

The UNITO teaching experiments

This part represents a common introduction to our two case studies.

It consists of 6 sections:

- 1) The schools involved in the FaSMEd Project in Italy;
- 2) Our didactical Methodology and the type of FA used;
- 3) The technology;
- 4) The activities;
- 5) The research methodology;
- 6) The methodology of work with teachers.

1. The schools involved in the FaSMEd Project in Italy

In Italy the FaSMEd project involves 18 teachers, from three different clusters of schools located in the North-West of Italy:

- Nine teachers and their ten classes (eight primary school classes, grades 4-5, and two lower secondary school classes, grades 6-7) from the Istituto Comprensivo di Vinovo (Torino);
- Five teachers and their seven classes (lower secondary school classes, grades 6-7) from the Istituto Comprensivo di Carcare (Savona);
- Four teachers and their four classes (primary school classes, grades 4-5) from the Circolo Salgari (Torino).

In Italy, schooling is based on mixed ability classes, and therefore attend regular classes with the other students. Low-achievers are identified mainly through the teachers' assessment. National assessment is carried out by the Invalsi Institute through a written test in grade 2, 5, 8, and 10.

2. Our didactical Methodology and the type of FA used

In our work within FaSMEd, we integrate *two main assumptions*:

- (1) The first assumption is that low achievement is linked not only to a lack of basic competences, but also to *affective and metacognitive factors*. For this reason, it is important to include these components and to focus students' attention to their own processes, not only to their products.
- (2) The second assumption is that *argumentation* can be exploited as a FA tool in the interaction between teacher and students. It is, therefore, fundamental develop effective class discussions, starting from questions such as: "Explain what you did", "Explain why your approach is effective", and to guide students in assessing the correctness, the clearness and the completeness of given explanations (their own or others).

According to these hypothesis, we planned and developed class activities with the aim of:

- (a) fostering students' development of ongoing reflections on the teaching-learning processes;
- (b) focusing on making thinking visible (Collins, Brown and Newmann, 1989) and on students' sharing of the thinking processes with the teacher and the classmates.

We think that this approach could support the activation of the five key-strategies (Black and Wiliam, 2009):

- 1) Clarifying and sharing learning intentions and criteria for success;
- 2) Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding;
- 3) Providing feedback that moves learners forward;
- 4) Activating students as instructional resources for one another;
- 5) Activating students as the owners of their own learning.

The teaching experiments were subdivided into two phases. During the first, exploratory, phase (May 2015), all the 18 teachers involved in FaSMEd proposed some of the planned activities to their classes during 4 lessons (2 hours each). After this phase, some of the activities have been re-designed (see paragraph 4), referring to the results of the teaching experiments.

The second phase (from October to December 2015) involved 6 of the teachers, who proposed the re-designed activities in their classes, during a cycle of 6-8 lessons (2 hours each).

3. The technology

In Italy, the FaSMEd project involved classrooms and teachers that were sensible to formative assessment practices (in some cases, due to their involvement in existing projects), but did not use new technology in their ordinary lessons. This choice was made both to be coherent with the Project aims, and also to adapt to the standard Italian school context.

When we planned our work within the FaSMEd project, in line with the assumptions outlined in the previous section, we chose to use a *connected classroom technology*, i.e. a networked system of personal computers or handheld devices specifically designed for classroom interactive teaching and learning (Irving, 2006). Connected classroom technologies, in fact, enable to share the ongoing and final productions of the students, as well as to collect their opinions at chosen times during the activities (Irving 2006, Roschelle et al. 2004, Shirley et al. 2011).

Specifically, we chose the IDM-TClass classroom management software, which offers a set of functions that enable teachers to broadcast, control, communicate, monitor or collaborate with students individually or as a group.

Through this software the teacher could:

- broadcast any multimedia file from teacher computer to selected student screens or to the entire class;
- group students into small group and assign a leader for each group (monitoring the group at any time);
- share his/her screen (and microphone) or any student screen (and microphone) with all the students, selected students or a group of students;
- observe the screens of all students or selected students in the class directly from his/her computer;
- control and operate one selected student computer and guide the student remotely through a particular task;
- be contacted by the students, who can ask questions or extra help to him/her;
- send documents to students from teacher computer or allow students submit assignments to teacher computer;
- remotely launch and close applications on each student's desktop from teacher computer;
- record the screen operations of teacher computer and teacher's voice into a video file;
- create quiz tests and distribute the tests directly from teacher to student computers.

The students' tablets are connected with the teachers' laptop through the IDM-TClass software. In order to foster collaborative work and argumentation, students are asked to work in pairs on the same tablet.

Each school has been provided with tablets for the students (who work in pairs), computers for the teachers and, where the interactive whiteboard was not available, a data projector.

3.1 The technology: intended implementation and redesign

Before the first phase of the teaching experiments, we decided to focus on the following selection of IDM-TClass functions:

- (a) monitoring students' screens;
- (b) showing, to one or more students, the teacher's screen and also other students' screens;
- (c) distributing documents to students and collecting documents from the students' tablets;
- (d) creating different kinds of tests and have a real-time visualization of the correct and the wrong answers;
- (e) creating instant polls and immediately showing their results to the whole class;
- (f) displaying the students' written productions through the data projector or the interactive whiteboard.

After the first phase of the teaching, we realised that:

- technical features prevent from effectively monitoring students' screens (in fact, the students screens rotate to the vertical position when they are monitored, and this disturb students' during their work) and showing the teacher's screen or other students' screens to the class;
- the collection and the displaying of students' written productions is complex for the teacher (also if one or more researchers are in the class during the activities), because it requires time to identify the protocols to be selected and to plan an effective order of presentation of these protocols;
- the displaying of selections of students' protocols and the instant polls were particularly effective in fostering students' argumentative processes and metacognitive reflections.

Starting from these considerations, in the re-design of the use of IDM-TClass (for the second phase of the study) to support FA processes, we, therefore, decided to focus on the following three main functions:

- the possibility of *distributing documents* to students and *collecting documents* from the students' tablets;
- the possibility of *creating instant polls* and immediately *showing their results* to the whole class;
- the possibility of *displaying the students' written productions* through the data projector or the interactive whiteboard.

