefano is good in applying known procedures. He is rather well intuitive, but not so able to construct argumentations. 10) Adriana and Ambra Their performances are usually at a high level. Both these students are gifted. Adriana is the one who is more able to analyse, foresee, reflect on situations. They are good in constructing argumentations. 11) Andromeda and Noé Their performances are usually at a low-medium level. Andromeda is becoming more calm when she works, but she is often worries when she has to face new situations. She is enough self-confident only when she is facing something that has been widely experimented. She is not so intuitive and, sometimes, she displays inadequate logical skills.

	Noé's performance is fluctuating because he often does not do his best. Moreover, this is the result of an insufficient level of attention, concentration and revision. Usually he is interested and he participates to class discussions. But, sometimes, he displays inadequate logical skills. Both the students are not able to construct argumentations to justify their choices. 12) Valeria, Rodolfo and Marianna Their performances are usually at a medium level. Valeria and Marianna are rather well in applying known procedures. They are intuitive, but they usually do not reflect on what they are doing, and they do not adequately revise what they have done. Marianna works harder than Valeria, but, during group activities, she is usually passive. Both these students are not able to construct argumentations. Rodolfo is insecure. He is intuitive and has good logical skills, but, sometimes, he is blocked, especially when he has to answer to an adult's question. Often he is not collaborative during group activities and, at the same time, he often appeals to his mates to confirm the correctness of what he has done. He is able to construct argumentations.

2. Report and analysis of three lessons

The case intervention under analysis refers to the second cycle of experimentations performed by the teacher DV. In the following, we present three lessons developed by the teacher DV in her class 5A.

Totally, 9 lessons were performed:

Lesson 0	October 21st, 2 hours		Activity with the motion sensor
Lesson 1	October 29th, 2 hours	Worksheets 1-1A-2	Specific questions on some parts of the graph representing Tommaso's journey.
Lesson 2	November 5th, 2 hours	Worksheets 2A-3-4-4A	Other questions on some parts of the graph representing Tommaso's journey.
Lesson 3	November 9th, 2 hours	Worksheets 5-6	A graph is given, students have to choose the corresponding story.
Lesson 4	November 16th, 2 hours	Worksheet 7 and helping worksheets	Students are required to match a set of cards of time-distance graphs with a set of cards with their possible interpretations.
Lesson 5	November 25th, 2 hours	Continuation of the work on worksheet 7	
Lesson 6	December 3rd, 2 hours	Discussion on worksheet 7	
Lesson 7	December 10th, 2 hours.	Worksheet 8	Students are required to draw a graph that represents a given story.

For this case study, we focus on lesson 1, 2 and 3. These lessons are focused on the time-distance graphs activities, specifically on the worksheets 1 - 1A – 2 - 2A – 3 – 4 - 4A – 5 – 6 – 6A (see paragraph 4 in the common part).

For each lesson, we will first summarize the main information, and then we will present a summary of the most significant events in the lesson, inserting also translated transcripts from the class discussions, which we will analyze in depth.

As we stated in the common part, one or two members of our UNITO team was always present during the activity, as participant observer and collaborating with the teacher. All the information that we are providing are, accordingly, the result of our first hand documentation of the lessons.
Since we prepared all the worksheets and met the teachers to share both the worksheets and the methodology with them, we are not going to document the lesson preparation (lessons were not prepared by the teachers). For the same reasons, the lesson re-design was documented in the common part (see the paragraphs devoted to the presentation of the activities).

During the teaching experiment the teacher did not propose tests involving technology and formative assessment, that is tests connected to the FaSMEd project. For this reason we are not going to document the tests that students faced in the period of the teaching experiments.

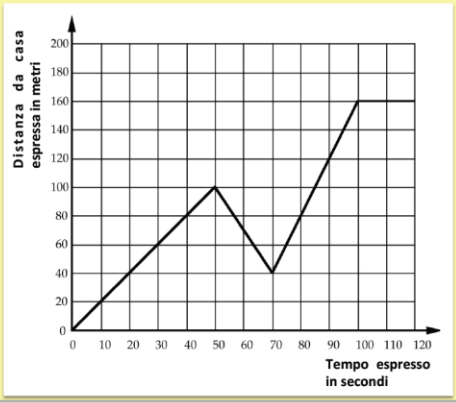
2.1 Lesson 1

Length of lessons, date & time	29 October 2015, 2 hours (10.30-12.30)
Year group & class size	5A (grade 5) – 27 students
Objectives & lesson theme	1) Guiding the students in the interpretation of a time-distance graph: - interpretation an ascending/descending line within the graph; - interpretation of an horizontal line within the graph. 2) Make the students focus on the reasons supporting the correct interpretation of a time-distance graph. 3) Make the students become aware of the meaning of the terms "correct", "clear" and "complete", when speaking about the justification to a given answer.
Tasks used	Worksheets 1 – 1A – 2
Resources used	• IDM-TClass software • Tablet for pairs and groups of students • PC for the teacher and the researchers • IWB

Lesson 1 is focus on the worksheets 1, 1A and 2. These worksheets are presented and analysed in paragraph 4.2.1 - Common part.
At the beginning of lesson 1, the worksheet 1 is projected on the IWB.

Scheda 1

Ogni mattina Tommaso cammina lungo una strada dritta, da casa sua alla fermata dell'autobus, che dista 160m da casa.
Il seguente grafico descrive come ha percorso ieri il tragitto.



Domanda 1: Cosa è successo nel periodo di tempo da 50s a 70s?

Come hai fatto a stabilirlo?

The question posed in the worksheet is:

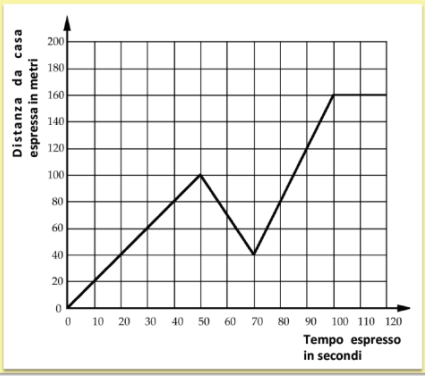
"*What happens in the period of time between 50s and 70s? How did you establish it?*"

Teacher DV reads the text of the problem, without analysing the graph. She says that, if someone has any doubts, he/she could ask afterwards.
She asks students the meaning of "50s" and "70s" and makes them notice that the question is specific: they do not have to analyse the whole graph.
The class is also led to discuss some terms within the text of the problem: "straight road", "distance of the bus stop from home".
The students work in pairs for about 40 minutes, sending their files to the teacher as soon as they feel to have finished their work.
During the activity, students can receive the "helping worksheet" 1A. The teacher and the researchers initially walk around the class to see if some students need some clarifications, then work at the computer, waiting for students' answers.

The teacher and the researcher select some of the students' answers, in order show them with the IBW to support the class discussion. The students' answers are usually selected in order to: (a) highlight typical mistakes; (b) discuss effective ways of processing the tasks; (c) compare different ways of justifying claims.
The selected answers are collected in the following file (the translation of the answers collected in this file is presented within the report of the lesson):

Scheda 1

Ogni mattina Tommaso cammina lungo una strada dritta, da casa sua alla fermata dell'autobus, che dista 160m da casa.
Il seguente grafico descrive come ha percorso ieri il tragitto.



Domanda 1: Cosa è successo nel periodo di tempo da 50s a 70s? Come hai fatto a stabilirlo?

RISPOSTA:

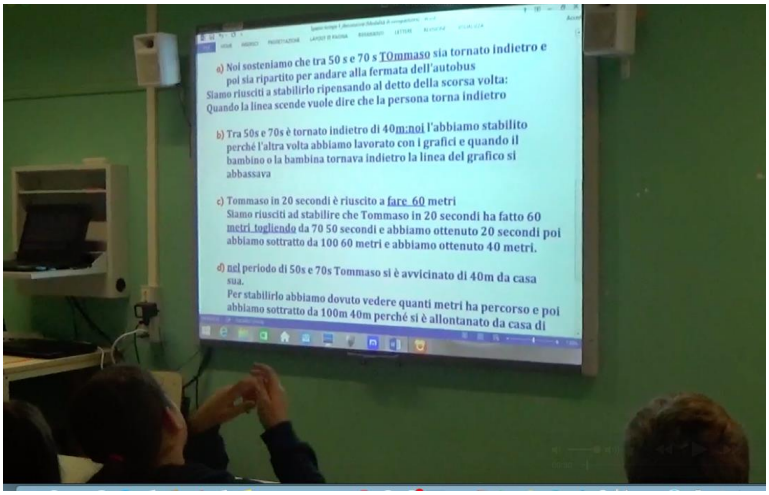
a) **Noi sosteniamo che tra 50 s e 70 s TOmmaso sia tornato indietro e poi sia ripartito per andare alla fermata dell'autobus**
Siamo riusciti a stabilirlo ripensando al detto della scorsa volta:
Quando la linea scende vuole dire che la persona torna indietro

b) **Tra 50s e 70s è tornato indietro di 40m;noi l'abbiamo stabilito perché l'altra volta abbiamo lavorato con i grafici e quando il bambino o la bambina tornava indietro la linea del grafico si abbassava**

c) **Tommaso in 20 secondi è riuscito a fare 60 metri**
Siamo riusciti ad stabilire che Tommaso in 20 secondi ha fatto 60 metri togliendo da 70 50 secondi e abbiamo ottenuto 20 secondi poi abbiamo sottratto da 100 60 metri e abbiamo ottenuto 40 metri.

d) **nel periodo di 50s e 70s Tommaso si è avvicinato di 40m da casa sua.**
Per stabilirlo abbiamo dovuto vedere quanti metri ha percorso e poi abbiamo sottratto da 100m 40m perché si è allontanato da casa di 100m poi si è avvicinato a casa di 40m.

The screen of the IWB, where students' answers are projected:



The main functionality of the technology that is used in this part of the lesson is, therefore, ***sending and displaying***:
- *sending* in double direction, because the worksheets are sent to the students, who, in turn, send their answers to the teacher's computer when they finish;
- *displaying* because the answers of the students are projected on the IWB during the classroom discussions.

2.1.1 Episode 1: Identification of the correct answer

Starting the discussion, teacher DV communicates that the first answers to be showed will be those of the students that did not receive any helping worksheet, then some answers proposed by students who received the helping worksheets will be discussed.
She observes that each pair/group should have answered to two questions: what happened to Tommaso in the period of time from 50s to 70s and "how did you establish it?".

Teacher DV reads all the answers that have been selected and are projected on the IWB. Students are asked to carefully read them, and to answer to the following questions:
1) Are these answers *correct* or do they contain mistakes?
2) Are these answers *clear*, i.e. easily understandable?
3) Are these answers *complete*, i.e. do they give sufficient motivations, in particular from a mathematical point of view?
These specific questions can be interpreted as an operative way of activating the ***formative assessment strategy 1: Clarifying and sharing learning intentions and criteria for success***, in particular with respect to argumentation. Our aim, in fact, is to share with students some fundamental criteria that students can use also to assess their own arguments: *correctness*, *clearness*, and *completeness*.

Livio intervenes, saying that, according to him, answer C is not correct.

Answer C:

c) Tommaso, in 20 seconds, was able to walk for 60 metres. We know that in 20 seconds he walked for 60 metres because we took 50s away from 70s, obtaining 20s, then we subtracted 60m from 100m and we obtained 40 metres.

Livio specifies that he does not understand how the result "20 seconds" has been obtained. After having clarified that it is the result of the difference between 70s and 50s, teacher DV asks Livio what is not correct, according to him.
Livio declares that it is not right that, during these 20s, Tommaso walked for 60m.

Teacher DV asks to the other students if they agree or disagree with Livio and why.
After having looked at the graph on their tablet, Livio and Giacomo add that they think that Tommaso walked for 40m (not 60m) during these 20s.
Stefano intervenes to support Livio and Giacomo's observation: he goes close to the IWB, indicates the point (70,40) on the graph, and says: "The line lowers itself, so he went back … and he went back for 40m".

We make the students notice that the authors of answer C declared that, in that period of time, Tommaso walked for 60m. Some other students intervene to say that they think that answer C is not right and they agree with Stefano and Livio.
Vincenzo and Mirco, the authors of answer C, at this point say that, after this discussion, they think that their answer is not correct anymore. When we ask them to explain why they changed their mind, Vincenzo and Mirco explain that they obtained 60m subtracting 40m from 100m, but they are not convinced of this result anymore: they think that Tommaso walked for 40m, since the last point on the right of the part of the graph that had to be analysed is (70,40).

While Vincenzo and Mirco have changed their mind and so are now convinced that their correct answer was wrong, Arturo raises his hand and says that answer C is correct. Teacher DV asks him to explain why.

Transcript	***Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback***
140) Teacher DV: Let's listen to what Arturo has to say on answer C, that, according to him, is right. 141) Arturo: I think that it is right because, if you look at the graph…from 50s to 70s there are, actually, 20 seconds. 142) Teacher DV: He says "from 50s to 70s there are 20 seconds". How did you establish it? What calculation do you have to perform? 143) Arturo: 70 minus 50. 144) Teacher DV: 70 minus 50. Do we all agree? *The pupils nod*. 145) Arturo: However, if we look at the	When many students (even Vincenzo and Mirco, those students that proposed answer C) agree erroneously on the fact that, in the period of time from 50s and 70s, Tommaso walked for 40m, the teacher exploits Arturo's disagreement to activate ***strategy 4***: Arturo, in fact, is activated ***as an instructional resource for his classmates***. His explanation, which clearly highlights how to determine for how many meters Tommaso walked back, represents a ***feedback about the task***. ***Strategy 3*** (***Providing feedback that moves learners forward***) is therefore activated.

graph, he (*Tommaso*) arrives at 100m, then he goes back. 146) Teacher DV: Do we all agree that he goes back? *A chorus of students answer "yes".* 147) Teacher DV: Who don't agree on the fact that he goes back? *None of the pupils raises his/her hand*. 148) Arturo: However, he goes back "to 40m", not "for 40m". So we have to do the subtraction "100 minus 40". And the result is 60, not 40. So (*answer C*) is right.	
149) Teacher DV: So is it right? Do you agree with Arturo? *Silence*. 150) Researcher 1 (*speaking with Arturo*): Repeat the words you used, since they are very precise … Listen to them (*speaking with the other students*).	Seizing the effective and precise distinction made by Arturo in order to highlight that 40m, which is the distance from home, should not be confused with the walked distance, Researcher 1 (line 149) recognizes that the student has provided a correct argument, by asking him to repeat them, and positively assessing them ("they are very precise"). In this way, she is giving students a ***feedback about the processing of the task***, because she wants to make them focus on Arturo's way of interpreting the graph in order to understand what 40m represents. ***Strategy 3*** is, therefore, again activated.

Arturo repeats his reasoning, stating it slower and stressing the most important words, as researcher 1 asked him to do. He explains, in particular, that 60m is the result of the difference between 100m and 40m.
We then read again answer C, asking to Vincenzo and Mirco if they agree with Arturo's observation or if they still think that their written answer should be emended.

Transcript	***Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback***
166) Researcher 1: You (*speaking with Vincenzo e Mirco*) said that you wanted to change your answer. Would you still change it or would you keep it as it is? 167) Mirco: We would keep our first answer.	Researcher 1 asks Vincenzo and Mirco if they changed again their mind to activate ***Strategy 5*** (***Activating students as the owners of their own learning***).
168) Researcher 1: Ok. I have one question for all of you (*speaking to the whole class*): what is missing in answer C? 169) Mirco: That Tommaso went back! We did not write it. 170) Researcher 1: You did not say that Tommaso went back.	By accepting Mirco's answer without further questioning it or asking for additional justification, Researcher 1 is communicating that the answer is correct. (***feedback on the task***). At the same time, she is asking to the class to identify something that is missing in answer C (again, ***feedback on the task***).

	Mirco (line 169) shows that he really has activated himself as ***the owner of his own learning*** ("we did not write it").

Then, Teacher DV reads answer D:

> **d) In the period of time from 50s to 70s, Tommaso went back for 40m, getting close to his home. We know it because we saw the distance that he walked through. And we subtracted 40m from 100m, since he first went away, for 100m, from home, then he went back for 40m.**

Teacher DV focuses on "for 40m", stressing that the authors should have written "he went back to 40m" (***feedback on the task***).

Teacher DV reads answer B:

> **b) From 50s to 70s, he went back of 40m. We know it because last time we worked with graphs and, when a child went back, the line of the graph was descending.**

Teacher DV makes the students observe that, in this answer, there is the same mistake as in answer D ("he went back of 40m") and that the answer is mainly focused on the fact that the "descending line" means that Tommaso is going back (***feedback on the task***).