In particular, we introduced a systematic way of planning the discussions on the students' answers to the different worksheets: since this planning requires to identify an effective order of the answers to be presented (according to specific criteria, that could depend on the class

or on the specific lesson), many discussions were “delayed”, that is they were proposed during the following lesson.

During the teaching experiments, a typical lesson was organized in the following way:

- Students worked in groups on an assigned worksheet (see paragraph 4) and produced a joint written answer (to be written on the tablet and sent to the teacher by means of IDM T-class software).
- The teacher made a selection of written group productions to be displayed to the whole class and promoted a discussion on them; two options were experimented: the selection was done by the teacher on the spot, during the same lesson, and the discussion took place immediately after; the selection was done by the teacher out of the classroom, at the end of the lesson, and the discussion took place at the beginning of the subsequent lesson; in the latter case, the teacher could set a power point presentation displaying the selected productions to be discussed.
- Some worksheets encompassed instant polls (see paragraph 4), to be answered by the groups; the poll usually served as a starting point for a discussion on the answers.

4. The activities

4.1 Planning of the activities: general premises

The use of IDM-TClass was integrated within a set of activities on relations and functions, and their different representations (symbolic representation, tables, graphs).

Specifically, we adapted activities from the ArAl project (Cusi, Malara & Navarra 2011) and from The Mathematics Assessment Program, designed and developed by the MARS Shell Center team at the University of Nottingham (<http://map.mathshell.org/materials/lessons.php>).

Each lesson is organized with the aim of:

- (a) supporting the students in the verbalisation and the representation of the relations introduced within the lesson;
- (b) enabling them to compare and discuss their answers;
- (c) making them reflect at both the cognitive and metacognitive level.

In the teaching experiments documented in the two case studies, each class worked on:

- some introductory activities (carried out in May and October 2015), on functions and graphs, adapted from two ArAl Units (“L’archeologo Giancarlo” and “La festa di Primavera”);
- other activities on time-distance graphs (carried out from October 2015 to December 2015), which are our adaptations of the toolkit activity “Interpreting distance-time graphs” (part of the materials from the Centre for Research in Mathematics Education at the University of Nottingham).

For each activity, we have prepared a set of different worksheets, to be sent by the teacher to the students’ tablets, aimed at:

- (a) supporting the students in the verbalisation and the representation of the relations introduced within the lesson;
- (b) enabling the students to compare and discuss their answers;
- (c) making the students reflect at both the cognitive and metacognitive level.

Some of the worksheets are conceived as helps for the students.

Some of these “helping worksheets” are sent only to some students:

- if students ask us to receive an help;
- if, going around within the class, the teacher realises that some students are blocked because of the difficulties they are facing;
- if the answers they send us highlight mistakes or difficulties.

Sometimes, other “helping worksheets” are sent to the whole class, after all the students sent their answers, specifying that the “helping worksheets” must be used to check the correctness of the answers.

The “helping worksheet” are also discussed within the whole class to highlight the role played each help, fostering a meta-level analysis of the tasks.

During the first phase of the teaching experiments (May 2015), the worksheets for the activities on time-distance graphs were directly proposed to students in grade 5, 6 and 7, without planning a possible introductory activity.

The difficulties in facing the initial worksheets, met in particular by grade 5 students, suggested us to plan differently the second phase (from October to December 2015) of the teaching experiments. In particular, we designed an introductory activity on the use of a motion sensor (a device connected to a graphic calculator, showing, in real time, the Cartesian representation of a movement produced), so as to ground the distance-time graph on a meaningful laboratorial activity. The students could move along a line on the floor, and a motion sensor generated distance-time graphs in real time on the screen of a calculator, that was projected as a big image on the wall. In this way, the students could experience the link between the movement on a straight line and the time-distance graph on the Cartesian plane. The laboratorial activity encompassed: moving, observing and interpreting the resulting graph; making hypothesis on the expected graph before moving; making hypothesis on the kind of movement to perform in order to obtain a given graph; comparing graphs related to different speeds.

In our re-design of this activity, we also decided, in order to foster students’ argumentative competencies, to favour the collective analysis, during class discussions, of the correctness, the clearness and the completeness of the justifications provided the students.

The students’ attention was focused on these aspects to specific questions¹ such as:

- Are these justifications correct? Or are there some mistakes to be corrected?
- Are these justifications clear? Is every reader able to easily understand them?
- Are these justifications complete? Do they contain all the information necessary to draw these conclusions? Do they refer to mathematical aspects? ...

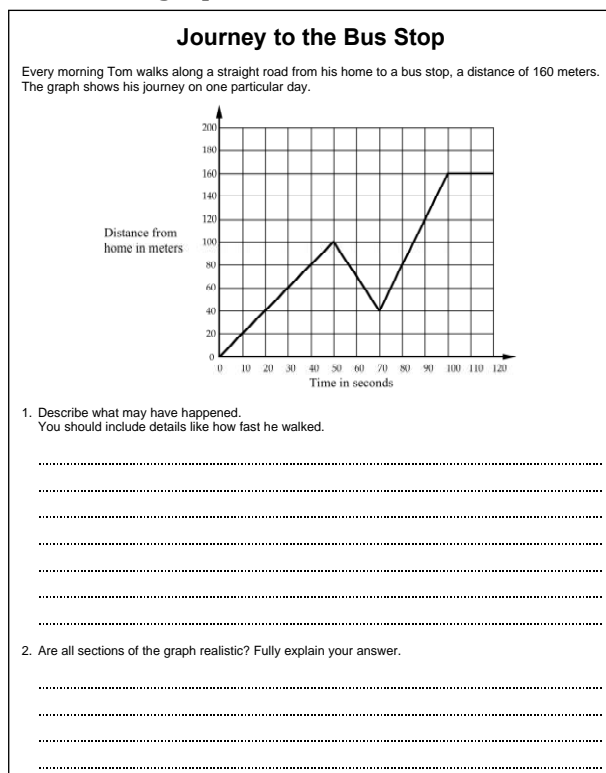
In the following, we are going to present the worksheets prepared for the activities on time-distance graphs, since they are those documented in our case studies.

¹ This is in tune with the approach adopted within the approach adopted within the Project AVIMES, in which involves some of the teachers who participated to the FaSMEd activities (see the paragraph 1.1 of the Case study 1-Garino).

4.2 Activities on time-distance graphs: adaptation from the activity “Interpreting distance-time graphs”

4.2.1 Activity “Tommaso goes to the bus stop”: first implementation and subsequent adaptation

The Worksheets 1-1A-1B-2-2A-3-3A-4-4A-5 were developed starting from the following activity “Interpreting distance-time graphs”:



Since we work with young students (grades 5-6-7), who, in some cases, are not used to the interpretation of time-distance graphs, we conceived different worksheets aimed at guiding them to a step-by-step interpretation of the graph.

These worksheets were experimented, for the first time, in May 2015.

In the first version of the worksheets, the questions proposed to the students were in this order:

- 1) After how many seconds does Tommaso reach the bus stop? How did you establish it?
- 2) Does he walk for 160m? Why?
- 3) What happens in the period of time between 50s and 70s? How did you establish it?
- 4) What happens during the last 20s? How did you establish it?

As stated in the previous paragraph, the experiments carried out in May 2015 highlighted some problems:

- when the students tried to answer to questions 1, they also discussed what could have happened in the period of time from 50s to 70s;
- since many students (especially grade 5 students) had never been introduced to this distance-time graphs, they did not manage to give a meaningful interpretation of the graphs.

For these reasons, in the second phase (October-December 2015), besides introducing time-distance graphs through a dedicated lesson with the motion sensor (see previous paragraph), we changed the order of the questions, making students initially focus on the period of time between 50s and 70s.

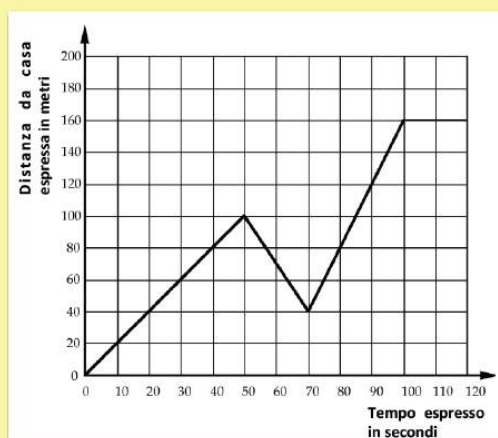
Moreover, we decided to transform some of the worksheets, that, initially, were all characterised by open questions, into polls to be proposed to the classes. In the following we present the final version of the worksheets.

Worksheet 1

In the first worksheet, the students are asked to answer to the question “*What happens in the period of time between 50s and 70s? How did you establish it?*”

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:

Worksheet 1A

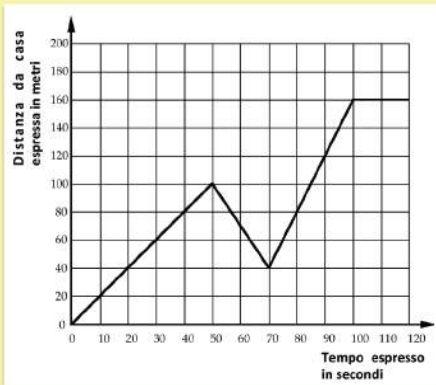
Worksheet 1A is conceived as a help for those students who have difficulties in facing Worksheet 1.

The students find this suggestion:

“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?”

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:

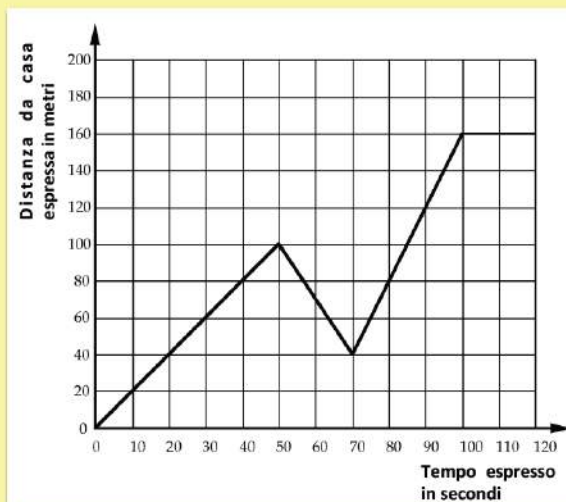
Worksheet 1B

Worksheet 1B represents a possible poll to be proposed to students with the aim of discussing possible typical difficulties in answering question 1 (such as interpreting the graph as the path on which Tommaso walks or as a hill). Three answers, given by other fictitious students, are proposed, with the request of identifying the correct one:

- (a) *In the period from 50s to 70s, Tommaso comes back.*
- (b) *In the period from 50s to 70s, Tommaso change his road.*
- (c) *In the period from 50s to 70s, the road, on which Tommaso is walking, goes down.*

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

Quale risposta è corretta secondo voi?

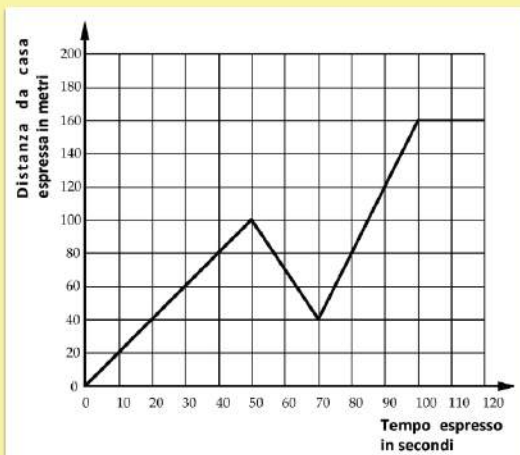
- A) Nel periodo da 50s a 70s Tommaso torna indietro
- B) Nel periodo da 50s a 70s Tommaso cambia strada
- C) Nel periodo da 50s a 70s la strada che Tommaso sta percorrendo è in discesa

Worksheet 2

In worksheet 2, the students are asked to answer to the question “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:

Worksheet 2A

Worksheet 2A represents a possible poll to be proposed to students with the aim of focusing the discussion on the characteristics that a *complete justification* should have.