2.1.2 Episode 2: Focus on the completeness of the given explanations and introduction of the idea of "mathematical justification"

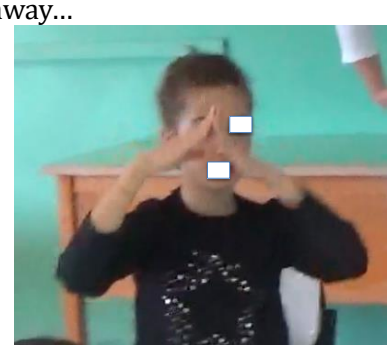
Teacher DV reads the text of answer A:

> **a) We think that, from 50s to 70s, Tommaso went back, and, then, he left again to go to the bus stop.**
> **We know it because we thought about what we said during last lesson: when a line is descending, it means that the person is going back.**

In agreement with the teacher, we decided to comment this answer, focusing on the criterion of *completeness*:

186) Researcher 1: I would like to consider all the justifications that were proposed. I have a question for you (*to the whole class*). Here, especially in the first and second answer (*answer A and B*), they refer to the experience we did during last lesson with the sensor. You remember that, when the graph is descending, that is the line is descending, it means that he is going back, he is going toward the sensor. In this case, he is going toward …? 187) Chorus: Home. 188) Researcher 1: He is going toward his	Researcher 1's interventions (line 186-188) are aimed at shifting students' attention from the correctness of students' answers to the completeness of the provided justifications, especially from the mathematical point of view. She is trying to activate ***strategy 1*** because she aims at sharing with students the criteria for success.

home. So I ask you: why, when a line is descending, does it mean that he is going back? We saw that, if (*the line*) is descending, he goes back, but we did not say why.	
Luca, Carlo and Arturo raise their hands. 189) Luca: Because, if the straight line (*with his forefinger, he traces a hypothetical horizontal axis*), we may say, is the sensor, when the line approaches the sensor (*with his forefinger, he traces a descending line*), it means that the child himself is approaching the sensor. 190) Researcher 1: Because something is decreasing…what? 191) Ambra: The distance between the sensor and the child. 192) *Researcher 1* (*to the other students that have risen their hands*): Do you want to add something? *No one answers*.	In this phase of the discussion, a first mathematical justification is constructed. Referring to the experience made in the previous lesson with the motion sensor, Luca associates a descending segment to a person approaching the sensor. Through his gesture he is stressing that the horizontal axis is referring to the sensor: in mathematical terms, this would mean that the points on the line represents positions at a distance zero from the sensor. This interpretation is fostered by Researcher 1, who explicitly asks "what" is decreasing (line 190). Ambra correctly intervenes, enriching Luca's explanation. These students become, therefore, *instructional resources for each other*. ***Strategy 4*** is, therefore, again activated.
193) Researcher 1: Other pairs, for example those who wrote answer D and C, mainly focused on how much (*Tommaso*) walked. He walked for 60m. However, to give this answer, where did they look within the graph? 194) Ambra: The two lines (*she is referring to the two axis*)… 195) Livio: They look at the time, and, above all, at the metres. 196) Researcher 1: They, in particular, looked at two points? Is it right? 197) Chorus: Yes. 198) Researcher 1: Look at these two points. First this one (*she indicates the point (50,100)*), then this (*she indicates the point (70,40)*). Does looking at these points help us to understand that he is approaching his home?	After having focused on answers A and B, Researcher 1 shifts students' attention to answers C and D (line 193), with the aim of highlighting another possible *way of providing a mathematical justification*. In this way, she is activating ***strategy 1***, because she aims at making students' aware of what "giving a mathematical justification" means. Moreover, she aims at activating ***strategy 3***, because she is directing students' attention on the ways in which the graph should be *looked at* to highlight that the distance from home is decreasing (lines 196-198). Overall she provided ***feedbacks about the processing of the task***.
199) Chorus: Yes. 200) Researcher 1: Why? 201) Livio: Because, when the line is going down again, it means that he is approaching the sensor. 202) Researcher 1: I made a different question because I said: if we read these points – that is I read this one (*she indicates the point (50,100)*) and I see where I am, then I read this one (*she indicates the point (70,40)*) and I see where I am – does it help	Livio (line 201) and Anna M. (line 204) face difficulties in correctly interpreting the Researcher 1's question. For this reason, Researcher 1 tries to guide the students in the interpretation of the meaning of the points of the graph as "bearers" of two information: one about the distance from home, and the other one about the time that passed (line 205).

me in understanding that Tommaso is going back? 203) Chorus: Yes! 204) Anna: Because you see, in … (*she makes the gesture in the picture below*) … when they meet … when it is like this, at 100m, it means that he went away, because we read exactly 100, then it means that he went away…  205) Researcher 1: But, if I look at this point (*she indicates the point (50,100)*), what does it tell me? …that … where is Tommaso at 50s? 206) Livio: He is at a distance of 100m from his home. 207) Researcher 1: Ok. 208) Livio: Instead, between 50s and 70s, that is in 30s… 209) Teacher DV: Again? (*she is referring to the fact that he is repeating the same mistake he did before*) 210) Researcher 1: They are 20s. 211) Livio: Ah, yes! …in 20s he walked for 60s to go back… 212) Researcher 1: 60m, you mean… 213) Livio: Yes, 60m!	
Sabrina raises her hand. 214) Sabrina: Maybe, I want to say something similar to what Anna said. I want to say that, if you look at the distance from home, in metres, if you look at the higher point, it (*the distance*) is 100m. If you look at the lower point, it (*the distance*) is 40m. So you understand that he went back. 215) Researcher 1: So she answered to my question! If I look at the first point, the distance is 100m. If I look at the second point, the distance is 40m. It means that he is approaching. This justification is not alternative to the one about the descending line, but it help in better understanding why, if the line is descending, it means that the child is going back. 216) Teacher DV: It (*the line*) is descending	Sabrina clearly explains how, looking at the specific point of the graph suggested by Researcher 1, helps in establishing that Tommaso is coming back. The preceding part of the discussion (lines 205-213) has therefore represented an important support for her. Researcher 1 (line 215) specifies that Sabrina is the one that really answered to her question. Giving a ***feedback about the task*** in this way, she is trying to better activate Sabrina as *an instructional resource for her classmates* (***strategy 4***). Afterwards, in line 217 Researcher 1 speaks at a more general level, stressing why the justifications constructed during this phase of the discussions could be considered "mathematical justifications"

because the distance is decreasing. 217) Researcher 1: Every time that we will refer to a graph, we will say that a justification like this one is "more mathematical" than the other one (*the one focused on the experience with the motion sensor*). Because, if I only say "I remember that, when we used the sensor, when it (*the line*) was descending, the person is going back", it is not enough. While, if you add "through the graph I can see that the distance is decreasing", I am also explaining why, if I see a descending line, it means that he is going back. So it is a more complete justification. This (*observation*) will be useful in the future lessons.	that can be considered more complete than explanations based on the memory of lived experience with the motion sensor. In this way, she is sharing the *criteria for success* (***strategy 1***).

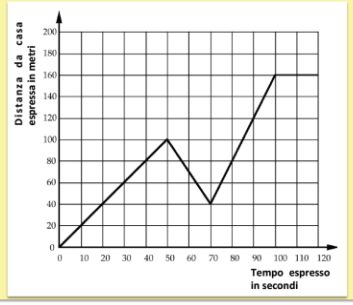
Episodes 1 and 2 testify how the ***Sending and displaying functionality of the technology*** support the teacher (and the researcher) in activating ***strategy 2*** (*Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding*). Projecting the collection on students' answers on the IWB, in fact, enables to focus on different aspects, through the comparison of different answers and justifications proposed by students.

2.1.3 Episode 3: Students are guided to reflect on the role played by the helping worksheet

We project worksheet 1A (helping worksheet) received by some pairs/groups of students that were struck with the task.
The main functionality of the technology that is used is, again, ***sending and displaying***.
This worksheet is shown with the aim of making those who did not received this "helping worksheet" understand what are the main aspects on which the worksheet suggest to focus: these *learning intentions are therefore clarified to the students* (***strategy 1***).

Scheda 1A - AIUTO

Ogni mattina Tommaso cammina lungo una strada dritta, da casa sua alla fermata dell'autobus, che dista 160m da casa.
Il seguente grafico descrive come ha percorso ieri il tragitto.



Domanda 1: Cosa è successo nel periodo di tempo da 50s a 70s?

Come hai fatto a stabilirlo?

Aiuto per rispondere alla domanda 1:

Ricorda che si sta muovendo lungo una strada dritta.
A che distanza da casa si trova dopo 50s?
A che distanza si trova dopo 70s?

RISPOSTA:

220) Researcher 1: The first ones who are going to speak are those who did not receive this helping worksheet. Let's read the help that is given and try to say why, in your opinion, it is an help….what it helps you to do… 221) Researcher 1: The main question to be answered is still this one (*she indicates question 1*). The help says "Remember that Tommaso is walking on a straight road. What is his distance from home after 50s? What is his distance from home after 70s?" 222) Teacher DV: Why do the suggestions focus on this? 223) Researcher 1: What do these questions help to do? *Different students raise their hands.* 224) Carlo: Because they help you understand the distance in the period between 50s and 70s. Because, at 70s, he is nearer… 225) Researcher 1: So you are saying that it enables to look at the distance. Aren't you?	Researcher 1 (line 221-223) and Teacher DV (line 222) are leading the discussion at a metacognitive level: the focus is on the reasons why the questions posed on worksheet 1A could provide help in answering questions 1. Their aim is, therefore, to activate ***strategy 3***, giving ***feedback about self-regulation***. Moreover, Carlo is activated as a resource for his classmates (***strategy 4***), because he correctly highlights that these questions enable to focus on the change in Tommaso's distance from home, during that period of time.
226) Teacher DV: And why does it (*the help*) suggest that Tommaso is moving on a	Teacher DV (line 224) focuses on another suggestion that is given in worksheet 1A.

straight road? 227) Carlo: Because it wants to make us reason on the fact that he is going back. 228) Researcher 1: What mistake couldn't be done if I remember that the road is straight? *Silence*. 229) Researcher 1: If I don't know that the road is straight, what could I think? *Anna mimes a curvy road with her hands.* 230) Arturo: I could think that the sensor initially indicates a direction, then he goes on the right… 231) Teacher DV: So a change in the direction. 232) Researcher 1: That we are zigzagging, in a strange way. 233) Teacher DV: It is the reason why it remembers us that the road is straight. You recalled, with your memory, what we experimented last time. If we hadn't worked with the sensor, you, maybe, would have proposed different answers.	Researcher 1 (lines 226-227) aims at making students reflect on the possible misinterpretations that this suggestion wants to prevent. ***Strategy 3*** is therefore activated, since ***feedback about the processing of the task*** are given. Moreover, becoming aware of the possible mistakes that could be done in the interpretation of this kind of graphs, students learn how to monitor their work. In this sense, ***feedback about self-regulation*** are also shared. Also the teacher in line (233) provides a ***feedback about self-regulation*** because she is making the students notice how the previous experience has influenced their answer to the current question.

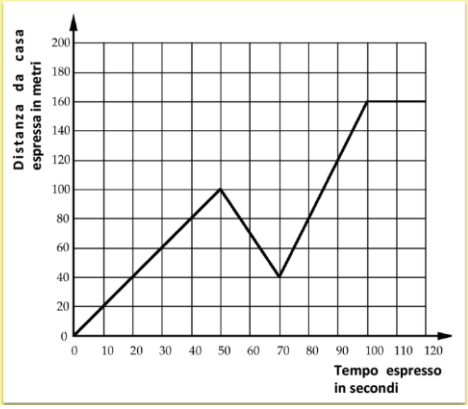
When the discussion on worksheet 1 ends, we send worksheet 2 to the students, stressing on the importance of proposing a justification that is *complete from the mathematical point of view*, a learning criterion which is once again made explicit to the students.

2.1.4 Episode 4: Consolidating the criteria of correctness, clearness and completeness

Worksheet 2 is projected on the IWB. The question posed in the worksheet is: "*What happens during the last 20s? How did you establish it?*"

Scheda 2

Ogni mattina Tommaso cammina lungo una strada dritta, da casa sua alla fermata dell'autobus, che dista 160m da casa.
Il seguente grafico descrive come ha percorso ieri il tragitto.



Domanda 2: Cosa è successo durante gli ultimi 20s?

Come hai fatto a stabilirlo?

RISPOSTA:

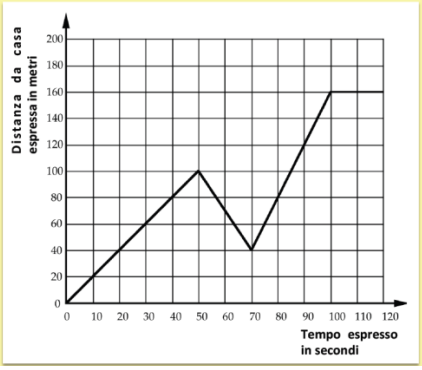
Teacher DV reads the text of the problem and the question.
We observe that, in other classes, some students did not understand the meaning of "the last 20 seconds". Stefano intervenes to say that it means the period of time from 100s to 120s.

The pairs of students work for about 20 minutes on this worksheet.

Some of the students' answers are collected, selected and inserted in the following file to support the discussion (the translation of the answers collected in this file is presented within the report of the lesson):

Scheda 2

Ogni mattina Tommaso cammina lungo una strada dritta, da casa sua alla fermata dell'autobus, che dista 160m da casa.
Il seguente grafico descrive come ha percorso ieri il tragitto.



Domanda 2: Cosa è successo durante gli ultimi 20s?
Come hai fatto a stabilirlo?

RISPOSTA:

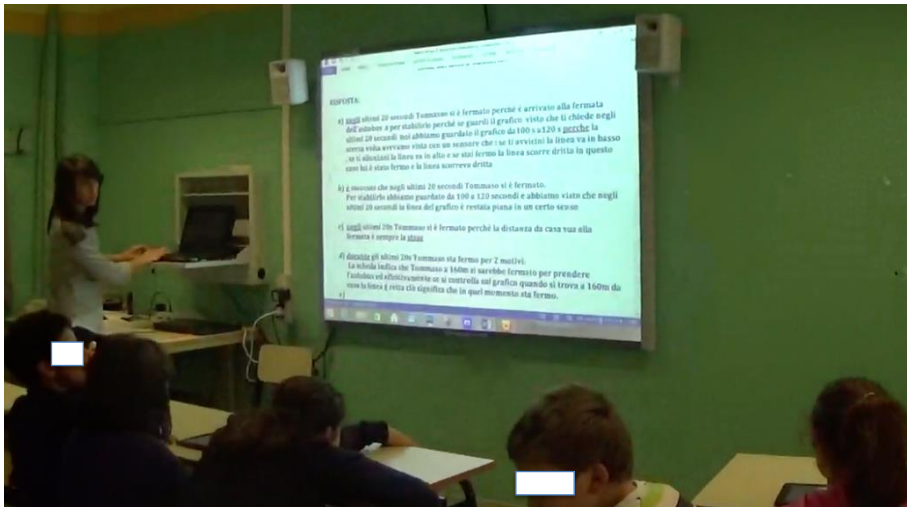
a) **negli ultimi 20 secondi Tommaso si è fermato perché è arrivato alla fermata dell`autobus a per stabilirlo perché se guardi il grafico visto che ti chiede negli ultimi 20 secondi noi abbiamo guardato il grafico da100 s a120 s perche la scorsa volta avevamo vista con un sensore che : se ti avvicini la linea va in basso , se ti allontani la linea va in alto e se stai fermo la linea scorre dritta in questo caso lui è stato fermo e la linea scorreva dritta**

b) **è successo che negli ultimi 20 secondi Tommaso si è fermato.**
Per stabilirlo abbiamo guardato da 100 a 120 secondi e abbiamo visto che negli ultimi 20 secondi la linea del grafico è restata piana in un certo senso

c) **negli ultimi 20s Tommaso si è fermato perché la distanza da casa sua alla fermata è sempre la stssa**

d) **durante gli ultimi 20s Tommaso sta fermo per 2 motivi:**
La scheda indica che Tommaso a 160m si sarebbe fermato per prendere l'autobus ed effettivamente se si controlla sul grafico quando si trova a 160m da casa la linea é retta ciò significa che in quel momento sta fermo.

The students' answers were selected in order to: (a) highlight typical mistakes; (b) discuss effective ways of processing the tasks; (c) compare different ways of justifying claims.



Also in this episode, the main functionality of the technology that is used is ***sending and displaying***.
Teacher DV reads answer A:

> **A) During the last 20 seconds, Tommaso stopped because he arrived at the bus stop. We know it because, if you look at the graph, since it requires you what happens during the last 20s, we looked the graph from 100s to 120s, because last time, through the sensor, we saw that: if you are approaching, the line is going down; if you are going away, the line is going up; if you stop, the line is straight. In this case, he stops and the line is straight.**

Transcript	***Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback***
253) Teacher DV: Do you think that it is a mathematical justification? *Many students answer "yes". Some students answer "no".* 254) Teacher DV: Yes or no? 255) Anna: It not so much mathematical… 256) Vincenzo: It is based on memory. 257) Teacher DV: Or is it based on the experience with the sensor? 258) Chorus: On the experience. 259) Vincenzo: On the experience, so (*it is based*) on the memory.	The question posed by Teacher DV makes the student reason, again, at a meta-mathematical level. The students show that the previous discussion on the different kind of explanations that could be constructed was effective for many students. Vincenzo (lines 256-258), in particular, is able to highlight that answer A could not be considered a "mathematical justification" because it is based on the memories about the experience with the motion sensor. ***Strategy 1*** and ***Strategy 4*** are, therefore, activated.

Teacher DV directly reads answer B:

> **B) During the last 20 seconds, it happened that Tommaso stopped.**
> **We know it because we looked at the period from 100s to 120s and we saw that, during the last 20s, the line of the graph stayed flat, in a certain sense.**

Teacher DV asks if answer B is different from answer A. Anna states that answer A represents a better argumentation. We ask to the rest of the class if they agree with Anna, and Anna specifies that, according to her, answer B is not clear.

We ask to the authors of answer B (Livio and Giacomo) if they want to add something to make this answer clearer. Livio says that the word "flat" is not so clear and suggests to substitute it with "straight". We ask him if, when he says "straight", he means "horizontal". Livio nods.

Teacher DV reads answer C:

> **C) During the last 20s, Tommaso stopped because the distance from his home to the bus stop is always the same.**

Some students declare that, in their opinion, this answer is not correct. Teacher DV and Researcher 1 ask them to explain why. This discussion enables to highlight that, actually, for these students, answer C is not clear. Noé says that, in his opinion, answer C is not correct because it is not true that the distance from home is always the same.
Some students explain that they do not understand the meaning of "the distance is always the same", as the first line of the following transcript highlights.

Transcript	***Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback***
294) Anna: It is not clear because I cannot understand what they mean when they say "always the same", however… 295) Teacher DV: Who are the authors of answer C? *Stefano and Sabrina raise their hands*. 296) Teacher DV: Do you want to add something? 297) Stefano: In my opinion, it is not correct because he did not stopped at home… 298) Sabrina: No…it is the distance from home! *Sabrina speaks quietly to Stefano, indicating the IWB.* 299) Researcher 1: What did you want to say? *Stefano looks at the IWB.* 300) Teacher DV: Do you want to express your reasoning in another way? 301) Researcher 1: Sabrina, do you also think that what you wrote is not correct? 302) Sabrina: No, I don't think so. 303) Researcher 1: What did you mean in your answer? Maybe, if you extensively explain it, the others could understand. 304) Teacher DV: Try to say it in another way. 305) Sabrina: Because, in the graph…	In front of Stefano's disorientation (line 297), researcher 1 (lines 301-303-306) tries to activate Sabrina *as an instructional resource for her classmates* (***Strategy 4***), asking her to widely explain the reasoning subtended to their answer.

306) Researcher 1: Come to the IWB. Looking at the graph, maybe, could help you.	
Sabrina comes next to the IWB. 307) Teacher DV: Now Sabrina tries to explain. Maybe someone did not understand what they (*Sabrina and Stefano*) wanted to say… 308) Sabrina: From here (*she indicates the point (100,160), then she traces the segment from the point (100,160) to the point (0,160)*), the distance is always 160 from home. 309) Teacher DV: Noé, did you understand what she wanted to show? 310) Sabrina: And the line (*she indicated the horizontal segment from (100,160) to (120,160)*) is not descending, nor ascending, so the distance, in our opinion, is always the same. 311) Teacher DV: Noé, so do you think that (*Sabrina*) is right or not? 312) Chorus: She is right! 313) Noé: Yes, she is right! 314) Teacher DV: So, Noé, what is the distance from home, during those 20 seconds? 315) Noé: 160. 316) Teacher DV: Does it change? 317) Noé: No. 318) Anna: It (*answer C*) is right!	Since Noé previously declared that he thought that the distance from home is not always the same, Teacher DV makes him reflect on the implications of Sabrina's intervention. Noé shows to have understood that, in the period of time from 100s to 120s, the distance from home is always the same. This excerpt highlight, therefore, that Sabrina's interventions (line 308-310) actually represented a *feedback about the processing of the task* for her classmates. In this way, Sabrina is activated as an instructional resource for him (***strategy 4***), who, in turn, is activated as the owner of his own learning (***strategy 5***).

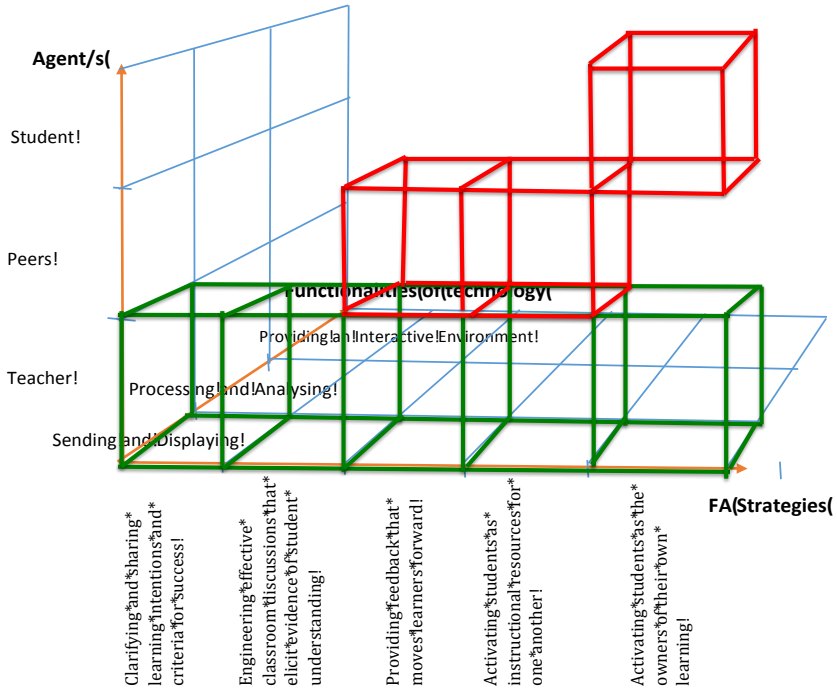
Teacher DV reads answer D:

> **D) During the last 20s, Tommaso stopped for two reasons:**
> **The worksheet says that Tommaso has to stop at 160m, to take the bus. Actually, if you check on the graph when Tommaso is at 160m from home, the line is straight, so it means that, in that moment, he stops.**

Anna says that this answer is correct, but not clear. She declares that, in her opinion, the best answer is A. Teacher DV makes her notice that we have already highlighted that answer A refer only to the sensor. Teacher DV stresses, also, the need of referring to the graphs.
Anna and other students conclude that the best answer is C.

The final part of the discussion is focused on how to integrate answer C in order to make it complete and clear.

The following diagram highlights how the sending and displaying functionality of the technology supported the activation of all the formative assessment strategies by the three main agents (student, peers, teacher) during lesson 1:


Agent/s(
Student!
Peers!
Teacher!
Providing!an!Interactive!Environment!
Processing!and!Analysing!
Sending!and!Displaying!
FA(Strategies(
Clarifying*and*sharing*learning*intentions*and*criteria*for*success!
Engineering*effective*classroom*discussions*that*elicit*evidence*of*student*understanding!
Providing*feedback*that*moves*learners*forward!
Activating*students*as*instructional*resources*for*one*another!
Activating*students*as*the*owners*of*their*own*learning!

2.2 Lesson 2

Length of lessons, date & time	5th November 2015, 2 hours (10.30-12.30)
Year group & class size	5A (grade 5) – 27 students
Objectives & lesson theme	1) Guiding the students in the interpretation of a time-distance graph: - interpretation of a point of the graph as "bearer" of two information (the distance from home and the time spent). 2) Make the students become aware of the difference between two concepts: the distance from home and the distance that was walked through. 3) Make the students consolidate the idea of "completeness of a justification".
Tasks used	Worksheets 2A – 3 – 4 – 4A
Resources used	• IDM-TClass software • Tablet for pairs and groups of students • PC for the teacher and the researchers • IWB

Lesson 2 is focused on the worksheets 2A, 3, 4 and 4A. These worksheets are presented and analysed in paragraph 4.2.1 - Common part.

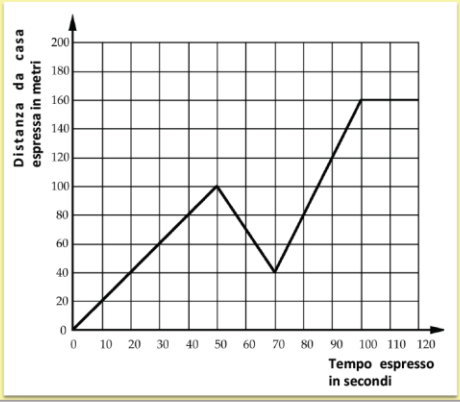
Worksheet 2 is projected on the IWB to resume what was done during the previous lesson (lesson 1). Since Elisabetta and Valeria were not present during lesson 1, Teacher DV asks to the rest of the class to explain them how they reasoned to answer the questions in the worksheets 1 and 2. Moreover, Teacher DV involves Elisabetta and Valeria in the construction of the reasoning that should be developed to answer the questions in worksheets 1 and 2.

2.2.1 Episode 1: The poll as a starting point for a discussion focused on the consolidation of the criterion of completeness of a justification

At the end of this introductory phase, worksheet 2A is projected on the IWB:

Scheda 2A

Ogni mattina Tommaso cammina lungo una strada dritta, da casa sua alla fermata dell'autobus, che dista 160m da casa.
Il seguente grafico descrive come ha percorso ieri il tragitto.



Domanda 2: Cos'è successo durante gli ultimi 20 secondi? Come hai fatto a stabilirlo?

Durante gli ultimi 20s, Tommaso è fermo perché prima abbiamo detto che è già arrivato alla fermata.

Secondo me, durante gli ultimi 20s, Tommaso è fermo perché dal grafico si può capire che, da 100s a 120s, resta sempre alla stessa distanza da casa, cioè 160m.

Ho capito che, durante gli ultimi 20s, Tommaso è fermo perché la linea del grafico è orizzontale.

Alcuni studenti di un'altra classe hanno dato queste risposte. Qual è la più completa?

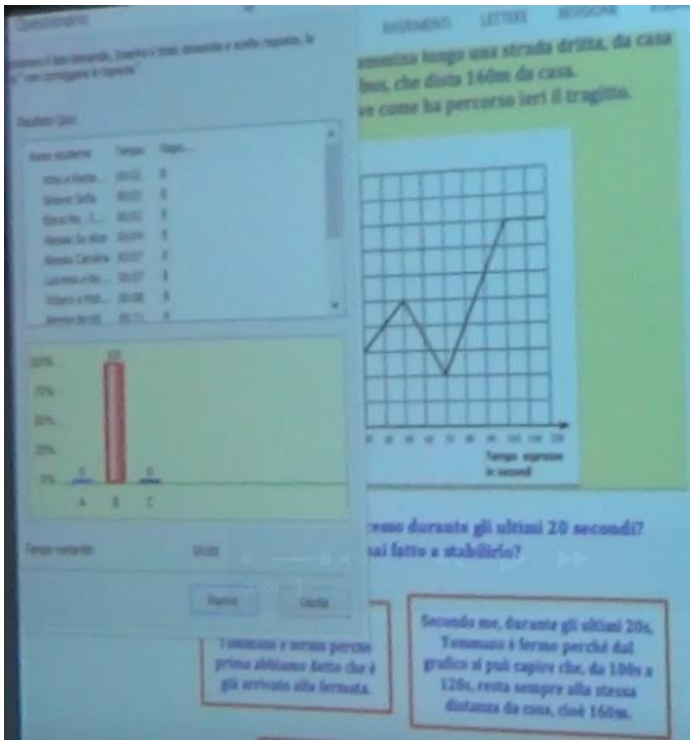
The task is a poll, through which the class is asked to identify, among three answers to question 2, which is the most complete.
It is an activity aimed at enabling students make their idea of "complete justification" explicit, therefore at highlighting, thanks to the discussion on the poll results, possible misunderstanding or doubts.
This activity is, therefore, aimed at activating both ***strategy 2*** (Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding) and ***strategy 3*** (Providing feedback that moves learners forward).

The main functionality of technology that is used is ***Processing and analysing***.

We tell students that we will denote:
- with the letter A, the justification "During the last 20s, Tommaso is not walking because we have already said that he has reached the bus stop";
- with the letter B, the justification "I think that, during the last 20s, Tommaso is not walking because, from the graph, it is possible to understand that, in the period between 100s and 120s, he is always at the same distance from home, that is 160m";

- with the letter C, the justification "I understood that, during the last 20s, Tommaso is not walking because the line of the graph is horizontal".

The poll is activated.
Once all pairs/groups have answered, the screen with the outcome is displayed:



All the couples/groups have identified justification B as the most complete.
Veronica raises her hand to intervene.

Transcript	***Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback***
68) Veronica: A because it was… it did not explain the distance from… and C because this answer did not explain the distance…the distance from ho...it did not explain the distance. 69) Researcher 1: You said: "We rejected both A and C because neither of them referred to the distance"... from where? 70) Veronica : From Tommaso's home. 71) Researcher 1: From Tommaso's home to the bus stop. Ok… *Sabrina raises her hand*. 72) Teacher DV: What do you want to say, Sabrina? 73) Sabrina: That…in my opinion, C, if someone did not, perhaps, made the experiment with the sensor, he does not understand what "the graph is horizontal"	Veronica (lines 68-70) and Sabrina's (line 73) interventions highlight that these two students are activated as owners of their own learning (***strategy 5***). Moreover, Researcher 1 tries to make these interventions more explicit (lines 69-74), with the aim of activating Veronica and Sabrina as instructional resources for their classmates (***strategy 4***). In particular, Researcher 1's intervention on the discussion developed during the previous lesson (line 74) represents both a *feedback about the processing of the task* and a *feedback about self-regulation*.

means. Therefore, he does not understand... 74) Researcher 1: You remembered what we said last time, when we discussed about this... If the memory about the experience with the sensor was sufficient … or not. Any other ideas?	
Anna raises her hand. 75) Teacher DV: Anna. 76) Anna: Because B, differently from A and C, explains you that, during the last 20s, it happened as in the others. It happened… 77) Teacher DV: That he stopped. 78) Anna: However, B tells you how many seconds he stopped … with the graph in front of you, you understand that from 100s to 120s he does not move (*with the hand she traces an horizontal line*). It is explained also in the answer, which is more complete…	Anna integrates Veronica and Sabrina's interventions focusing on the reasons why answer B is more complete than answers A and C.

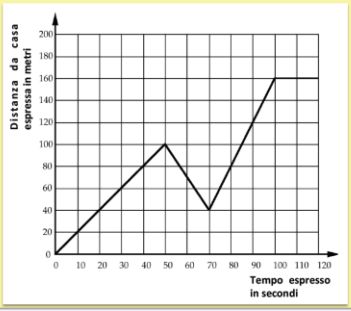
Carlo adds that answer A gives an unacceptable justification because it is based on something that was said by someone else and not on a real understanding. Elisabetta points out that answer B is more complete because it tells how far Tommaso is from home during the period from 100 to 120 seconds. Other children agree with Elisabetta.

2.2.2 Episode 2: The effective interpretation of the graph as a key-point in providing complete "mathematical justifications"

Worksheet 3 is projected on the IWB:

Scheda 3 - SONDAGGIO

Ogni mattina Tommaso cammina lungo una strada dritta, da casa sua alla fermata dell'autobus, che dista 160m da casa.
Il seguente grafico descrive come ha percorso ieri il tragitto.



Domanda 3: Dopo quanti secondi Tommaso è arrivato alla fermata?

A) Dopo 120 secondi

B) Dopo 50+70+100+120 secondi, cioè dopo 340 secondi

C) Dopo 100 secondi

D) Dopo 50 secondi

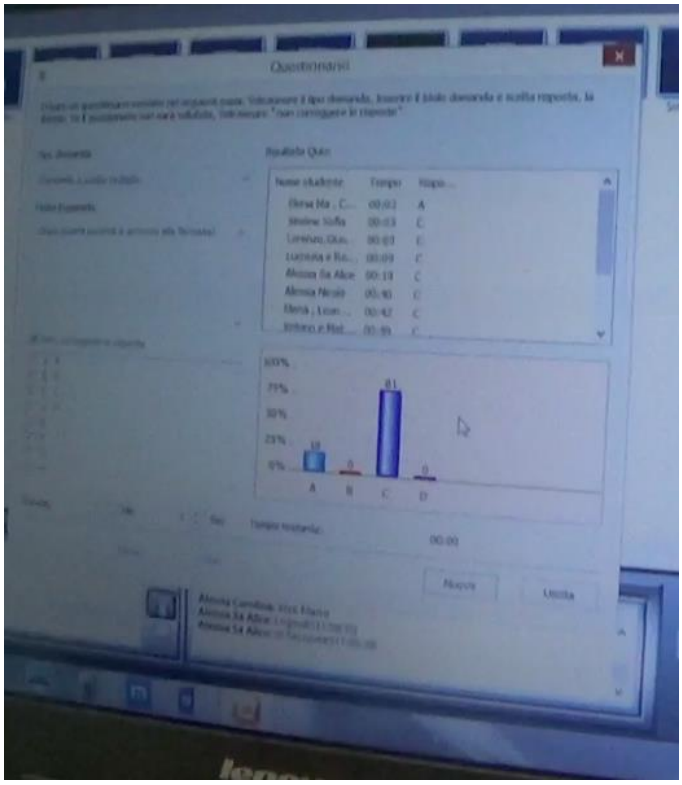
Worksheet 3 involved, again, a poll, aimed at highlighting possible:
- inappropriate approaches (for example, summing the numbers of seconds that correspond to the right end of each part of the graph – as in answer B);
- misconceptions (for example, thinking that the arrival at the bus stop corresponds to the last point of the graph – as in answer A).

The aim is, therefore, to activate ***strategies 2*** (*Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding*) and **3** (*Providing feedback that moves learners forward*).
The functionality of the technology that is used is, again, ***Processing and analysing***.

We read the question ("*After how many seconds does Tommaso reach the bus stop*?") and tell students that we are not going to read the four options together, in order to give them the opportunity to focus on the answer.

The pupils excitedly discuss within the pairs/groups before answering.
The teacher helps the group Veronica - Anita - Gregorio.

The outcome of the poll is projected on the IWB:



The 18% of the couples answered A (after 120s) and the 81% answered C (after 100s).

Several pupils declare that, in their opinion, C is the right answer.
Initially the discussion is focused on the answer provided by two couples: Elsa & Carlo and Anna & Claudia.
Anna tells that they (Anna and Claudia) had not read carefully the question and had not realized that the question asks the precise moment in which Tommaso reaches the bus stop.
Carlo tells that they (Carlo and Elsa) were deceived by the fact that, on the horizontal axis, the last value represented is exactly 120 seconds.
In commenting the result of the poll, the students are invited to reflect on their own reasoning and the possible causes of mistakes, thus at a meta-cognitive level.

We ask to the students who answered C why they chose this answer.
Teacher DV notices that the group Rodolfo-Marianna-Valeria had to discuss a lot before answering because they were undecided between B and C. Since Marianna and Valeria wanted to choose answer B and Rodolfo convinced them to the choice of C, we ask Rodolfo to explain how he convinced his classmates. Rodolfo approaches the IWB and provides his justification.

Transcript	***Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback***
130) Rodolfo: So... he starts from 50s	This brief excerpt highlights how Rodolfo

(*with his finger, he traces the segment from the point (0,0) to the point (50,100)*), then we add 20s (*with his finger, he traces the segment from the point (50,100) to the point (70, 40)*), that is 50 plus 20 equals 70. Then he moves and you arrive at 100 (*with his finger, he traces the segment from the point (70,40) to the point (100, 160)*), so we add other 30s. 70 plus 30 is 100. And then he stops. 131) Researcher 1: So you split the time ... You say: to complete the first part it takes him 50s (*she points, with two fingers, at the two ends of the segment (0,0)-(50,0)*), to complete the second (*part*) (*she points, with two fingers, at the two ends of the segment (50.0)-(70.0)*), it takes him… 132) Rodolfo: 20 133) Researcher 1: And we get to 70 … To complete the third (*she points, with two fingers, at the two ends of the segment (70,0)-(100,0)*) it takes him ... 134) Rodolfo: 30 135) Researcher 1: …and I get to 100. 136) Researcher 1: Ad why are you sure that … (*indicating the point (100,160)*) 137) Rodolfo: Because then he stops and does not walk anymore. 138) Researcher 1: So, you say: if he stops, it means that he has reached the bus stop for sure ...	has activated himself as the owner of his own learning (***strategy 5***). In his interventions (lines 130, in particular), in fact, he clearly presents the reasoning he constructed to identify the correct answer. Researcher 1 (lines 131-133-135-136) guides him in making his reasoning more explicit, so that Rodolfo could be also activated as an instructional resource for his classmates (***strategy 4***). Line 137 highlights a possible source of misconception: the idea that Tommaso has reached the bus stop because, then, he stops. Researcher 1 is aware of this, as it will be evident in the following excerpt.

Elsa adds that, with Carlo, they have realized they got wrong by looking at the graph and noticing that the point (100,160) represents when Tommaso stopped. Therefore she tells that 100s is the correct answer to the question.
During this discussion, we make students observe that both Elsa and Rodolfo have identified (100,160) as the point which represents when Tommaso stops, and that, for this reason, they have considered that this point also represents when Tommaso arrives at the bus stop.