In this poll three justifications, given by fictitious students, are proposed, with the request of identifying the most complete one among these:

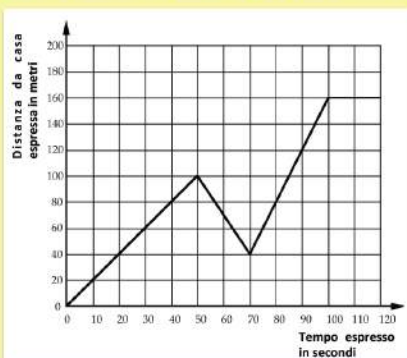
(a) During the last 20s, Tommaso is not walking because we have already said that he has reached the bus stop.

(b) 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.

(c) I understood that, during the last 20s, Tommaso is not walking because the line of the graph is horizontal.

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?

RISPOSTA:

Worksheet 3

In Worksheet 3 the question “After how many seconds does Tommaso reach the bus stop?” is proposed as a poll.

The four options are:

(a) After 120s;

(b) After $50+70+100+120$ seconds, that is after 340 seconds;

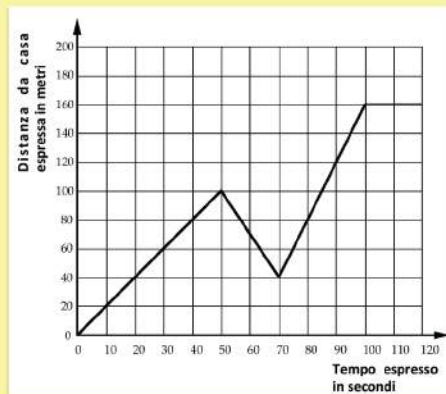
(c) After 100 seconds;

(d) After 50 seconds.

This poll is conceived as a starting point for a discussion focused on the reason underlying the choice of the answers.

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

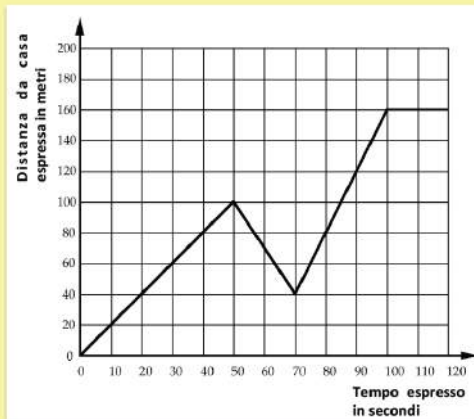
D) Dopo 50 secondi

Worksheet 4

In Worksheet 4 are asked to answer to the question “Does he walk for 160m? Why?”.

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:

Worksheet 4A

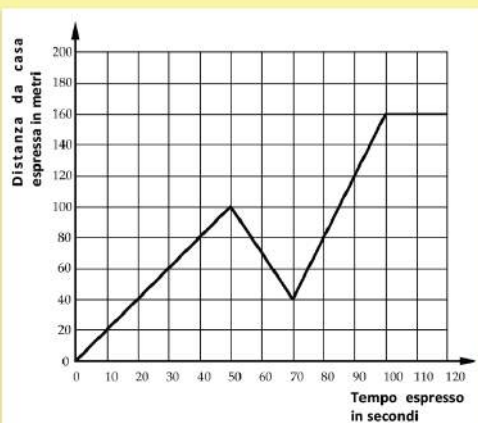
Worksheet 4A represents an help for those students who have difficulties in facing Worksheet 4.

The students are suggested to analyse separately the different parts of the graph, answering to the following questions:

- What is the distance that Tommaso has walked through during the first 50s?
- What is the distance that Tommaso has walked through in the period of time from 50s to 70s?
- What is the distance that Tommaso has walked through in the period of time from 70s to 100s?
- What is the distance that Tommaso has walked through in the period of time from 100s to 120s?

Scheda 4A - 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 4: Ha percorso esattamente 160m? Perché?

AIUTO per rispondere alla domanda 4: Analizza i vari tratti del grafico e rispondi alle seguenti domande:

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

RISPOSTA:

Worksheet 5

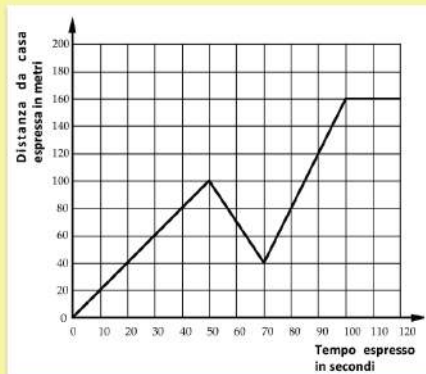
Worksheet 5 asks for a global interpretation of the graph. It should enable the students to recall all the aspects highlighted in the previous worksheets and discussions.

The following questions is asked to the students:

“After having answered to the questions in the previous worksheets, describe how Tommaso has walked on the road from his home to the bus stop. What could have happened to him?”

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.

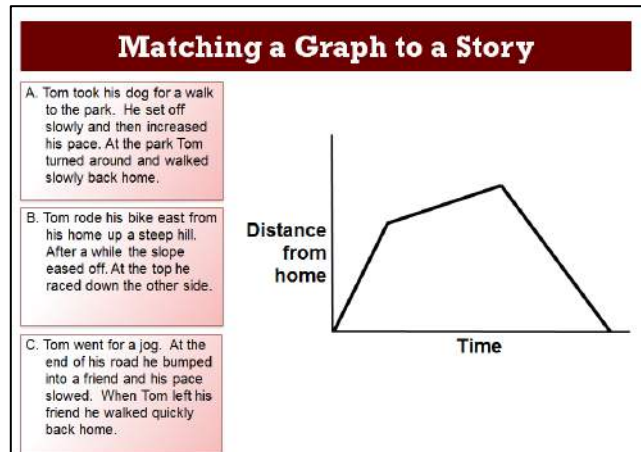


Ora che abbiamo risposto alle domande, descrivi come Tommaso ha percorso il tragitto da casa sua alla fermata dell'autobus. Cosa potrebbe essergli successo?