Transcript	***Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback***
148) Researcher 1: I ask one thing to everyone. In another class, this observation came out: "After, he stopped. So, this means that he had already reached the bus stop." But there was a child who said: what if, instead, he stopped to tie his shoes? Who tells me that he was right at the bus stop? 149) Sabrina: Over there (*pointing at the graph*). 150) Researcher 1: Come next to the	Researcher 1 (line 148) proposes a possible doubt to the class, in order to activate the students *as owners of their own learning* (***strategy 5***) and connecting with Rodolfo and Elsa previous remarks ("Tommaso has reached the bus stop, because, then, he does not walk anymore", lines 237-138). Sabrina (line 151) shows to have

IWB to show it. *Sabrina goes next to the IWB*. 151) Sabrina: Because, here, is at 160m (*with her finger, she traces the segment from the point (120,160) to the point (0, 160)*) and, above (*pointing at the text of the problem*), it tells you that the path between his home and the bus stop is 160m. 152) Researcher 1: Did you hear what she said? 153) Chorus: Yes. 154) Researcher 1: Do you agree with what she has …? 155) Teacher DV: He did not stop before, Sophia says, to tie his shoes, but he arrived at a distance of 160m. And the text says "every morning ... a distance of 160m". So, she says, he stopped at the bus stop! ... Do you agree? 156) Chorus: Yes!	understood the problem that Researcher 1 wants to highlight, showing what part of the graph she focused on and the key-sentence in the text of the problem. She is activated as an *instructional resource for her classmates* (***strategy 4***) because she is giving important ***feedback about the processing of the task***. This is confirmed by both the researcher and the teacher (lines 152-155).
157) Researcher 1: There were other hands… 158) Teacher DV: Carlo, tell us! 159) Carlo: Also because, above, it says "road from his home to the bus stop." If he had just tied his shoes, the graph would continue. 160) Researcher 1: You say: I know for sure that he arrives at the bus stop. So, even if he tied his shoes, the graph should continue to arrive at the bus stop. Since it does not continue... Ok. 161) Researcher 2: I saw that that group (*referring to Elisabetta-Arturo-Luca*) continued to comment the activity. Do you want to add something? 162) Luca: I was telling that, in my opinion, it was 120. Then, I realized it was 100 seconds. 163) Researcher 1: You were still hesitating. You thought he got to the bus stop after 120s, instead of 100. But now, what do you think? 164) Luca: 100s. 165) Researcher 2: What made you change your mind? 166) Luca: That... to tie his shoes. Because, if he had stopped, then it would have moved again to go to the bus stop. Instead, it stopped. So, this means that he is at the bus stop.	The discussion goes on and Carlo (line 159) and Luca (lines 162-166) show that they have not grasped that the distance from home is the key-information that enables to declare that Tommaso reaches the bus stop after 100s. Teacher DV and the researchers activate ***strategy 2***, with the aim of activating a discussion that could elicit evidence of their understanding.
167) Vincenzo: However the graph could also have been interrupted, for example...	Vincenzo (lines 167-170) recalls the experience with the motion sensor to

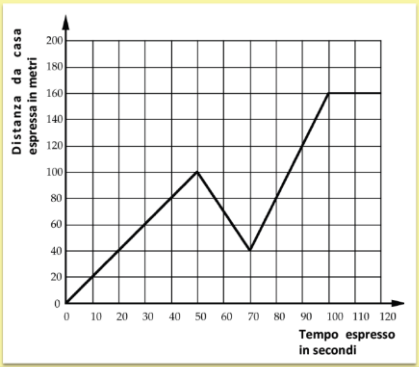
when the time ran out, it stopped recording... the child may also have stopped to tie his shoes, then, as he was tying his shoes, the time ran out... 168) Anna: No, no, no!!! 169) Teacher DV: Let him finish, then we listen to those who are saying "no". 170) Vincenzo: So, the rest of the path was not recorded. ... However, if he is at 160, he has arrived at the bus stop. 171) Researcher 1: He says: It is 160 that convinces me.	stress that, even if we know that everyday Tommaso reaches the bus stop, the information that he stops is not sufficient to declare that he stops exactly at the bus stop. Researcher 1 (line 171) stresses that Vincenzo was convinced by the information that, after 100s, the distance from Tommaso and his home is 160m. Her intervention gives a ***feedback about the processing of the task*** and aims at activating Vincenzo *as an instructional resource for his classmates* (***strategy 4***).
172) Researcher 2: Someone said "no". It's interesting, when someone says "no", to find out why. 173) Researcher 1: Why do you say "no" to what he said ...? 174) Sabrina: Ah, no. Because... at the beginning, when he spoke, it seemed that ... the graph had to continue and not to stop. And then it seemed that... 175) Teacher DV: You stopped him too early. You did not give him the possibility to finish his reasoning ... 176) Researcher 1: Yes, because he says: let's imagine that there was a sensor that was recording Tommaso and that this sensor had a limit of two minutes, 120 seconds. He stopped, by mistake, to tie his shoes. How do we know that he has exactly got to the bus stop at that moment? 177) Carlo: The text. 178) Researcher 1: Don't trust the text too much, however. Sometimes… 179) Teacher DV: In fact, he said: the text tells about the 160m... 180) Researcher 2: There are two aspects. One tells: you read it in the text…which is a way… 181) Researcher 1: Sometimes we should trust the text, sometimes not... 182) Researcher 2: And then you check the graph. 183) Researcher 1: Instead, 160 gives us a hint. Because the distance is the one between the home and the bus stop. So, this means that he has arrived.	During this part of the discussion, Teacher DV and the researchers activate ***strategy 3***, giving two different ***feedbacks***: - ***about self-regulation***, stressing on the importance of letting other students complete their reasoning before stopping them or judging their interventions (line 175) and highlighting the importance of being aware that the text of the problem, sometimes, could make us draw conclusions that are not the necessary ones (line 178-181); - ***about the processing of the task***, focusing again on the key-information that the graph gives (lines 176-183).

2.2.3 Episode 3: The comparison between students' answers as a way of highlighting and overcoming misunderstandings

Worksheet 4 is projected on the IWB:

Scheda 4

Ogni mattina Tommaso cammina lungo una strada dritta, da casa sua alla fermata dell'autobus, che dista 160m da casa.
Il seguente grafico descrive come ha percorso ieri il tragitto.



Domanda 4: Ha percorso esattamente 160m? Perché?

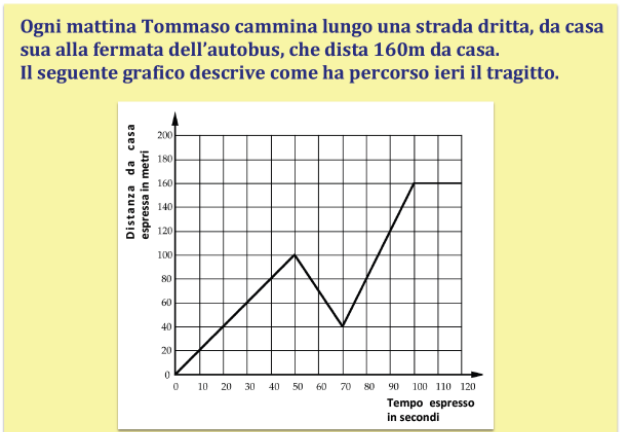
RISPOSTA:

Teacher DV reads again the text of the problem and the question: "*Does he walk for 160m? Why?*"
We emphasize the need to motivate both affirmative and negative responses and the importance of providing answers as complete as possible.

The pairs/groups work for about 40 minutes (delivery time of the last pair).

Some answers are collected (according to the criteria presented in the previous paragraphs) and projected on the IWB, as shown in the following picture:

Scheda 4



Domanda 4: Ha percorso esattamente 160m? Perché?

RISPOSTA:

(A) **Si perché, se guardi il grafico vedi che la linea di 160 m arriva esattamente dove si ferma Tommaso**

(B) **no perché la distanza da casa sua alla fermata è di 160 metri però lui torna anche indietro quindi aggiunge 60 metri al suo percorso. Perciò lui quella mattina percorre 220 metri**

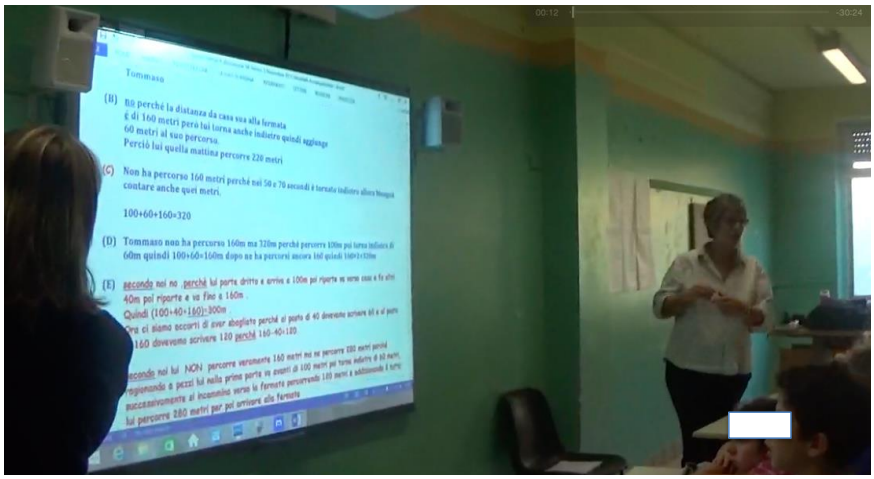
(C) **Non ha percorso 160 metri perché nei 50 e 70 secondi è tornato indietro allora bisogna contare anche quei metri.**

100+60+160=320

(D) **Tommaso non ha percorso 160m ma 320m perché percorre 100m poi torna indietro di 60m quindi 100+60=160m dopo ne ha percorsi ancora 160 quindi 160×2=320m**

(E) secondo noi no ,perchè lui parte dritto e arriva a 100m poi riparte va verso casa e fa altri 40m poi riparte e va fino a 160m . Quindi (100+40+160)=300m . Ora ci siamo accorti di aver sbagliato perché al posto di 40 dovevamo scrivere 60 e al posto di 160 dovevamo scrivere 120 perchè 160-40=120.

(F) secondo noi lui NON percorre veramente 160 metri ma ne percorre 280 metri perché ragionando a pezzi lui nella prima parte va avanti di 100 metri poi torna indietro di 60 metri, successivamente si incammina



Teacher DV reads answer A:

> **(A) Yes, because, if you look at the graph, you see that the line of 160 m arrives exactly where Tommaso stops.**

Teacher DV asks if this answer is correct. The students (even those who have initially proposed this answer) agree that it is not correct because, since Tommaso comes back, he walks more than 160m.

Answer B (written by Lavinia and Rita) is read:

> **(B) No, because the distance between his home to the bus stop is 160 meters. However, he goes back then he also adds 60 meters to his path.**
> **So that morning he walks for 220 meters.**

The class agree that the reasoning subtended to Lavinia and Rita's answer is: "If Tommaso had not come back, he would have walked for 160m. Since he walked back for 60m, we must add 60 to 160".
We ask them what is the underlying mistake (focusing students' attention to processes rather than products). Elisabetta correctly observes that adding 60m is not sufficient because, if you add only 60, you are not considering part of the path that Tommaso walks through when he comes back again toward the bus stop (when, from the distance 40m, he reaches again the distance 100m from home).

Teacher DV reads answer C:

> **(C) He did not walk for 160 meters because, during the period of time between 50 and 70 seconds, he went back, so you have to count even those meters.**
> **100+60+160=320**

Vincenzo and Mirco, the authors of this answer go next to the IWB, and explain their reasoning. They declare that they are convinced of their approach, not realising that, adding 160m, they are adding the distance from home (at 100s) instead of the distance he walked in the period of time from 70s to 100s.
Stefano asks to speak:

Transcript	***Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback***
279) Stefano: First the calculation is 160 meters, however, from 40 to 160, there is 120, so you should do 160 plus 120, which is 280. 280) Carlo: This is the same reasoning we did! 281) Stefano: However, we did it wrong. We've realized it now! 282) Researcher 1: Ah? Have you realised it now? 283) Stefano: Yes! 284) Researcher 1: What did you write? 285) Sabrina (*in pair with Stefano*): D was our answer! (*pointing at the IWB*)	In this excerpt it is evident that Stefano is activated as owner of his own learning (***strategy 5***). The student, in fact, highlights the mistake in Vincenzo and Mirco's answer, showing to be aware that it was the same mistake he did himself. Another interesting aspect is that Stefano has recognised his mistake (line 281) thanks to the discussion developed within the class. This testifies that the teacher and the researchers were effective in engineering an effective classroom discussion that elicited evidence of student understanding (***strategy 2***) and provided students with important feedback (***strategy 3***).

We read answer D (by Stefano and Sabrina):

(D) Tommaso did not walk for 160m, but for 320m, because he travels 100m, then he goes back for 60m. So 100+60=160m. Later, he walks for other 160, so 160×2=320m.

Teacher DV asks to Vincenzo and Mirco if they understood Stefano's explanation. Since Vincenzo declares that he did not understand, we ask Stefano and Sabrina to come next to the IWB to highlight again the mistake they did and to explain why they changed their mind thanks to the discussion.

Transcript	***Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback***
297) Researcher 1: They (*Stefano and Sabrina*) said they understood their mistake, and therefore they are going to tell us which mistake they made. 298) Stefano: It is because we did 160 plus 160, which is 320. But it is wrong because... 299) Researcher 1: So you have given the same answer they give. Haven't you? (*pointing at Vincenzo and Mirco*) 300) Stefano: Yes, because we wrote 320. But... he walks, at the beginning, for 160 meters... 301) Researcher 1: Wait. I'll show you the graph (*she projects the graph on the IWB*). 302) Stefano: Initially, he walks for 160 meters (*with the finger he quickly traces, the*	Two main FA strategies are activated: - ***strategy 5***, because Stefano clearly explain the mistake they did, highlighting that their approach is the same that Mirco and Vincenzo proposed; **- *strategy 4***, because Stefano's explanation is used by the teacher to provide a ***feedback about the processing of the task*** for his classmates.

segment from the point (50,100) to the point (70,40), then the segment from the point (70,40) to the point (100,160)). However, from 40 to 160, there is 120, then 160 plus ... *Teacher DV asks Stefano to explain, referring to the graph, how he determined the terms to be added to obtain the correct result. When Stefano stresses again that the last term to be added is 120m (instead of 160m, as Vincenzo and Mirco said), Teacher DV asks to Stefano and Sabrina to explain this reasoning to Vincenzo and Mirco:*	
332) Teacher DV: Why? How do you know this? Explain it to Vincenzo! What calculation have you done? 333) Sabrina: Because, from 100 (*indicating 100 on the vertical axis*), he walked for 60 meters (*with her finger, she traces, on the vertical axis, the segment from 100 to 40*) and arrived at... (*she indicates 40 on the vertical axis and then she traces, with her finger, the segment between (0,40) and (70,40)*). 334) Teacher DV: Where does he arrive...? You see it on the graph. 335) Sabrina (*pointing at 40, on the vertical axis*): At 40 metres. 336) Teacher DV: From 40 to… (*Sabrina indicates the point (70,40)*) 337) Sabrina and Stefano: To 160 (*Sabrina indicates 160 on the vertical axis*). 338) Teacher DV: So, how many meters has he walked through? What calculation do you have to do? 339) Stefano: It is 120 metres. 340) Sabrina: It is 160 minus 40. 341) Teacher DV: That is 120. Ok? 342) Stefano: So, then you have to do… 343) Teacher DV: During the last 20 secondi, then, what does he do? *Sabrina indicates the segment between the point (100,160) and the point (120, 160).* 344) Vincenzo: He stops! 345) Stefano: He stops! 346) Teacher DV: He stops. …so …the sum is…? 347) Stefano: 160 plus 120 … that is 280. … so we got wrong, but now we have understood.	Also in this phase of the discussion, Sabrina and Stefano are activated as instructional resources for the other students (***strategy 4***). After having explained, together with Sabrina, the correct reasoning, Stefano, again, shows to have recognised his mistake (line 347), becoming owner of his own learning (***strategy 5***).

We explain to all students that Marianna, Valeria and Rodolfo sent their answers, then re-thought about what they did and changed their mind, correcting their answers. So we read answer E (by Marianna, Valeria and Rodolfo):

(E) We think not, because he starts walking straight and arrives at 100m, then he again goes home and walks for other 40m, then starts again and goes till 160m.
So (100+40+160)=300m

Now we have realized it was wrong because, instead of 40, we had to write 60 and, instead of 160, we had to write 120 because 160-40=120.

We ask to Marianna, Valeria and Rodolfo to explain the different phases of their resolution and, in particular, why they initially wrote 40m and 160m and they substituted 40m with 60m and 160m with 120m.

Transcript	***Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback***
362) Marianna: Because the first piece (*with her finger, she traces the segment between the point (0,0) and the point (50,100)*) is till 100 (*indicating the point (50,100)*), then he goes back (*with her finger, she traces the segment between the point (50,100) and the point (70,40)*) and reaches 40 (*with her finger, she points the segment between (70,40) and (0,40)*). And then he starts again (*she moves her finger on the segment between the point (70,40) and the point (100,160)*) and gets to 160 (*with her finger, she traces the segment from the point (100,160) to the point (0,160)*). We did like this... 363) Researcher 1: Is it why you wrote those three numbers over there? (*She is referring to 100, 60 and 160*) 364) Marianna: Yes. 365) Researcher 1: 100, I read it here (*she traces, with her finger, the segment from (50,100) to (0,100)*); 40, I read it here (*she traces, with her finger, the segment from (70,40) to (0,40)*) and 160, I read it here (*she traces, with her finger, the segment from (100,160) to (0,160)*). 366) Researcher 1: Why did you later change your mind? 367) Marianna: Because Tommaso reaches 100, but he then goes back to 40 and 100 minus 40 is 60. Then he starts again and arrives at 160. 160 minus 40 is 120. 368) Researcher 1: This is why, at the beginning, instead of writing the distance Tommaso walked through, … what did you write? 369) Researcher 1: What is 40? (*pointing at 40 on*	This is another interesting example of how the discussion on students' answers enables, on one side, the activation of ***strategy 4*** and, on the other side, to give fundamental ***feedback about the processing of the task***. Marianna, in fact, is able to make the initial mistake they did explicit (lines 362-371) and to describe how the reasoning they developed to correct their answers (lines 367).

the vertical axis) 370) Teacher DV: The distance… 371) Marianna: The distance from home. 372) Researcher 1: Instead of the distance Tommaso walked through, you wrote the distance from home. 373) Researcher 1: Even here (*she first indicates the point (100,160), then she traces, with her finger, the segment from (100,160) to (0,160)*), what 160 represents? 374) Marianna: It is the distance from home.	

We read the last to answers (F and G), with the aim of making them identify which is the most clear and complete.

Answer F:

> **(F) We think he does NOT actually walked for 160 meters, but for 280 meters because, splitting the reasoning, in the first part, he goes to 100 meters, and then he goes back of 60 meters. Later, he walks for 120 meters to the bus stop and, adding everything, he walks for 280 meters to get to the bus stop.**

Answer G:

> **(G) No, because, from his home he walks for 100m in 50s. But, he goes back for 60 m and, therefore, he has already walked for 160m. Then, he walks for other 120m. The calculation is this: (160 + 120) = 280**

Some students declare that answer F is more complete than answer G. Other students say that answer G better explain the calculation that was performed. We ask them how we can integrate these two answers with the aim of making them more complete. We conclude that both these answers do not explain how 60m and 120m were determined, stressing that giving a "mathematical justification" means to explain, in detail, the reasoning process and how all the data were determined.

2.2.4 Episode 4: Focus on the helping worksheet 4A

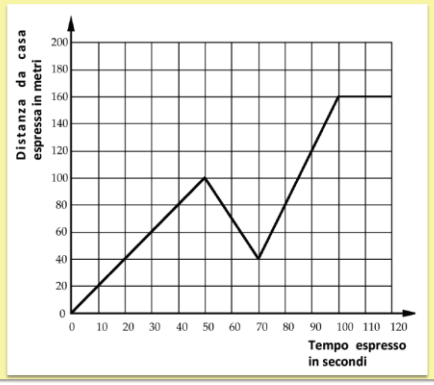
We project worksheet 4A, in particular Anna and Claudia's worksheet:

Scheda 4A - AIUTO

Domanda 4: Ha percorso esattamente 160m? Perché?

AIUTO per rispondere alla domanda 4: Analizza

Ogni mattina Tommaso cammina lungo una strada dritta, da casa sua alla fermata dell'autobus, che dista 160m da casa.
Il seguente grafico descrive come ha percorso ieri il tragitto.



i vari tratti del grafico e rispondi alle seguenti domande:

Che distanza ha percorso Tommaso durante i primi 50s?	**Risposta: 100m**
Che distanza ha percorso Tommaso nel periodo tra 50s e 70s?	**Risposta: 60m**
Che distanza ha percorso Tommaso nel periodo da 70s a 100s?	**Risposta: 160m**
Che distanza ha percorso Tommaso durante gli ultimi 20s?	**Risposta: 0m**

RISPOSTA: no, Tommaso non ha percorso esattamente 160m perché intorno a 70s è tornato indietro di 40m e poi è andato alla fermata e ci ha impiegato 30s e poi ha camminato per 160m.
A questo punto addizionando 160m con 40m abbiamo scoperto che fa 200m che è + di 160m e quindi ha fatto più passi del dovuto.

Anna and Claudia answer on the worksheet:
No, Tommaso did not walk for exactly 160m, because, at about 70s, he went back of 40m, then he went to the bus stop and it took him 30s, then he walked for 160m. So, if you add 160m and 40m, you find 200m, which is more than 160m, so he walked more (*than 160m*).

The main functionality of the technology that is used is, again, ***sending and displaying***.

We tell students that the worksheet projected at the IWB is the one on which a pair of student answered. We also explain that the help was the suggestion of answering to some intermediate questions, before answering to question 4. We ask the pupils if, according to them, these intermediate questions could help or not.
We are, therefore, clarifying the *learning intentions* (***strategy 1***).

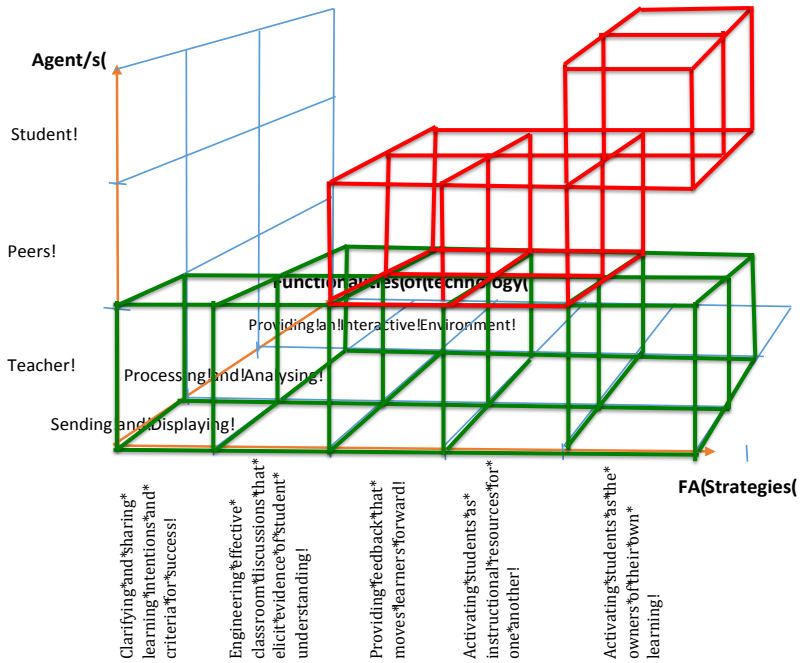
Carlo asks to approach the IWB to explain why he considers this helping worksheet effective.

Transcript	***Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback***
453) Carlo: Maybe someone...could say that (*Tommaso*) walks for 160m (*with his finger, he traces the segment from the point (0,160) to (100,160)*) ... but, for example, through the first question – "What is the distance that Tommaso has walked through during the first 50s?" - it makes you split the reasoning (*with two fingers he points at the segment (0,0)-(50,100), then at the segment (50,100)-(70,40), then at the segment (70,40)-(100,160)*) and then you calculate... 454) Teacher DV: The sum. 455) Carlo: The sum. 456) Researcher 1: He says: these questions enables you to split your reasoning. 457) Carlo: Yes. 458) Researcher 1: Do those who raised their hands before want to add something? 459) Elisabetta: In my opinion, that is ... in the helping questions, since they are subdivided, piece by piece, you work out and then you finish. So you can say no...	The discussion is led at a metacognitive level: the focus is on the reasons why the questions posed on worksheet 4A could help in answering questions 4. Since ***feedback about self-regulation*** are given, ***strategy 3*** is activated. Carlo (line 451) and Elisabetta (line 457) are activated as instructional resources for their classmates (***strategy 4***), because they highlight the role played by the questions, posed within worksheet 4A, in enabling to develop a "step-by-step reasoning".

The discussion goes on, analysing Anna and Claudia's answer.

We want to stress that episodes 3 and 4 are examples of the use of the ***sending and displaying functionality of the technology*** as a way to effectively activate ***strategy 2***, since receiving students' answers, identifying a list of these answers and projecting them on the IWB foster the development of a discussion during which the students' ways of reasoning are analysed and compared.

The following diagram summarises all the FA strategies activated during lesson 2, by the three agents, thanks to the support given by the sending and displaying and by the processing and analysing functionalities of the technology. Thanks to this sort of "picture" of the lesson, it is possible to highlight the complexities that characterise the processes developed during this kind of lessons.


Agent/s(
Student!
Peers!
Teacher!
Providing!an!Interactive!Environment!
Processing!and!Analysing!
Sending!and!Displaying!
FA(Strategies(
Clarifying*and*sharing*learning*intentions*and*criteria*for*success!
Engineering*effective*classroom*discussions*that*elicit*evidence*of*student*understanding!
Providing*feedback*that*moves*learners*forward!
Activating*students*as*instructional*resources*for*one*another!
Activating*students*as*the*owners*of*their*own*learning!

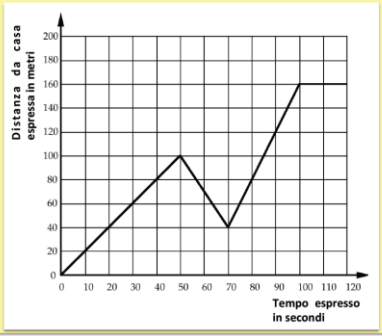
2.3 Lesson 3

Length of lessons, date & time	9th November 2015, 2 hours (14.15-16.15)
Year group & class size	5A (grade 5) – 27 students
Objectives & lesson theme	1) Consolidating students' competences in the interpretation of a time-distance graph. 2 Guiding the students in the interpretation of a time-distance graph: - interpretation of the slope of the graph as an indication of the speed. 3) Consolidating students' competences about the "completeness of a justification" and about "mathematical justification".
Tasks used	Worksheets 5 – 6
Resources used	• IDM-TClass software • Tablet for pairs and groups of students • PC for the teacher and the researchers • IWB

Lesson 3 is focused on the worksheets 5 and 6. These worksheets are presented and analysed in paragraph 4.2.1 - Common part.
At the beginning of lesson 3, the worksheet 5 is projected on the IWB.
As it was planned, the pupils answered to this question on paper worksheets, during the preceding lesson.
In this part of the activity the digital technology is not used. The only functionality that is partially exploited is ***sending and displaying***, since the graph is projected on the IWB to enable the students to refer to it when they comment on their work or on the work of their classmates.

Scheda 5

Ogni mattina Tommaso cammina lungo una strada dritta, da casa sua alla fermata dell'autobus, che dista 160m da casa.
Il seguente grafico descrive come ha percorso ieri il tragitto.



Ora che abbiamo risposto alle domande, descrivi come Tommaso ha percorso il tragitto da casa sua alla fermata dell'autobus. Cosa potrebbe essergli successo?

RISPOSTA:

After having asked pupils to explain what was the task in worksheet 5, we ask them to read the stories they invented. Many pupils raise their hands.

2.3.1 Episode 1: Effective activation of strategies 4 and 5 in the discussion on the coherence between the invented stories and the graph

Carlotta reads the story created with Emilia:

RISPOSTA: a Tommaso gli potrebbe essere caduta la merenda perché aveva lasciato la tasca aperta allora continuò per la sua strada poi dopo un po' si accorse che aveva la tasca della merenda aperta allora intuì che più indietro aveva perso la merenda allora tornò indietro recuperò la merenda, chiuse le tasche e si avviò verso la fermata dell'autobus, arrivato alla fermata Tommaso si sedette su una panchina e per aspettare l'autobus chiacchierò con gli amici	Maybe Tommaso lost his snack because he left his pocket open, hence he continued his own way, then after a while he realized that he had his pocket open then he guessed that he had lost his snack further back, then he went back, got back his snack, closed his pocket and restarted towards the bus stop; arrived at the bus stop, Tommaso sat down on a bench to wait for the bus, chatting with his friends.

Transcript	***Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback***
11) Researcher 1: Before telling other stories, tell me if this story can be ok.	Researcher 1's intervention (line 11) is aimed at activating students as

12) Chorus: Yes. 13) Valeria: Yes, but at the beginning she didn't say that…she's soon jumped at the piece (*of the graph*) in which he (*Tommaso*) came back. *Voices*. 14) Researcher 1: So what did she have to add? 15) Valeria: That he walked from home… 16) Researcher 1: That he went out from home, maybe? That he has walked? *Valeria nodds*. 17) Researcher 1: And the accident that happened to Tommaso? Did he loose his snack, come back, take it, close his pocket… (*miming the scene with gestures*)? 18) Vincenzo: Eh, no! 19) Sabrina: Because… 20) Researcher 1: Let's listen to Sabrina. 21) Sabrina: Because, if not, there would be a line… (*gestures with her finger an horizontal segment*) horizontal. 22) Researcher 1: Where would it be? Come and show us. *Sabrina come to the IWB*.	instructional resources for one another (***strategy 5***). She tries, in particular, to make students focus on the coherence between the graph and part of the story created by Carlotta and Emilia (line 17). This leads Sabrina to activate herself as an *instructional resource for her classmates*. She, in fact, gives a ***feedback about the processing of the task***, highlighting that the story implies that Tommaso stops for a while, therefore an horizontal segment should be drawn in the graph.
23) Sabrina: It would be like this, here…(*tracing an horizontal segment with her finger, from the point (50,100) to the point (70,100)*). 24) Chorus: No!!! 25) Researcher 1: Where would it be? Would it be here? …(*tracing an horizonal segment with her finger, from the point (50,100) to the point (70,100)*). *Some students answer "yes"*. 26) Chorus: No, no! Below!!! 27) Researcher 1: They say below…but below where? *Livio raises his hand*. 28) Researcher 1: Livio? *Livio comes at the IWB*. 29) Livio: Here… (*tracing an horizontal segment with his finger, from the point (70,40) to the point (90,40)*). 30) Researcher 1: Why do you say that it should be there? 31) Livio: Because here (*indicating the point (70, 40)*) he took up his snack, then he closed his pocket …(*tracing an horizonal segment with his finger, from the point (70,40) to the point (90,40)*) and then (*tracing a vertical segment with his finger, from the point (100,40) to the point (100,160)*). *Anna suggests that, maybe, Tommaso closes his*	This excerpt highlights that ***strategies 4*** and ***5*** are effectively activated: - the students activate themselves as owners of their own learning, since they react to Sabrina's proposal (line 26 and following), identifying her mistake; - Livio, in particular, gives a feedback on Sabrina's suggestion (lines 29-31), correctly describing the graph that should be drawn in order to represent the story proposed by Carlotta and Emilia.

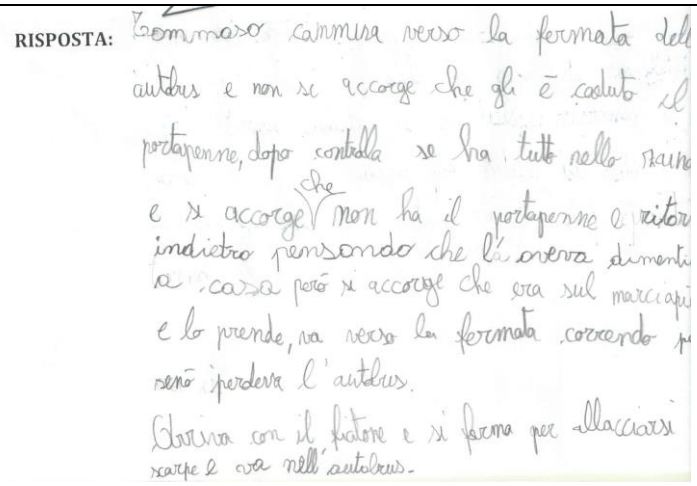
bag while he is walking. *Vincenzo asks Carlotta to read their story again because he thinks that Tommaso could not have come back. Teacher DV asks him to come next to the IWB and explain.*	
Vincenzo comes at the IWB. 44) Vincenzo: From home (*he indicates the point (0,0)*), until 100 (*he indicates the point (50,100)*), then he realizes that he lost his snack…before (*he indicates a point about at the half of the segment (0,0)-(50,100)*), while he was walking… 45) Some pupils: No! 46) Vincenzo: And so he comes back (*he moves his finger backwards on the first part of the graph, from the point (50,100) to halfway*)…and there should be a double line (*he moves again his finger backwards on the first part of the graph, from the point (50,100) to halfway*), instead he comes back (*he moves his finger on the segment from the point (50,100) to the point (70,40)*), but in another sense. 47) Chorus (*loudly*): No!!! No!!!! No!!!! (*many children raise their hands*) 48) Researcher 1: Wait! One by one… Luca? 49) Luca: No, because… 50) Researcher 1: Would you like to come at the IWB? *Luca comes next to the IWB*. 51) Luca: Let's imagine that in the house there is a sensor. When we did the experiment (*with the sensor*), we see that, when he comes back (*indicating the point (50, 100)*)…this is the line of the sensor (*indicating the horizontal axis*)…it goes closer (*tracing with his finger the segment from the point (50,100) to the point (40,70)*). What Vincenzo says is not right because, with the experience, instead of coming back to the sensor (*he traces again with his finger the segment from the point (50,100) to the point (40,70)*), he should do continuously this (*he moves his finger, in both directions, along the segment (0,0)-(50,100)*). 52) Researcher 1: Let's listen to what the others say. *Several pupils raise their hands. Anna comes next to the IWB and observes that the part of the graph that indicates that Tommaso is coming back to home is the segment (50,100)-(40,70).*	This excerpt testifies that the discussion planned by the researchers and the teacher was effective in *eliciting evidence of students' understanding* (***strategy 2***), since the comparison with his classmates enables Vincenzo to make his doubt explicit, taking the responsibility of his own learning (***strategy 5***). Vincenzo's interventions (lines 44-46) show a typical students' misconception: the graph is seen as a sort of map, where the origin of the axis represents Tommaso's home. The students (line 47) activate again themselves as instructional resources for one another (***strategy 4***). Luca, in particular, recalls the experience with the motion sensor, explaining why Vincenzo's statement is not correct (***feedback about the processing of the task***).
Arturo raises his hand. 56) Arturo: It could not be like that (*he moves his finger along the first segment of the graph,*	In this excerpt, also Arturo activates himself as an instructional resource for the class (***strategy 4***),

from (50, 100) to (0,0)), because it should come back with… 57) Teacher DV: Come and show it. *Arturo comes next to the IWB*. 58) Researcher 1: He is saying: "it cannot be as Vincenzo has said, because…" and now he is going to show us 59) Arturo: These here are the seconds (pointing the horizontal axis), he cannot come back that (*he moves his finger along the first segment of the graph, from (50, 100) to (0,0)*), because, if these are the seconds (*he is indicating the horizontal axis, moving his finger from (0,0) rightwards*), he should go back in time…it's impossible. 60) Teacher DV: He goes back in time. 61) Researcher 1 (*to the whole class*): What do you think about it? 62) Chorus: Yes. 63) Arturo: Instead, here, he (*Tommaso*) comes back because it goes down (*indicating the segment from (50,100) to (70,40) and moving his finger along it*), and so it is like that 64) Teacher DV: Is it right, Vincenzo? 65) Vincenzo: Yes.	highlighting that moving from the right to the left on the graph means "going back in time", which is not possible. This represents an important ***feedback about the processing of the task*** for the whole class.

We ask students if it is right to say, as Vincenzo said, that the graph is the road that Tommaso is walking through. During this discussion, we make them observe that the graph represents a relation between the distance from home and the time.

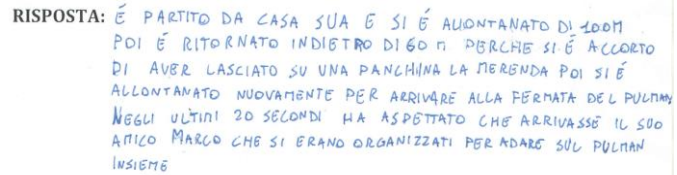
We ask if other pairs/groups made the same mistake that Carlotta and Emilia made. This request aims at making the students ***owners of their own learning*** (***strategy 5***), showing if the discussion about Carlotta and Emilia's story enabled them to rethink about what they have done.
Different pairs intervene, reading their stories and correctly identifying their mistakes in the construction of the same stories. In the following we present a meaningful example.

Noé reads the story he wrote with Andromeda:

	Tommaso walks toward the bus stop and he does not realise that his pencil case has felt down. Then he checks if everything is in his backpack and he realises that his pencil case is not inside the backpack. So he goes back, thinking that he has left he pencil case at home, but he finds it on the pavement. He takes it, he runs toward the bus stop, otherwise he can loose the bus. He arrives at the bus stop, stops to tie his shoes and gets on the bus.

Transcript	***Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback***
99) Noé: Our mistake was that, when he (*Tommaso*) checks in his backpack, … he cannot check while he is walking. 100) Researcher 1: So how would change this graph if he (*Tommaso*) really stopped before to check…? - Come at the IWB to show it (*to Noé*) - …if he really stopped before to check inside his backpack? *Noé goes next to the IWB*. 101) Noé: He walks for 100m (*he moves his finger along the segment from the point (0,0) to the point (50,100), where he stops*), but the line (*with his finger, he traces a horizontal segment passing through the point (50,100)*) is not going down (*he moves his finger along the segment from the point (50,100) to the point (70,40)*) …it goes straight (*with his finger, he traces an horizontal segment passing through the point (50,100)*), because he stops. 102) Researcher 1: If Tommaso has to check, there would be a moment during which he stops (*with her finger, she traces the same horizontal segment, passing through the point (50,100), that Noé traced before*), so, here, we would see a small horizontal piece (*of the graph*) (*she traces again the same horizontal segment, passing through the point (50,100)*).	This excerpt highlights how the students (in this case, Noé) take the responsibility of their own learning (***strategy 5***), correctly identifying the mistake they have done in the creation of a story in tune with the graph. Noé's interventions (lines 99-101) testify that Sabrina and Livio's observations (lines 21-31) were effective feedback for him. This, again, testifies a real activation of ***strategies 2***, ***3*** and ***4***.