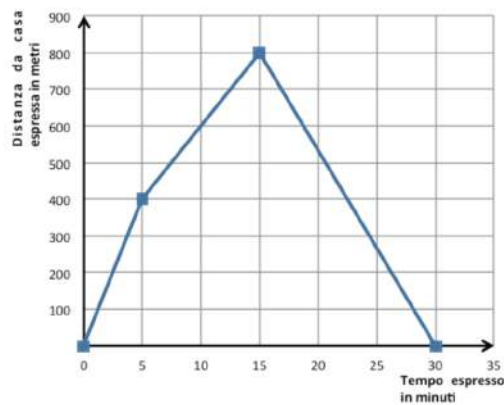
RISPOSTA:

4.2.2 Activity “One graph and three stories”: our adaptation

The Worksheets 6-6A-6B were adapted from the activity “Matching a graph to a story”.



We inserted data on the two axes and modified the graph, in order to enable the students to easily identify how Tommaso’s speed changes during the different periods of time.

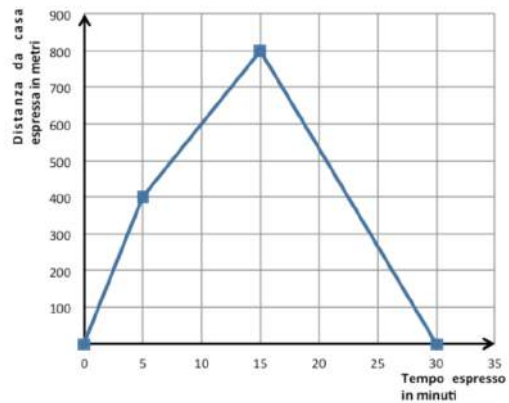


Worksheet 6

In Worksheet 6 the graph and the three corresponding stories are presented, with the following question: “What is the story that this graph represents? Justify your answer.”

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:

Worksheet 6A

Worksheet 6A represents a first help for those students who have difficulties in facing Worksheet 6.

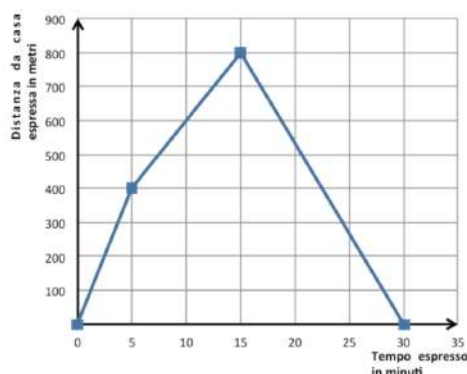
Students are suggested to collect, within the given table, the distances from home next to the corresponding times (0 minutes, 5 minutes, 15 minutes).

Students are also asked to answer to the following questions:

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

Scheda 6A - AIUTO

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.

UN AIUTO PER TROVARE LA STORIA:

Raccogli in questa tabella le informazioni che il grafico fornisce:

Tempo	Distanza da casa
0 minuti	
5 minuti	
15 minuti	

Rispondi ora alle domande:

- Quale distanza percorre Tommaso nei primi 5 minuti?
- Quale distanza percorre nel successivo intervallo di tempo da 5 a 15 minuti?
- In quale di questi due intervalli di tempo si muove più rapidamente?
- Quale storia è quindi quella corretta secondo te?

Worksheet 6B

Worksheet 6A represents a second help for students, in case the help proposed through Worksheet 6A is not enough for them.

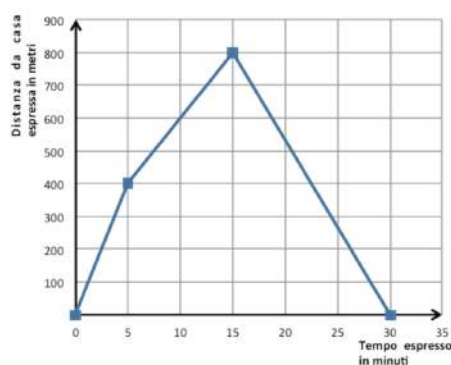
The table, within which the distances from home are next to the corresponding times, is completed.

Students find this suggestion:

"We observed that, at the beginning, Tommaso walks for 400m in 5 minutes. Afterward, he walks for 400m in 10 minutes. For this reason he moves quickly during the first 5 minutes, because it takes less time for him to walk through the same distance. What is the story that, surely, is not represented by the graph?"

Scheda 6B

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.

Secondo aiuto
per rispondere
alla domanda
6:

Abbiamo osservato che all'inizio Tommaso percorre 400m in 5 minuti. Successivamente percorre ancora 400m, ma in 10 minuti. Quindi si muove più rapidamente nell'intervallo da 0 a 5 minuti perché percorre lo stesso spazio in tempo inferiore. Quale storia, quindi, sicuramente non è rappresentata dal grafico?

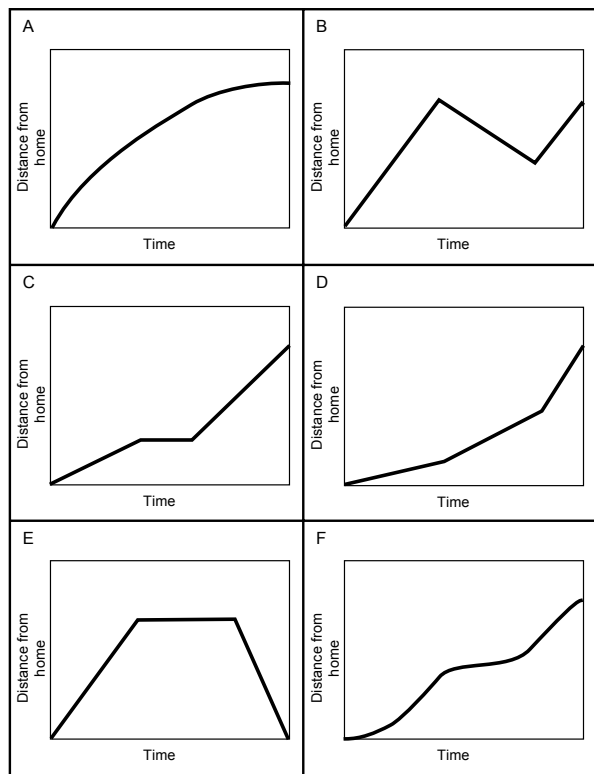
Tempo	Distanza da casa
0 minuti	0m
5 minuti	400m
15 minuti	800m

RISPOSTA:

4.2.3: Activity “Match the stories with the graphs”: our adaptation

The Worksheets 7-7A-7B-7C-7D were adapted from the activity “Matching cards sets A and B”, which requires students to match a set of cards of time-distance graphs (set A) with a set of cards with their possible interpretations (set B).