Also Livio is able to recognize the mistake he did, together with Giacomo, in writing their story:

 RISPOSTA: É PARTITO DA CASA SUA E SI É ALLONTANATO DI 100M POI É RITORNATO INDIETRO DI 60 m PERCHE SI É ACCORTO DI AVER LASCIATO SU UNA PANCHINA LA MERENDA POI SI É ALLONTANATO NUOVAMENTE PER ARRIVARE ALLA FERMATA DEL PULMAN NEGLI ULTIMI 20 SECONDI HA ASPETTATO CHE ARRIVASSE IL SUO AMICO MARCO CHE SI ERANO ORGANIZZATI PER ANDARE SUL PULMAN INSIEME	He (Tommaso) left his home and went away for 100m. Then he went back for 60m because he had realised to have left his snack on a bench. Then he went away again to go to the bus stop. During the last 20 seconds, he waited for his friend Marco, because they had planned to get on the bus together.

117) Livio: So … in my opinion, we did a mistake. Here we wrote "he had realised to have left his snack on a bench". If he left his snack on a bench, it means that he had to stop for a while.

Livio's observation highlights again how this discussion fosters the activation of ***strategy 5***: Livio shows to have taken the responsibility of his own learning, becoming aware of the implications, within the story, of their choice of speaking about a "snack left on a bench".
Luca observes that, in all the stories that have been read till now, Tommaso stops on the pavement to wait for the bus. Luca says that, when the bus arrives, Tommaso will have to move to get on the bus, so the graph should be different.
Discussing with students, we stress that it is possible to think that Tommaso, after having reached the bus stop, already finds the bus and gets on it. In that case, if the bus stops for a while before leaving, the graph would be coherent with this story.
We also discuss if we can be sure that, after 120s, the bus arrives.

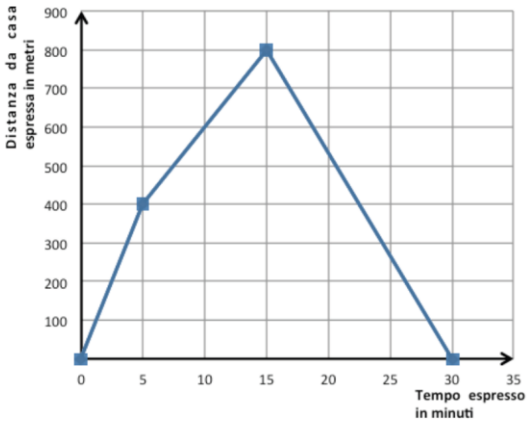
During the remaining part of the discussion about worksheet 5, other stories are read. Some students recognize the mistakes within their stories or within the stories written by others and are able to make them explicit. They are also able to propose changes in the stories aimed at making them more coherent with the graph.

2.3.2 Episode 2: The interpretation of the graph to identify the correct story to be associated to it

Worksheet 6 is projected on the IWB. In this episode the functionality of the technology that is used is ***sending and displaying***, since students' answers are collected and projected on the IWB, to foster the sharing and the comparison.

Scheda 6

Qual è la storia rappresentata da questo grafico? Motiva la tua risposta.



Storia A: Tommaso esce da casa per fare una passeggiata con il suo cane. All'inizio cammina lentamente, poi più rapidamente. Arrivato al parco, decide di tornare indietro.

Storia B: Tommaso esce da casa con la sua bicicletta, percorrendo una strada che sale sopra una collina. All'inizio la strada e molto ripida, poi un po' meno. Arrivato in cima alla collina, scende giù dall'altra parte.

Storia C: Tommaso esce per fare una corsa. Alla fine della sua strada incontra un suo amico e rallenta per camminare un po' con lui. Dopo averlo salutato, torna a casa.

RISPOSTA:

Before making the students work in pairs/groups, we read the story together and ask them to compare this new graph to the one that we analysed thanks to the previous worksheets. We make them notice that, on the vertical axis, the distance is expressed in metres. The pupils notice that, on the horizontal axis, the distance is expressed in minutes.
We say them that the request ("*What is the story that this graph represents? Justify you answer*") is to match the correct story to this graph, motivating their answers. With the aim of activating ***strategy 1***, we, again, clarify the meaning of "*Justify your answer*": the justification should be correct, clear for those who are going to read it, and also complete from a mathematical point of view (it should be understood how, starting from the graph, the correct matching was identified).

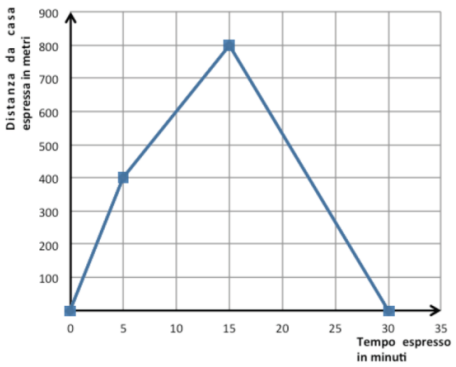
We read the three stories and tell the students to think about the possible matching and to justify their answers. We also remind them that, if they face some difficulties, they can ask for the "helping worksheets".

Students work in pairs/groups for about 40 minutes.

While students are working and sending us their answers, we collect some of their answers and prepare the following file, to be projected during the discussion:

Scheda 6

Qual è la storia rappresentata da questo grafico? Motiva la tua risposta.



Storia A: Tommaso esce da casa per fare una passeggiata con il suo cane. All'inizio cammina lentamente, poi più rapidamente. Arrivato al parco, decide di tornare indietro.

Storia B: Tommaso esce da casa con la sua bicicletta, percorrendo una strada che sale sopra una collina. All'inizio la strada è molto ripida, poi un po' meno. Arrivato in cima alla collina, scende giù dall'altra parte.

Storia C: Tommaso esce per fare una corsa. Alla fine della sua strada incontra un suo amico e rallenta per camminare un po' con lui. Dopo averlo salutato, torna a casa.

RISPOSTA:

- **Secondo noi la B non è giusta perché un sensore non può misurare anche l'altezza.**
  La C non è corretta perché il grafico dice che Tommaso prima cammina lentamente e poi va più rapidamente invece la storia di cui stiamo parlando dice tutto il contrario.
  La storia A racconta una cosa molto probabilmente possibile.

- **Secondo noi è la A perché nel grafico l'ultima parte va verso il basso, quindi Tommaso torna indietro al parco invece le altre ritornano a casa .**

- **Secondo noi è la c perché all'inizio corre poi incontra il suo amico e allora rallenta.**
  Infatti nel grafico si vede che in 5 minuti fa 400 metri poi rallenta e percorre altri 400 metri ma in 10 minuti perché cammina poi ritorna indietro di 800 metri in 15 minuti correndo

- **La storia lettera C l'abbiamo scelta perché Tommaso è andato velocemente i primi 5 minuti quando ha percorso 400 metri, dopo, va più lentamente perché ha percorso in 10 minuti gli stessi metri di prima, cioè 400 metri.**
  Poi Tommaso dopo 15 minuti è tornato indietro verso casa, dopo aver salutato il suo amico.

We read the first answer:

> **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.**

This answer was given by Carlo and Elsa, who immediately declare that they realised to have done a mistake. Carlo says that, however, he thinks that the

justification they gave to discard the story B is right. We make them notice that it is possible to think to use the sensor also to study how Tommaso walks on a hill. The focus on the story B foster the development of a discussion on the reasons why this story could not be accepted, enabling the activation of ***strategy 2***, as the following excerpt testifies.

Transcript	***Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback***
Sabrina raises her hand. 347) Sabrina: (*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 1: So you are saying: "The story B…the graph resembles a hill…it is like this to lead me to make a mistake".	Sabrina correctly highlights that the reference to the hill, in story B, could make the student think that the graph represent the same hill that Tommaso is climbing. This represents a ***feedback about self-regulation*** because, highlighting possible misconceptions that should be avoided, it could guide students' monitoring of their work.
349) Researcher 1: There is also another reason why (*the story*) B is not right… Let's look at the graph for a while. Let's see if you can find it (*the other reason*) looking at the graph. Why B is not right? *Many pupils raise their hands.* 350) Researcher 1: A lot of hand have been risen. Who can start (*speaking*)? Giacomo… 351) Giacomo: The story C: " La C: "Tommaso went … When Tommaso left his friend, he walked back home". And you cannot find it over there (*he is referring to story B*)… *Voices*. 352) Researcher 1: Wait (*speaking to the other students*). Maybe I understood what Giacomo wants to say. He says: here we can read "he walked home" (*she indicates this sentence in the story C*). Here you can read "he goes back" (*she indicates the sentence in the story A*). Here (*she indicates the 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 1: Why do you say that it is not correct that here we cannot find the sentence "he goes back home"? (*to Giacomo*) 354) Giacomo: Because, over there, we can find that (*the line*), then, goes down (*he indicates the graph on the IWB*). 355) Researcher 1: You say: here, the graph is going down (*she moves her finger*	Researcher 1 (line 349) aims at making students focus on a fundamental part of the story B, which assures that this story could not be associated to the graph. This excerpt is another example of an effective activation of ***strategies 4*** and ***5***. Giacomo, in particular, activates himself as the ***owner of his own learning***. The following interventions by researcher 1 (line 352-353-355-356) aim at making Giacomo's ideas more explicit, enabling him to become an ***instructional resource*** for the other students.

along the last part of the graph, that is the segment 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 1: What is Tommaso doing? 357) Giacomo: He is going back… 358) Teacher DV: Good!	
359) Researcher 1: Let's listen to other observations. 360) Teacher DV: Did you listen to what Giacomo said? …I don't know. Someone, in my opinion, lost himself. 361) Carlo: Can I explain it? 362) Researcher 1: Carlo is going to explain what Giacomo said. 363) Carlo (*speaking with his classmates*): Because Giacomo said that, in the answers (*he means the stories*) 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 DV: Instead of "It doesn't' specify"… 365) Researcher 1: Doesn't B only specify it? It tells something that contradicts… *Livio, Adriana, Ambra raise their hands.* *We let Ambra speak.* 366) Ambra: It tells that …that it goes down to the other side. It seems a hill (*she is referring to the graph*), so it goes down to the other side. But … 367) Noé: It is a graph, not a hill! 368) Researcher 1: Noé says: "it is a graph, not a hill". 369) Noé: Because… 370) Researcher 1: 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". Eh, yes! …and then, in C, it's written "he comes back home". 374) Researcher 1: He (*indicating Arturo*) says: "he wouldn't be at home".	Teacher DV's intervention (line 360) aims at highlighting if the other students have understood Giacomo's idea and at fostering a real sharing of Giacomo's idea. Carlo asks to explain his classmate's observation (line 361), activating himself as ***an instructional resource for the other students*** (***strategy 4***). This enables the rest of the class to take the responsibility of their own learning (***strategy 5***), as Ambra (line 366), Noé (lines 367), Arturo's (line 372) and Valeria's (line 373) interventions testify.

Several pupils intervene, noticing again that the graph was constructed to make students think that it represents a hill.
We ask them how the last part of the graph would be, if the story to be matched with it was B. Together with the pupils, we observe that the last part of the graph should be an ascending line and we remind that the "moving away from home" is represented through an ascending line within the graph.

Later, after having summarised the reasons why the story B could not be matched with the graph, we shift the attention on the other two stories and ask to the pupils what is the correct one.
Some pupils say "story A". Many pupils say "It is C!".

Noé is one of the pupils that answered "A". We ask him to go next to the IWB to explain why, in his opinion, the story A should be matched with the graph.
Noé says that, thanks to the previous discussion, although he chose "A", now he is hesitant: he doesn't know if he has to choose A or C. He also observes that he initially chose A because the first part of the graph tells that Tommaso is walking slower, then more rapidly. What he mainly convinced him to choose story A is the fact that the final part of the graph means that Tommaso is going back.

Transcript	***Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback***
468) Noé: Now I have noticed that, the last part … at the park, Tommaso decides to go back home" (*he indicates the story A*). …Also here (*indicating C*): "When Tommaso left his friend, he walked back home". 469) Researcher 1: And what justification did you (*Noé and Andromeda*) write? (*She looks through the file projected one the IWB, until she finds and projects Noé and Andromeda's answer*)	Thanks to the previous discussion, Noé has become aware that the motivation proposed in his answer is not correct, because he did not realise that both the story A and the story C say that Tommaso, at the end, goes back. He, therefore, has become ***owner of his own learning***.

Researcher 1 reads Noé ed Andromeda's answer:

> **In our opinion, A is the correct answer because, in the graph, the last part goes down, so Tommaso goes back to the park, while in the other (stories) he goes home.**

During the discussion, we observe that Andromeda and Noé, while they were answering to this question, did not realise that both the story A and the story C tell that Tommaso goes back home. We ask Noé to read the two stories again to highlight what are the main differences between them. Noé notice that, while, in the story C, Tommaso is initially moving fast, then slower, in the story A it is the contrary.
We ask to the other pupils if they want to intervene.
Carlo, Livio, Giacomo, Valeria, Sabrina, Anna, Adriana, Ambra e Mirco raise their hand.

Transcript	***Analysis according to the FaSMEd***

	three-dimensional framework and the four levels of feedback
We let Adriana start speaking. 488) Adriana: In my opinion, C is right because… 489) Researcher 1: Come and show it. *Adriana goes next to the IWB*. 490) Adriana: In my opinion, he (*Tommaso*) initially goes faster (*she indicates the segment from the point (0,0) to the point (5,400)*), then he goes slower (*she indicates the segment from the point (5,400) to the point (15,800)*), because here it takes him 5 minutes (*indicating 5 on the horizontal axis*) to walk for 400m (*indicating 400 on the vertical axis*). Then it takes him 10 minutes (*indicating the segment from the point (5,0) to the point (15,0)*) to walk, again, for 400m. So he initially goes faster, then he slows down because he meets his friend. 491) Researcher 1: Have you understood what she said? (*to Noé*) 492) Noé: Yes. 493) Researcher 1: Do you agree with her? (*to Noé*) 494) Noé: Yes. 495) Researcher 1: So, what is the period of time in which Tommaso walk faster? (*to Noé*) 496) Noé: The period from 0 to 5 minutes. 497) Researcher 1: From 0 to 5 minutes.	This excerpt testifies how the reflections developed during the discussion enable the students, the teacher and the researchers to provide important *feedback to one another* (***strategy 3***). Adriana (line 490) activates herself as an ***instructional resource for her classmates***, in particular for Noé, who shows to have understood her interpretation of the role played by the slope of the graph, correctly identifying the period of time in which Tommaso is quicker (line 496).

Valeria says that she is still not sure about the story C because, if Tommaso really went home, the graph would end "in the zero" (she is referring to the origin of the axis).
Other pupils remind Valeria what Arturo previously (line 59) observed. We stress that the graph does not represent the map of the city where Tommaso lives and that each point of the graph gives us information: about the distance from home and about the time.

Giacomo asks to comment on the answer he wrote with Livio.

Researcher 1 projects Livio and Giacomo's answer on the IWB:

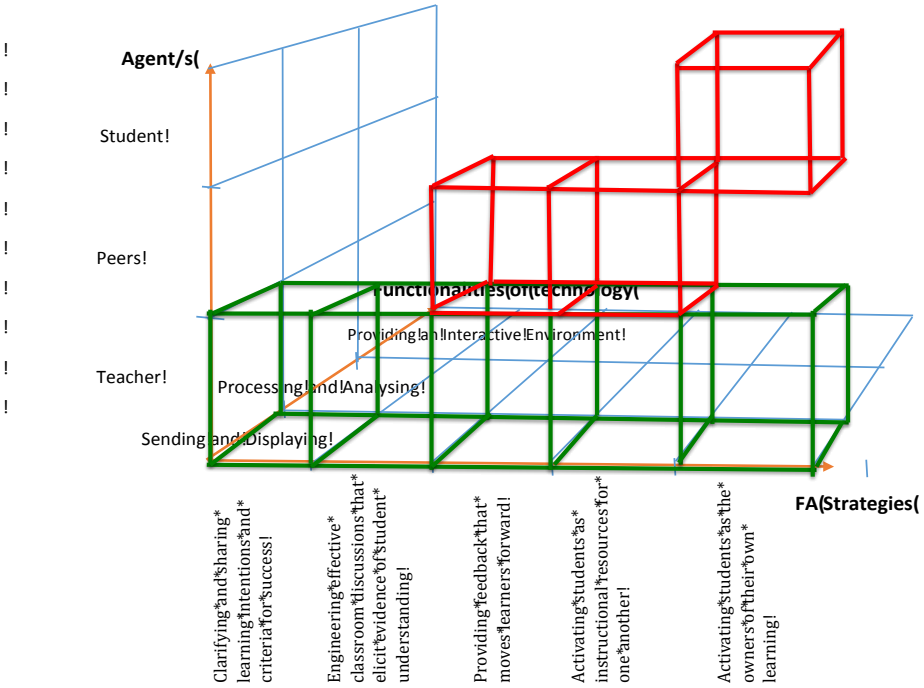
> **In our opinion, C is the right story because, at the beginning, he (Tommaso) runs, then he meets his friend, so he slows down. In the graph, in fact, you can see that in 5 minutes he walks for 400m, then he slows down and walks for other 400m, but in 10 minutes, because he is walking, then the goes back for 800m in 15 minutes, running.**

We say that Livio and Giacomo sent us their answer very soon, so, for this reason, we suggested them to check it again. Livio and Giacomo explain to the other pupils what part of their answers they corrected after they re-checked it.

Livio observes that they initially erroneously interpreted the meaning of the unit of measure on the horizontal axis (they thought that each segment on the horizontal axis corresponded with 10 minutes).

We ask to the other pupils if Livio and Giacomo's justification could be considered complete. Carlo suggests to add that it takes Tommaso 15 minutes to walk the first 800m. Stefano notices that Livio and Giacomo wrote that, during the first 5 minutes, Tommaso walks for 400m, then he walks for 400m in 10 minutes, so it is not necessary to add what Carlo suggests.
During the discussion, we make them notice that Livio and Giacomo did not clarify how they found the distance Tommaso walked through during the different periods of time.
Some pupils propose how to integrate this answer with this information to make it more complete.

This lesson, like lesson 1, is characterized by an effective use of the sending and displaying functionality of the technology to support the activation of all the formative assessment strategies by the three agents, as the following diagram summarises:



3. Classroom teaching

In this paragraph we present Teacher DV's point of view, reporting:
- her reflections on the three lessons documented in the previous paragraph (as answers to the interview we made after these three lesson);
- the final interview on general aspects of classroom teaching.

3.1 Interview on this series of lessons

(1) *Have you changed something, with respect to the initial planning of the lesson? If yes, what are the changes? Why?*
We usually did not change anything. Sometimes, it only happened that there was not enough time to propose all the worksheets that were planned for the lesson.