Card Set A: Distance–Time Graphs

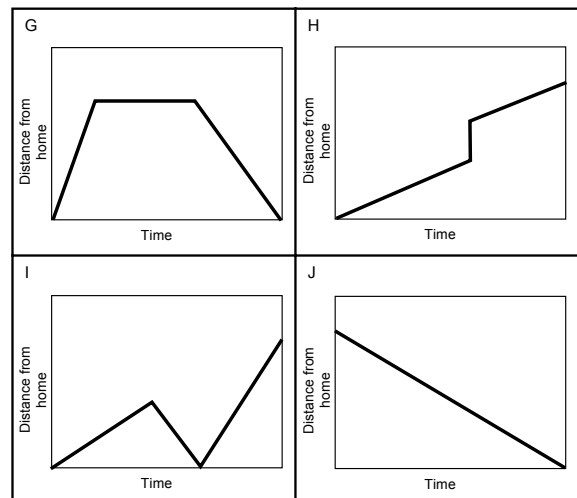


Student Materials

Interpreting Distance-Time Graphs
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S-2

Card Set A: Distance–Time Graphs (continued)



Card Set B: Interpretations

1 Tom ran from his home to the bus stop and waited. He realized that he had missed the bus so he walked home.	2 Opposite Tom's home is a hill. Tom climbed slowly up the hill, walked across the top, and then ran quickly down the other side.
3 Tom skateboarded from his house, gradually building up speed. He slowed down to avoid some rough ground, but then speeded up again.	4 Tom walked slowly along the road, stopped to look at his watch, realized he was late, and then started running.
5 Tom left his home for a run, but he was unfit and gradually came to a stop!	6 Tom walked to the store at the end of his street, bought a newspaper, and then ran all the way back.
7 Tom went out for a walk with some friends. He suddenly realized he had left his wallet behind. He ran home to get it and then had to run to catch up with the others.	8 This graph is just plain wrong. How can Tom be in two places at once?
9 After the party, Tom walked slowly all the way home.	10 Make up your own story!

Student Materials

Interpreting Distance-Time Graphs
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S-4

Worksheet 7

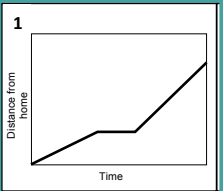
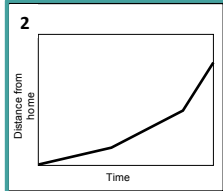
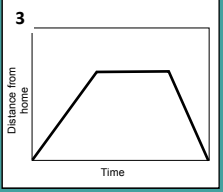
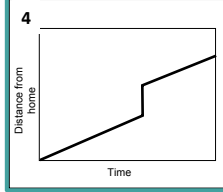
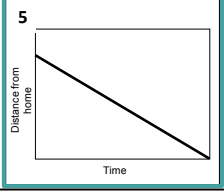
Because of the age of the students, we decided not to use all the cards proposed in the activity “Matching cards sets A and B”.

Worksheet 7 consists, therefore, of our *selection of card* from the two sets A and set B.

We selected the graphs with the aim of making students recall what they have learned through the previous worksheets: (1) The meaning of a horizontal segment within a time-distance graph (graph 1, in the following); (2) The connection between the slope of the graph and the speed of the person whose motion is represented in the graph (graph 2, in the following); (3) The meaning of ascending/descending segments within a time-distance graph (graphs 1, 2, 3, 5, in the following).

We decided to make students analyse also a graph that represents an impossible situation (graph 4 in the following) and to ask them to create a story that could be represented through the unmatched graph (graph 3, in the following).

These are the two sets of paper cards used during the activity:

GRAFICI		STORIE
		<p>A) Marco esce di casa e cammina lungo la strada, si ferma per controllare l'ora e capisce che è tardi, quindi comincia a correre.</p>
		<p>B) Luca esce di casa per andare a prendere il treno. Una volta raggiunta la stazione, si siede su una panchina in attesa del treno.</p>
		<p>C) Alice esce dalla scuola di danza e torna a casa.</p>
		<p>D) Questo è un grafico impossibile.</p>
		<p>E) Giulia esce di casa e si arrampica sulla collina di fronte, prima lentamente, poi un po' più rapidamente. Dopo aver raggiunto la cima della collina, scende dall'altra parte correndo.</p>

Students are asked to write their matches in worksheet 7:

“Together with this worksheet, you will receive 10 cards, on which you will find 5 graphs and 5 stories that could be matched with the graphs. Match the stories with the graphs that represent them. Attention!!! There could be graphs without a corresponding story. If you find this kind of graph, invent a story.

Write your matches, explaining how you chose the stories to be matched with the graphs. If you found a graph without a story, write the missing story. Make a picture of your matches and send it to the teacher.

We matched graph ... with story ... because ...

We matched graph ... with story ... because ...

We matched graph ... with story ... because ...

We matched graph ... with story ... because ...

No story could be matched with graph ...

This is the story, to be matched with this graph, that we invented.”

Scheda 7

Assieme a questa scheda di lavoro riceverai 10 altre schede cartacee, sulle quali troverai 5 grafici e 5 storie che potrebbero essere abbinate ai grafici. **Abbina le storie ai grafici che le rappresentano.**
Attenzione!!! Possono esserci grafici ai quali non corrisponde nessuna delle storie. **Se ne trovi uno, inventa tu la storia!**

Scrivi qui sotto gli abbinamenti che hai fatto e motiva come hai scelto le storie da abbinare ai grafici.

Se hai trovato un grafico senza storia, **scrivi la storia mancante.**

Fai una foto degli abbinamenti che hai fatto ed **inviata** all'insegnante.

Al grafico _____ ho abbinato la storia _____ perché ...

Al grafico _____ ho abbinato la storia _____ perché ...

Al grafico _____ ho abbinato la storia _____ perché ...

Al grafico _____ ho abbinato la storia _____ perché ...

Non c'è nessuna storia da abbinare al grafico _____

Questa è la storia che si potrebbe abbinare: ...

The worksheets 7A-7B-7C-7D were conceived to help students doing the correct matches. In particular during this activity, we decided to send these help-worksheets also to those students that did not require them: in this way, these worksheets become tools, for students, to check their answers and could, therefore, be considered as further feedback for them.

Worksheet 7A

Worksheet 7A represents a help to match graph 1 with the corresponding story.

Students are asked:

“Observe graph 1.

The second section of the graph is a horizontal segment. What does it mean?

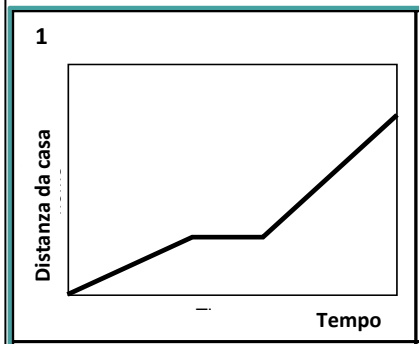
The first section of the graph is less steep if compared to the third section. What does it mean?

Where is the speed greater?

After these observations, can you discard some of the stories?

What is the story that could match this graph?”

Scheda 7A - AIUTO PER ABBINARE IL PRIMO GRAFICO



Osserva il grafico 1.

Il secondo tratto del grafico è un **segmento orizzontale**. Cosa significa?

Il primo tratto del grafico è meno **pendente** del terzo tratto. Cosa significa?

Dove la velocità risulta maggiore?

Dopo aver fatto queste osservazioni, **puoi scartare alcune storie?**

Quale storia è in sintonia con questa osservazione?

Worksheet 7B

Worksheet 7B represents a help to match graph 2 with the corresponding story.

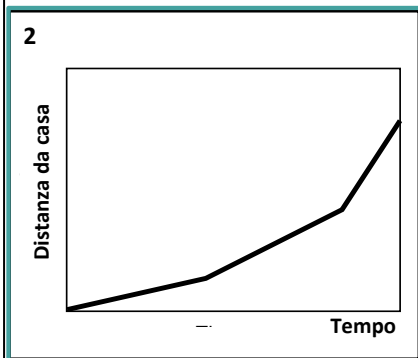
Students are asked:

“Observe graph 2.

The slope, in the three parts of the graph, is increasing. What does it mean? The speed is increasing or decreasing?

After these observations, can you identify the story that could match this graph?”

Scheda 7B - AIUTO PER ABBINARE IL SECONDO GRAFICO



Osserva il grafico 2.

La pendenza, nei tre tratti di grafico, **aumenta**. Cosa significa? **La velocità sta aumentando o diminuendo?**

Dopo aver fatto queste osservazioni, **quale storia ti sembra più in sintonia con questa osservazione?**

Worksheet 7C

Worksheet 7C represent a help to match graph 5 with the corresponding story.

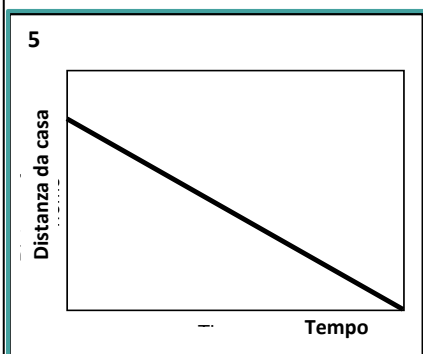
Students are asked:

“Observe graph 5.

The point (0,0) is not the initial point of the graph. What does it mean? The person who is moving is going near home or away from home?

Do these observations enabled you to identify the story that could be matched with this graph?”

Scheda 7C - AIUTO PER ABBINARE IL GRAFICO 5



Osserva il grafico 5.

Il grafico non parte dall'origine. Cosa significa? **La persona che si sta muovendo si sta avvicinando o allontanando da casa?**

Dopo aver fatto queste osservazioni, **quale storia ti sembra più in sintonia con questa osservazione?**

Worksheet 7D

Worksheet 7C represent a help to understand that graph 3 cannot be matched with any story.

Students are asked:

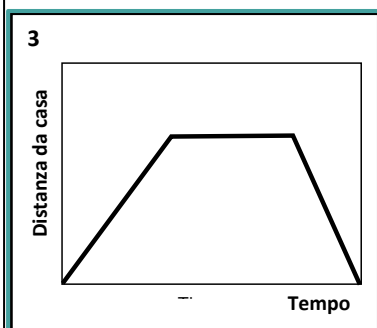
“Observe graph 3.

The second section of the graph is a horizontal segment. What does it mean?

The initial point on the left and the last point on the right are both on the horizontal axis. What does it mean? Where is the person that is moving at the beginning and at the end of its motion?

Do these observations enable you to find a story that could be matched with this graph?”

Scheda 7D - AIUTO PER INTERPRETARE IL GRAFICO 3



Osserva il grafico 3.

Il secondo tratto del grafico è un **segmento orizzontale**. Cosa significa?

Il primo punto a sinistra del grafico si trova sull'asse orizzontale e anche l'ultimo punto a destra. Cosa significa? **Dove si trova la persona che si sta muovendo all'inizio e alla fine dell'intervallo di tempo considerato?**

Dopo aver fatto queste osservazioni, esiste una storia che possa essere abbinata a questo grafico?

4.2.4: Activity “Create a graph that could match the story”

The last activity on time-distance graphs is not taken from “Interpreting time-distance graphs”. We created it with the aim of making students consolidate the competences developed thanks to the previous activities, working on the construction of a graph that represents a given story.