(2) *What was the most effective moment during this lesson? Why?*
The most effective moment of Lesson 1 (29th Oct. 2015) was the final discussion, during which the pupils understood that the graph represents the relationship between the distance and the time. Another effective moment was the one in which a reflection about the meaning of "mathematical justification" has been developed.
The most effective moment of Lesson 2 (5th Nov. 2015) was the one in which Rodolfo came at the IWB to explain his reasoning. I think it was useful for him, to increase his motivation. It was also effective to make students focus on the need of constructing a mathematical justification.
The most effective moment of Lesson 3 (9th Nov. 2015) was the initial one, because the pupils had the possibility to read their stories and identify their mistakes. Moreover, it enabled students to reflect on their work, comparing and contrasting their work and their classmates' work.

What was the most problematic moment during this lesson? Why?
I can't find real problematical moments. All the pairs/groups of pupils were always very attentive and actively participate. The pupils were not scared and they always tried to face the questions.
Maybe, the main problem was that some pairs/groups sent their work early, while others sent it late. This generated, sometimes, some chaos.

(3) *Were there some students' interventions, in relation to the received feedback, that particularly surprised you? How did you react to these interventions?*
It was always nice to realize that, in spite of some negative feedback they received (for example, when their mistakes were highlighted), all the pupils always reacted showing their will of doing and changing.

(4) *Rate (1 to 4) the support the technology gave to formative assessment during the lesson.*
I would choose 3.

In which moment of the lesson the technology was most effective? Why?
An effective aspect of the work we did is to give pupils the possibility to always look at the graph.
Other effective moments are the polls, since they are immediate and interesting. Polls work for a lot of pupils. Most of them, in fact, are able to take advantage of the poll to compare with their classmates and to immediately look at the result.
Projecting students' answers at the IWB is particularly effective, because it enables pupils to reflect on the comparison between the different answers, highlighting what complete, clear and correct mean.

In which moment of the lesson the technology was less effective? Why?
I think that the use of technology never represented an obstacle.

(5) *Do you think that the use of the technology supported the low-achievers?*
During this kind of activities, the pupils are often able to keep a high level of concentration. And, especially when we work during the afternoon, this is a good result. It represented an interesting support because it was immediate, it did not require them to write and it enabled them to keep their concentration. Globally, it's been a positive work.

In particular, which functions of the technology?
A good support is represented by the possibility to see and compare the different answers in an immediate, fast and captivating way.
It is also a support to keep the students very focused, to invest in oneself in a different way, to compare. But the support depends on the kind of pupil. It is always difficult to draw the attention of certain pupils.

Do you think that some aspects of the technology were an obstacle for low-achievers during the lesson?
No, I think that technology did not create obstacles for low-achievers.

(6) *What would you change in the plan of the lesson?*
What, in particular, would you change in the use of technology for formative assessment during this lesson?
I would not change anything. In my case, I would always need the support of someone else to use the technology during my lessons.

(7) *Do you want to add other comments?*
Thanks, because it is a wonderful way of intervening in the classes and of working with students.

3.2 Interview on general aspects of classroom teaching

This interview to Teacher DV Vittone was carried out on the 17th of December, on the last day of the teaching experiments.

What is your educational background?

I attended to a high school for future primary teachers, then I attended to the university, but I did not graduate.

How long have you been teaching? In this school, or …?

I have been teaching since 1975.

I have been teaching in this school since 1980.

What were the important states in your professional career?

I was a temporary teacher only for 2 years, then I became a permanent teacher through a National exam. After having passed the written part of the exam, there was a period of apprenticeship, during which I had to write a thesis aimed at making me study in depth some specific topics. This experience was very useful for my professional development, because, since it represented a fieldwork, it gave me important new tools, that the only National exam would not have given me.

Have you worked with (a) technology; and (b) formative assessment before? Please describe your experiences.

Experience with technology

Time ago, I attended to brief courses aimed at making us learn how to use specific technological tools, when they were introduced in our school. But they were only course on the use of technologies.

One of these courses was about the use of a platform aimed at fostering the exchange of experiences, but this experience was not fruitful, so, at the end of the course, we never used the platform anymore.

Experience with formative assessment:

Our school is in the AVIMES network[1]. Due to personal problems, I was able to participate only to some initial AVIMES meetings, aimed at preparing materials to be shared and used. But the students of my classes were always involved in the AVIMES activities, which resulted to be very important for them.

AVIMES made our school and our cluster of schools grow up, particularly the primary school.

At the beginning, we created a group, in which I was involved, focused on assessment. We prepared assessment tests for our cluster of schools, that our students face every year. The items vary, year after year, but all the tests are characterized by similar objectives and by a similar structure.

After some years, we realized that the tests had become too repetitive and that our students performed well especially for this reason. We, therefore, decided to share and exchange our tests with those prepared by the primary school of Chieri (Chieri is a small town near to Vinovo). The tests prepared by the primary school of Chieri were structured in a different way, similar to the one used for the National standardized tests (Invalsi), that is focused on different kinds of problem solving activities.

Now we are using both the kinds of tests, trying to continuously vary them. But the time available to work on these activities is not so much.

[1] See paragraph 1.1.

Moreover, the assessment group has now become the "group for the curriculum": it has been working on a vertical curriculum on Italian and Mathematics competences.

We are now attending at a course aimed at making us acquire new assessment tools.

During the AVIMES activities, the students work on worksheets that require them to motivate their answers and to construct argumentations.

During the period from one lesson and the following one, the teacher transcribes all the argumentations produced by the students and prepares a worksheet that includes all these argumentations (without putting the names of the students). This list of argumentations is then shared and analyzed with students, who are asked to state if they are effective or not, specifying why they are effective or not effective. Sometimes, a new argumentation is collectively created, if those on the worksheet are not complete. Class discussions are used every time an exercise or a problem is faced, during the lessons.

The individual tests faced by the students are corrected and given back to students, with the request of correcting their mistakes. When students correct their work, I usually analyze their productions again, correcting only what initially was not clear or not correct. This correction is made collectively.

Some years ago, with students with learning disabilities, we started working with conceptual maps and fostering a collective elaboration of solving strategies. This approach, focused on metacognition, is still used.

In your own words, how would you describe formative assessment in maths and/or science?

Doing formative assessment, within the class, means making students reflect on their difficulties. I always consider mistake a central point. Mistakes must be seen as "hitches that enable me to learn". I think that mistakes must always be valued.

In my daily practice, sometimes I get angry and do not react in the proper way, but I always focus on mistakes to make students identify what they did not understand, examine things in depth, rethink about something.

Moreover, it is important to devote time to argumentation and class discussions, but many constraints sometimes prevent you from focusing on these aspects.

How do you use it/them now? Please describe.

As I said before, I always focus on mistakes, even when I have to resume and expand a specific topic.

What are the advantages/disadvantages of using FA and ICT in maths & science lessons?

The main advantage is the fact that this approach fosters the students' personal development.

FaSMEd is the main experience I have done using technology for formative assessment. Some years ago, when these students were in grade 1 and 2, we experimented a software aimed at involving students in games connected to the resolution of problems. But, before FaSMEd, I never used technologies to carry out activities aimed at fostering the students' assessment or the teacher's

assessment. The software we used when my students were in grade 1-2 only gives a feedback such as “right” or “wrong”, but, if you make a mistake, it only suggests you to face again the problem, without an explanation. In this way, since they have to choose between three or four options, the students can work by trial and error.

I think that this kind of approach has a lot of other advantages: if it is carried out properly, it enables students to become aware of their difficulties and to learn how to overcome them.

The only disadvantage, in my opinion, is connected to time. This approach requires more time than, for example, giving students an exercise, collecting students’ solutions and correcting them.

What are the affordances, and the constraints?

If I think about the FaSMEd activities, a constraint, for me, is that often I am not able to read what is projected in the computer’s screen. Another constraint is that I am still not used to the IDM-TClass software.

I often use the computer, but not in the work with my students. We sometimes used the IWB, but we only have one IWB in this school and we have very few time to prepare materials to be used with the IWB.

Another, more general, constraint is that, in many school, there are very few computers that work. In my school for example, we only have few, obsolete computers. Since there are few computers, sometimes groups of 4 students have to work on the same computers. It is not fruitful.

For this reason, more technologies are requires in our schools. Another important prerequisite is the teachers’ capability in using these technologies and their desire to learn, study and apply these methodologies.

Technologies have many potentialities.

The IWB, for example, enable to capture students’ attention, showing videos or nice materials, that, for students, are often more interesting than a traditional lesson.

If I think, specifically, to formative assessment, the approach we adopted during the FaSMEd activities has a lot of potentialities: it enables to make students rethink about what they have done and to give personalized support.

But it also requires the teacher’s capability of autonomously using the software. For those teachers that are younger than me, it is easier learn how to use this kind of technologies.

What are important features of your teaching?

I always try to introduce topics, starting from what the students know and I make room for students. I try to construct together with them.

This is what, year after year, have characterise my teaching.

Which way/s of teaching do you consider effective?

I think that my way of teaching could be effective. This is way it is natural and spontaneous for me. Surely it is a way of working that in primary school could be more meaningful, but I think that starting from tangible experiences and/or from experiences that are affectively charged, could be useful at every grade, but especially during the first years of schooling.

It is effective to start from an engaging collective experience, during which students feel fine together. For example, when I teach additions, I usually play a game with my students, during which some objects are given to each students and then all these objects are put together.
Other examples are:
- the motion sensor, which was a really positive experience for my students;
- constructing a yardstick to measure the lengths of some objects;
- using a cake to introduce fractions.
This kind of experiences makes an impression on the students.

How do you support your students in class, in particular when they do not know how to progress/go on?

The answer is complex because it depends on the specific student.
For example, a student that is blocked and says "I have no ideas", a student that is scared… Rodolfo, for example, is a student that easily gets confused, due to his insecurities or to his family's pressures. With this kind of students, the best approach is to say them "now you have to breath and sit down; we will continue later".
In other cases, the best approach is to try to re-explain, possibly in a different way, or to make the student collaborate with another student that is more competent. I always had sufficiently harmonious classes, within which this kind of approach is really effective.
Sometimes you try to re-explain a lot of times, but you realise that you were not clear!

What difficulties students experience, in your view?

I think that the main difficulty, strictly connected to our way of working, is problem solving.
In my teaching experience, I worked with very good students, with students that were intuitive but did not cultivate this ability and with students that always faced a lot of difficulties.
I think that these difficulties are also related to our approach. During other activities, students are more relaxed and get better involved because of the structure of the activity, during which, for example, we use tables, schema, etc.
There are other difficulties, such as calculations, divisions…but this is not mathematics. We are not worried about them. We also work on exercises that involve calculations, and we require students to be correct, in the same way we require them not to make spelling mistakes when they write…but we do not think that being good in spelling is being good in writing.

What are the important activities for your students in your class?

The most important activities for students are those that foster their interest, enable them to pay attention to the activity itself for enough time, make them share their strategies and use the strategies proposed by other students.

Which resources, and teaching strategies, have you found particularly useful when teaching maths/science?

An important resource are those materials that enable students to experiment.

Among the strategies, the most important is making student to talk. For example: yesterday, in order to work on the factorization of numbers, we started from a brainstorming activity, during which the students recalled what we did, at grade 2, 3 and 4, on multiples and divisors. During the brainstorming activity, I always write everything on the blackboard, then we reorganize what we collected, trying to synthetically write them on the students' notebooks. This part of the activity is carried out together. I think that working together is very important because it helps students focus their attention, especially those who face difficulties. Afterward, I say "now we are going to learn something new". And I always make these "new things" explicit.

Sometimes you forget to make them explicit, but we think that it is very important to make students aware of what were are going to do, what is the context within which these "new things" are frames…

What is important for students to learn in math/science?

The fundamental thing to learn in Mathematics is problem solving, using or constructing intuitions to face problems. Constructing intuitions means applying methods such as: finding and highlighting data, analysing them, drawing a solving schema…

Problem solving is the most important thing, which includes everything else. It depends on the problem you are facing, but solving problems involve every mathematics competence.

How do you deal with the heterogeneity in your class; how do you attend to individual pupils' needs?

Usually, I do not work individually with students. Sometimes I prepare materials for specific students, but I always make all the students of the class work on those materials, so that all the students work together, because I think that studying together and giving mutual support to each other is very important.

I usually do not make students work in homogeneous groups because my teaching experience made me realise that heterogeneous groups are better, because the more competent students can support those that face more difficulties.

I work individually only with those students with learning disabilities. In that case, I plan specific individual activities.

I also often ask to the students to come to the blackboard. I realised that, sometimes, we suppose that students feel calm when they come to the blackboard, but it true. They can feel anxious also during activities such the FaSMEd ones, even if we said them we were not going to use their answers to evaluate them or their capabilities.

So I know that sometimes, when they are at the blackboard, they are not calm. However, I think that it is important to make them get used to coming to the blackboard and answering to my questions.

If a student face difficulties when working on equivalences, I ask him to come to the blackboard when we are working on equivalences. So I work with individual students, but the context is collective.

There are also moments devoted to individual students. For example, when I give them my correction of a written test, I tell them what were their mistakes,

with the aim of making them focus on these mistakes and understand why they made them.

However, although this kind of work would be really fruitful, it is difficult to carry it out in a class of 27 students.

What do you do when students make mistakes? Give examples.

As I said before, I conceive a mistake as a "hitch that enables me to learn".

It depends on the mistake. If the mistake is repeated, sometimes I loose my temper.

But usually, in front of a mistake I ask "Who agrees with him?", "Who does not agree?", "Why did you say this?", "Why did you say it in this way?".

I do not always say "Ah!!! This is a mistake!!!!". It depends on the mistake.

Usually, I pose these questions when we are working on an exercise that requires to apply a newly introduced concept.

If a student makes a mistake in the resolution of an exercise that was proposed for homework, I devote less time to the analysis of this mistake, because we cannot devote the same time to all the possible mistakes.

4. Pupils' perceptions

In this paragraph, after a brief presentation of the Q-sorting activity carried out in our schools, we analyse the work developed by two groups of students, and propose some concluding remarks.

4.1 General presentation of the Q-Sorting activity

After the whole teaching-experiment sessions, we carried out a Q-sorting activity based on the following cards:

- One set of cards regarded the ***view on mathematics***
- One set of cards regarded the ***view on technology***, including the classroom connected technology used (IDM-TClass)

Here below we present the lists of the two sets:

View on mathematics	***View on technology***
Mathematics is fun. Everybody can learn mathematics. In mathematics there is always only one right answer. I like mathematics Mathematics is difficult Doing mathematics means exploring and experimenting. To learn mathematics it is necessary to solve many of the same tasks. I learn things quickly in mathematics. When I do not understand (in mathematics) I ask for help. Learning mathematics needs a lot of memorising. Mathematics is a subject where one can be creative. Answers in mathematics are either right or wrong. Everybody can learn mathematics if s/he works hard enough If I cannot solve a task, I become frustrated and give up. In mathematics there is no time for reflection. In mathematics there is no room for expressing one's own ideas. Mathematics is best learnt in collaboration with others. Only few people can understand mathematics. I feel anxiety in mathematics lessons.	My friends help me to work things out, or the teacher, but not IDM-TClass. When I work with IDM-TClass during mathematics lessons, I better understand what I have to do to improve Since we use IDM-TClass with I solve quicker the exercises Working with technologies in mathematics is useful. I never remember what to do when I use IDM-TClass during the mathematics lessons. When I work with my mates and IDM-TClass, I can find the answers more quickly. I feel that the teacher knows much better where we are and whether we need some help, when she uses IDM-TClass. When I work with IDM-TClass it takes me twice as long, and cannot ask the teacher directly When I work with IDM-TClass during mathematics lessons, I quickly understand if I am wrong Using IDM-TClass during mathematics lessons is useless (*our adaptation of* "For me, the technology does not work, or help") Using IDM-TClass during mathematics lessons helps to understand what the teacher wants us to learn. [*for grade 7, it was phrased as:* Using IDM-TClass during mathematics lessons helps me to better understand the objectives of the activities]

I am good at mathematics. When I work on my own I learn better mathematics	

These two sets represent a selection from those proposed within the Project, because we had to adapt them to the children young age (grades 5-6-7).

The students faced the Q-sorting in groups of 4-6 components: the groups were formed merging two pairs /groups of students that had worked together during the FaSMEd lessons. After a short introduction to the activity, the students received the "mathematics" cards and were asked to classify them according to three columns: *completely agree, not completely agree, completely disagree*. We made the choice of asking to classify in three options after a first trial with four option. After the first set was completed, students received the second set, i.e. the one dealing with technology.

In case of disagreement within the group (e.g. one student was in agree with the card, whereas another one was in disagree), the students were asked to put the card in the middle group.

One researcher was present when students arranged the cards, but did not intervene if not for moderating behavioural excesses. After the two sets were positioned, the researcher carried out an ***interview***, based on the following questions:

1. Are there cards for which you did not discuss at all, because you immediately agreed on?
2. Are there cards for which you discussed a lot, because you could not agree on? Why?
3. Questions to clarify specific cards, to be chosen according to the group
4. Questions about the efficacy of IDM-TClass with respect to FA key-issues, such as
    a. Better understanding one's own mistakes
    b. Better understanding how to improve
    c. Better understanding the teacher's didactical goals
    d. Better facing problems and exercises
    e. Help the teacher to better understanding their needs
5. Questions on IDM-TClass functionalities, such as: Were you helped by…
    a. Seeing projected at the whiteboard the different answers and discussing them? How?
    b. Answering to the polls, visualizing the answers and commenting them? How?
    c. Receiving the helping worksheets (*for those who received them*)? How? Which one(s) in particular?
    d. Among the three options (a-b-c) which one do you think helped you the most? Why?

The interviewer chose among these questions, trying to cover at best all the points and asking for examples from the recent classroom experience in FaSMEd.

Since during the experimentation it happened that the researcher(s) acted as teachers in the classroom, we asked to include also them as "teachers" when reading the cards.

Both the Q-sorting activity and the interviews were videorecorded.

4.2 Analysis of the Q-Sorting activity

Five groups were set for the Q-sorting activity. They were formed keeping together the students with similar level, if possible. We present here the Q-sorting of a low-achieving group (group a) and of a high-achieving group (group b), in order to cover different levels.

4.2.1 Group a (low-achieving students)

Students: Livio, Giacomo, Veronica, Gregorio.

They are all low-achieving students. Gregorio has a learning disability.

After discussing each card, the students position them in the columns. The final picture is the following one:

Completely agree		***Not completely agree***		***Completely disagree***	
Mathematics	*Technology*	*Mathematics*	*Technology*	*Mathematics*	*Technology*
Mathematics is a subject where one can be creative	Since we use IDM-TClass with I solve quicker the exercises	Mathematics is fun	Using IDM-TClass during mathematics lessons helps to understand what the teacher wants us to learn.	In mathematics there is no time for reflection	I never remember what to do when I use IDM-TClass during the mathematics lessons
Everybody can learn mathematics if s/he works hard enough	Working with technologies in mathematics is useful	If I cannot solve a task, I become frustrated and give up	When I work with IDM-TClass during mathematics lessons, I better understand what I have to do to improve	In mathematics there is no room for expressing one's own ideas	When I work with IDM-TClass it takes me twice as long, and cannot ask the teacher directly
Mathematics is best learnt in collaboration with others	My friends help me to work things out, or the teacher, but not IDM-TClass	Mathematics is difficult	I feel that the teacher knows much better where we are and whether we need some help, when she uses IDM-	Only few people can understand mathematics	Using IDM-TClass during mathematics lessons is useless

			TClass		
Everybody can learn mathematics	When I work with IDM-TClass during mathematics lessons, I quickly understand if I am wrong	I am good at mathematics	When I work with my mates and IDM-TClass, I can find the answers more quickly	In mathematics there is always only one right answer	
Answers in mathematics are either right or wrong		Doing mathematics means exploring and experimenting		I like mathematics	
		When I do not understand (in mathematics) I ask for help		To learn mathematics it is necessary to solve many of the same tasks	
		I feel anxiety in mathematics lessons			
		I learn things quickly in mathematics			
		When I work on my own I learn better mathematics			
		Learning mathematics needs a lot of memorising			

On mathematics

From the video and the interview, we can see that the students immediately agreed on positioning the card "I like mathematics" under the label "completely disagree" (smiling when doing it) and the card "Only few people can understand mathematics" under the label "completely disagree" again: even if they do not like mathematics, they are confident that everybody can learn it.

On the other hand, they struggled a lot on the card "Learning mathematics needs a lot of memorising" because Veronica wanted to position it in "completely disagree", while Livio wanted to position it under "completely agree": the former was convinced that there is not a lot to memorize to do math, "just few things", and the latter replied that "for doing mathematics you have to study a lot of things, such as the properties of the operations, addition, multiplication…". But when explicitly asked about the FaSMEd activities, Livio and Giacomo immediately said

that there was very little to learn by heart, referred to how to use the IDM-TClass. Giacomo remarks that they "*have learnt something about graphs, but not by heart*". On the contrary, Veronica and Gregorio mention also the graphs.

On technology

Regarding technology, Giacomo and Livio disagree on the card "When I work with IDM-Tclass during mathematics lessons, I better understand what I have to do to improve". Giacomo claims that "*it is the same as with written sheets*", while Livio disagrees with him, without being able to express exactly in what the technology helped him.

On the other hand, a card that is positioned quite quickly is the card "When I work with IDM-Tclass it takes me twice as long, and cannot ask the teacher directly", which is positioned immediately, almost without thinking at it, because all the students strongly disagree with it, in particular with the part "cannot ask the teacher directly".

Also the card "I feel that the teacher knows much better where we are and whether we need some help, when she uses IDM-TClass" is positioned quickly. All students seem to recognize that the software helped the teacher in this sense, but underline that the teacher understands immediately when you have not understood. This is especially claimed by Giacomo, which is often reproached by the teacher in hard way, during the lessons. Giacomo says:

Giacomo: It does not change a lot, it does not change if you use a paper sheet or technology, because the teacher understand anyway when you do not understand, the mistakes you do. Also in the assessment tests.

He strongly claims that the relevant helps are given by his mates and the teacher also in the interview, concerning the card "My friends help me to work things out, or the teacher, but not IDM-TClass":

Giacomo: I completely agree, because the teachers teach, your mates teach you (*smiles and looks at Livio, his mate in FaSMEd*) to make mistakes (*indicating Livio*).

Veronica: No, they help you!

Giacomo: But using IDM-TClass or using the paper sheet is the same.

Giacomo is very active in the interview, and picks up also the card "When I work with IDM-TClass during mathematics lessons, I better understand what I have to do to improve" to further discuss it:

Giacomo: Ok, you use IDM-TClass, you make mistakes and then correct them, but then it is during the classroom discussion that you understand… Then the teacher tells you what to do to improve: she is always close to you and insists in telling you "Do it, do that!", and you improve…sooner or later you improve. […] The teacher looks at your sheets and says "This is wrong" and crosses it, "this is wrong" and crosses it…

Veronica: No, I would have put the card under "completely agree!", because IDM-TClass helps you a lot…in improving your reasoning.

Few moments later, when commenting the card "When I work with IDM-TClass during mathematics lessons, I quickly understand if I am wrong", Veronica recognizes the role of her mates in helping her during the activity:

> Veronica: Because since there are all your mates, they make you understand if you are wrong, so you understand quicker.

In order to challenge Giacomo, he was asked to reflect on the card "Using IDM-Tclass during mathematics lessons is useless" and to check if he would prefer to put it elsewhere. The student answers:

> Giacomo: It's useful, it's useful…and I don't say it because you are here…it's useful because you anyway learn something, about the tablet…differently from a paper notebook where you write and write what the teacher dictates. Instead here (*miming a tablet*) you get some questions and you have to answer.

4.2.2 Group b (high-achieving students)

Students: Elisabetta, Mirco, Arturo, Vincenzo, Luca. They are all high or medium-high achieving students.

The final disposition of the cards is the following:

Completely agree	***Not completely agree***	***Completely disagree***
Everybody can learn mathematics	I feel anxiety in mathematics lessons	In mathematics there is no room for expressing one's own ideas
Answers in mathematics are either right or wrong	Mathematics is difficult	In mathematics there is no time for reflection
Learning mathematics needs a lot of memorising	When I work on my own I learn better mathematics	Only few people can understand mathematics
When I do not understand (in mathematics) I ask for help	I am good at mathematics	If I cannot solve a task, I become frustrated and give up
Everybody can learn mathematics if s/he works hard enough	Doing mathematics means exploring and experimenting	To learn mathematics it is necessary to solve many of the same tasks
	When I study mathematics, I learn very quickly	
	Mathematics is best learnt in collaboration with others	
	When doing mathematics, you can invent	
	I like mathematics	
	In mathematics there is always only one right	

	answer	
	Mathematics is fun.	

On mathematics

Students discussed a lot on the card "Answers in mathematics are either right or wrong": some of them agreed with it, while others disagreed. It seems that the ones that agree were thinking about the *products*, whereas who disagreed were thinking at *processes* and are thinking at different processes yielding to the same result, and so are indeed discussing a slightly different sentence, which would be "In mathematics there is only one way of doing things":

> Vincenzo: Yes because indeed in mathematics a computation can be wrong or not.
>
> Elisabetta: Yes!
>
> Vincenzo: A thing is either one or the other! There cannot be the middle way.
>
> Arturo: Yes but it happens that in some problems, one has solved in a way, another in another way, but the total [*final result*] is…is the same, the computation is right, everything is fine, and so both modalities are the same.
>
> Elisabetta: Yes: either is right or it is wrong!

In addition, there emerge two meanings for the word "right":

- some students intended "right" as final synthetic assessment given by the teacher, such as "you did the job well",
- others were more technical and referred to "right" as one criterion for assessing a mathematical argument, together with "complete" and "clear", as done in the experimentation and as usual in the classroom.

For instance Elisabetta in the following sentence from the interview refers first to the technical meaning, then to the synthetic one:

> Elisabetta: An answer can be right but maybe not complete: it is not fully complete, so it's not wrong but neither right.

From this and similar passages, we have evidence that the assessment criterion shared in the classroom and exploited during the FaSMEd activities have been interiorized by the students, and this is a fundamental step towards FA ***strategies 1*** (Clarifying and sharing learning intentions and criteria for success) and ***5*** (Activating students as the owners of their own learning).

In many cases the reactions were "it depends on…" and so the card was placed in the middle column. Very few times a card was placed there because the group did not reach an agreement: in particular, with the card "I like mathematics" they did not try to get an agreement (Luca says yes with enthusiasm and Vincenzo replies no with same security).

Some cards were placed very quickly, because the students agreed on immediately:

- When I do not understand (in mathematics) I ask for help (strongly agree)

- Everybody can learn mathematics if s/he works hard enough (strongly agree)

- Mathematics is difficult (middle column)

- In mathematics there is no room for expressing one's own ideas (strongly disagree)

- In mathematics there is no time for reflection (strongly disagree)

- Only few people can understand mathematics (strongly disagree)

- If I cannot solve a task, I become frustrated and give up (strongly disagree)

Some cards needed further clarification, because students were very precise in discussing them and asked us specific questions:

- when discussing about being anxious during mathematical activities, they asked us if they had to refer to mathematics in general or to the FaSMEd mathematical activities, and we specified that it was to be intended in general;

- when discussing about "To learn mathematics it is necessary to solve many of the same tasks" they asked if the sentence had to be considered in its whole or if they could retain a part and reject another part. In fact, they agreed that in mathematics exercises are needed (otherwise, Arturo argues, "*when you solve well the problem, you solve it but the computation are wrong*")

In discussing the card "When I work on my own I learn better mathematics", the students underlined the help that the group can give you especially to correct you in case you make a mistake.

When discussing the card "Doing mathematics means exploring and experimenting", they gave different answers, showing different meanings associated to "experiment": Vincenzo referred to empirical experiment, Arturo to his own trials when doing long arithmetical expressions:

> Mirco: Yes! I think yes!
>
> Elisabetta: I agree
>
> Arturo: But not completely
>
> Vincenzo: You explore in science
>
> Arturo: Experimenting the computations, experimenting the function of a problem
>
> Vincenzo: But the computation is one only: if I do 3 times 3, it is not that I experiment
>
> Arturo: But I could do, for instance when I do long expressions, I do my experiments one after the other, so that then I try to do them all together in the same expression, so I experiment the expression instead of doing 3000 computations together

Usually, in arguing their claims the students chose example from the arithmetic domain, speaking about doing computations, the properties of the operations and so on. In one case we have the experimental evidence that the FaSMEd activity influenced at least partially the students view on mathematics: in fact, facing the card "When doing mathematics, you can invent": initially all the students agree on "Completely disagree", but when Luca mentions the FaSMEd activity of inventing a story associated to a graph, and they change place to the card. Here we report the transcript of this short discussion:

> All: Yes!
>
> Arturo: The rules, you need to know the rules of mathematics, you cannot invent them. Everything is fixed, you cannot invent.

Mirco: Exactly!

[…]

Arturo: But when we had to associate the graphs, we have invented a story, basing ourselves on the graph.

They read again the card.

Leo: Yes, so sometimes yes. Yes because in the FaSMEd activity, that is always mathematics. The problems are invented by the teachers (*indicating the researcher who is filming*).

Elisabetta: But the result is not invented…you cannot invent the result.

Vincenzo: Yes, when there is > or < and blank spaces, we have to invent the numbers.

Elisabetta: So it depends on the situation.

Also in the interview, the same example is provided, this time by Arturo and mentioning the task if inventing a graph associated to a story, in FaSMEd.

Another reference to the FaSMEd Project activities—made by the students without any input from researchers or explicit question—is done when discussing the card "When I do not understand (in mathematics) I ask for help". The card is immediately placed, because all students strongly agree with that. They specify that you need to think before establishing that you do not understand, and so at that point, after thinking alone without success, you ask for help. The FaSMEd "helping sheets" are mentioned to this regard.

A third reference is made when debating "In mathematics there is always only one right answer". In fact the first answer is yes, supported the example of the number resulting from a computation. Also, Elisabetta points out that in FaSMEd polls there was always only one right answer. Conversely, it is again the girl to mention that during the FaSMEd discussions there could be three right answers, more or less complete compared one to another. Also Vincenzo and Arturo later quoted the FaSMEd activities as examples of tasks in which there were more than one right answer. Finally, shifting to include also processes and not only products, they all agree that there can be more than one answer (they make the example of different ways to solve a problem: with an expression or with a text in natural language).

On technology

The technology cards are arranged as follows:

Completely agree	***Not completely agree***	***Completely disagree***
My friends help me to work things out, or the teacher, but not IDM-TClass.	I feel that the teacher knows much better where we are and whether we need some help, when she uses IDM-TClass	Using IDM-Tclass during mathematics lessons helps to understand what the teacher wants us to learn
Since we use IDM-Tclass with I solve quicker the exercises		When I work with IDM-Tclass it takes me twice as long, and cannot ask the teacher directly

When I work with IDM-Tclass during mathematics lessons, I better understand what I have to do to improve		I never remember what to do when I use IDM-Tclass during the mathematics lessons.
When I work with IDM-Tclass during mathematics lessons, I quickly understand if I am wrong		Using IDM-Tclass during mathematics lessons is useless
When I work with my mates and IDM-TClass, I can find the answers more quickly		
Working with technologies in mathematics is useful		

In discussing several cards, the students pointed out that the IDM-TClass software is a *means* that allow you do carry out things, and not a value per se. For instance, commenting the card "I feel that the teacher knows much better where we are and whether we need some help, when she uses IDM-TClass", Arturo insists on saying that he disagrees and imagines a situation in which the software is used without giving the students the possibility to interact directly with the teacher:

Arturo: No, because if we could not speak, and we could only send the message (*with IDM-TClass*), it would be worse; in the way we did (*in FaSMEd project*) we can speak and explain more, we can say "Teacher, I don't understand this, this and that", and she answers us

Vincenzo: Come on, Arturo! On the contrary, with IDM-TClass you can ask for the "help worksheet"

Luca: But if you send an answer

Vincenzo: Yes, the teacher reads it immediately, while on the contrary in standard lessons she sometimes does not read our notebooks.

Luca: You send your answer and she reads it, and she sees, maybe, it is partly right and partly wrong, and it goes…but if it is completely wrong, she sends it back to you, also with the "help worksheet".

Elisabetta: But this also in normal lessons.

Arturo: Yes, she says this is right or wrong.

Luca: Yes, but…

Vincenzo: I agree with Luca, because with the "help sheet" it becomes easier.

Mirco: I agree.

Luca: With the paper notebooks, we give them to the teacher, she corrects them with her pen, and it takes longer, and then she has to call each of us, explain it, and she does not have the "help sheets".

Elisabetta: We never sent it and then it was wrong.

Vincenzo: The "help sheets" are like saying "since you are struggling with it, or it is wrong, I give you a little help to do it right"

Elisabetta: But also in normal lessons, if you don't understand, you tell it to the teacher and she helps you.

As we can see in the excerpt above, different positions are taken, and the "help sheets" are mentioned as a supporting feature in case of wrong answers (feature which is not available in normal lessons).

Also discussing the card "Using IDM-Tclass during mathematics lessons is useless", the students in an intense discussion compared "standard" lessons to lessons with IDM-TClass within FaSMEd:

Vincenzo: I think it is useless because writing on a paper notebook or writing on the tablet it doesn't change anything.

Elisabetta: It is better in the normal lessons, because the teacher reads what you write and explains to you, whereas with IDM-TClass you write whatever, what *you* think it's correct… but normally the teacher explains to you directly.

Luca: I think it is useful because seeing the different answers grouped on the IWB helps, and this cannot be done with the paper sheets.

Arturo: You can do it, but reading the answers and copying them on the blackboard.

Leonard: But on the IWB the answers stay longer and you can read them. And to do the same work as in the IWB, the teacher should read every notebook, so with IDM-TClass it is easier.

Arturo: I don't know what to choose, because, because one the one hand it's useful, on the other it's useless. It's useful, for instance if I have drawn a graph on my notebook, the teacher cannot copy it perfectly on the blackboard; it is useless when I write down an answer: I can also dictate it to the teacher, and she can write it.

Vincenzo: but if the teacher uses the grid blackboard, she can copy well the graphs.

Luca: For me it's easier with IDM-TClass, you understand better if you look at all answers on the IWB. Also when we receive the sheets, we see a graph and the questions below, and it helps a lot because…in your notebook you cannot see all together.

Discussing the card "When I work with IDM-Tclass during mathematics lessons, I better understand what I have to do to improve", the role of collaborative work between students emerges, during both the problem-solving phases and the discussions. We remark that before facing this card, the students had positioned "Using IDM-Tclass during mathematics lessons is useless" under the middle column, and it is only after they notice that the activities have helped them to better understanding what they have to improve that they move the card to the "completely disagree" column, in particular following Mirco's proposal.

The collaboration with pairs is mentioned also to support the claim "When I work with IDM-Tclass during mathematics lessons, I quickly understand if I am wrong":

Elisabetta: When I work with another mate in the pair, if I say something wrong and he corrects me, I better understand that I was wrong.

The other students nod.

The following three cards did not need discussion among the students, because they immediately agreed on them:

- I never remember what to do when I use IDM-Tclass during the mathematics lessons (completely disagree)

- When I work with my mates and IDM-TClass, I can find the answers more quickly (completely agree)

- Working with technologies in mathematics is useful (completely agree)

When finally asked to choose the most useful methodology among the different ones exploited with IDM-TClass in FaSMEd (question 5), the different but fundamental roles of the mates and the teacher come to the fore:

> Vincenzo: For me the discussion within the group, because you can listen to the others' opinions: maybe you are convinced that something is right, and your mate can help you in understanding that it is wrong.
>
> Luca: Projecting the answers on the IWB, more than the help sheets, because you can do wrong also in the help sheet, whereas discussing all together then at the end we find the conclusion.
>
> Vincenzo: There is also an adult, the teacher, who can also direct the discussion.
>
> Elisabetta: I did not choose the work in pair also because they (*indicating the members of her group, Luca and Arturo*) were always fighting.
>
> Mirco: I agree with Luca, also because your mates help you in not making mistakes: being together helps.

4.3 Concluding remarks on students' view on FA and on technology from the Q-sorting activity

As reported in these excerpts and more generally from the Q-sorting activity in both groups, students appear to recognize the fundamental role of their *mates* and the *teacher* in FA ***strategies 3*** (Providing feedback that moves learners forward) and ***4*** (Activating students as instructional resources for one another).

In the case of high achieving students, we have evidence that the assessment criterion for an argument, shared in the classroom and exploited during the FaSMEd activities (i.e. to be correct, clear, complete) have been interiorized, and this is a fundamental step towards FA ***strategy 1*** (Clarifying and sharing learning intentions and criteria for success) and ***5*** (Activating students as the owners of their own learning).

For what concerns the use of the classroom connected software IDM-TClass, *graphs* and to *grouped answers* are quoted by the students as positive features, highlighting the positive role played by the functionality ***sending & displaying***.

Students often remarks that specific features of the FaSMEd lessons are *similar* as in the normal lessons in their classroom, in particular with respect to the attention that the teachers give to giving feedbacks to them, and to the classroom discussions. This is coherent with our choice for the teachers and classes for the FaSMEd teaching-experiment, i.e. contexts already sensible to FA and to the social aspects of teaching-learning processes (see general introduction to the case studies).

One negative feature regarding IDM-TClass is also mentioned: the fact that while in your paper notebook you can have your own answers but also all previous pages easy at disposal, using the tablet this is more tricky, from a practical point of view.