Worksheet 8

In Worksheet 8, students are asked to the time-distance graph that correspond to the following story:

“Samuele goes out from home, running toward the gym. When he is halfway, he feels too tired, so he decides to stop and rest under a tree. After some minutes, he gets up and walks toward the gym.”

Scheda 8

Disegna il grafico distanza-tempo che rappresenta questa storia.

Samuele esce di casa correndo per raggiungere la palestra. Quando arriva a metà strada si sente troppo stanco e decide di fermarsi sotto un albero per riposare. Dopo qualche minuto di sosta, si alza e prosegue, camminando, verso la palestra.

Worksheet 8A

The Worksheet 8A represent a help for the students meeting difficulties with Worksheet 8. The following suggestion is given to the students:

“The story can be divided into three moments.

At the beginning (first moment) Samuele runs.

Then (second moment) Samuele stops for some minutes.

At the end (third moment) Samuele walks and continues going away from home.

How the second section of the graph should be in order to correspond to the second moment?

What section of the graph should have the grater slope: the first or the third?”

Scheda 8A

Disegna il grafico distanza-tempo che rappresenta questa storia.

Samuele esce di casa correndo per raggiungere la palestra. Quando arriva a metà strada si sente troppo stanco e decide di fermarsi sotto un albero per riposare. Dopo qualche minuto di sosta, si alza e prosegue, camminando, verso la palestra.

La storia può essere suddivisa in tre momenti.

All'inizio (**primo momento**) Samuele **corre**.

Poi (**secondo momento**) Samuele **si ferma** per qualche minuto.

Alla fine (**terzo momento**) Samuele **cammina** e continua ad allontanarsi da casa.

Come sarà il tratto di grafico corrispondente al secondo momento?

Sarà più pendente il tratto di grafico corrispondente al primo o al terzo momento?

5. The research methodology

During the FaSMEd Project, we worked in strict collaboration with the teachers.

Initially, we planned the activities, starting from the assumptions presented above. Each worksheet was later shared and discussed with the teachers during dedicated meetings in the schools.

When the activities were implemented, at least one of our team was always in the classes with the teachers to:

- take notes and video-record the lessons;
- help the teacher carry out the activities, supporting them in the use of IDM-TClass (since, for many of them, it was the first time they used technologies during their lessons) and proposing interventions to foster fruitful discussions.

Also, in many lessons Master thesis students, enrolled in the teacher education programs for primary school, collaborated as well. Researchers and Master students acted as participant observers.

The data collected during the lessons were:

- information about the students and, in particular, about the low achievers involved in the project;
- video-recordings of all the lessons;
- audio-recordings (sometimes video-recordings) of a-posteriori interviews with the teachers;
- field notes by the observers;
- students' written productions (the files where they write their answers to the questions in the worksheets; in some cases, paper worksheets; answers to an intermediate and a final questionnaire on their perceptions about the project...);
- shared reflections with teachers;
- final interviews with some students, during the q-sorting activity;
- final interviews with the teachers.

The a-posteriori analysis of the activities was developed with the teachers' support through:

- the teachers' interviews after each lesson;
- the joint analysis, during the cluster meetings and the other meetings in the schools, of the potentialities/limits of the worksheets and of our use of the technology;
- the informal meetings with the teachers before and after each lesson.

Our analysis of the selected episodes for the case studies will be developed referring to the FaSMEd *three-dimensional framework*, which takes into account:

- the three main agents involved in the FA processes (the teachers, the student, the peer);
- the functionalities of the technology (sending & displaying, processing & analysing and providing an interactive environment);
- the five FA key-strategies by Black and Wiliam (2009).

Moreover, to highlight the different feedbacks that are provided, in our analysis we also refer to the four major levels of feedback identified by Hattie and Temperley (2007):

- (1) *feedback about the task*, which includes feedback about how well a task is being accomplished or performed;
- (2) *feedback about the processing of the task*, which concerns the processes underlying tasks or relating and extending tasks;
- (3) *feedback about self-regulation*, which addresses the way students monitor, direct, and regulate actions toward the learning goal;
- (4) *feedback about the self as a person*, which expresses positive (and sometimes negative) evaluations and affect about the student.

6. The methodology of work with teachers

As stated in the previous paragraphs, our work with the teachers involved in the FaSMEd Project was characterised by a strong collaboration.

In addition to emails exchanges, we met each teacher every week (sometimes two times a week), during *informal meetings, before and after the FaSMEd lessons*.

During these meetings, the teachers were interviewed and the interviews were audio-recorded. These were the questions we posed during the interviews:

(1) Have you changed something, with respect to the initial planning of the lesson? If yes, what are the changes? Why?

(2) What was the most effective moment during this lesson? Why?

What was the most problematic moment during this lesson? Why?

(3) Were there some students' interventions, in relation to the received feedback, that particularly surprised you? How did you react to these interventions?

(4) Rate (1 to 4) the support the technology gave to formative assessment during the lesson.

In which moment of the lesson the technology was most effective? Why?

In which moment of the lesson the technology was less effective? Why?

(5) Do you think that the use of the technology supported the low-achievers?

In particular, which functions of the technology?

Do you think that some aspects of the technology were an obstacle for low-achievers during the lesson?

(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?

(7) Do you want to add other comments?

These meetings were also occasions to develop informal reflections on the effectiveness of the activities and on the evolution (if it was highlighted) of students' performances.

Other *more formal meeting between groups of teachers of the same school* were organised, especially before and at the beginning of the teaching experiments.

These are the contents of the meetings between teachers of the same school:

- *Meeting 1* (months before the beginning of the teaching experiments): First meeting with all the teachers of the school and the headmaster and Presentation of the FaSMEd Project (aims, the three polarities of the project)
- *Meeting 2* (before the first phase of the teaching experiments): Meeting with the teachers who have decided to participate to the FaSMEd project to share some initial ideas on the activities to be carried out in the classes (number of activities, time to be devoted to each activity, role of the technology to support formative assessment)
- *Meeting 3* (before the first phase of the teaching experiments): Analysis of possible activities to be carried out in the classes: presentation of some ArAl Units.

- *Meeting 4* (before the first phase of the teaching experiments): Analysis of possible activities to be carried out in the classes: possible adaptation of some activities from the ArAl Units.
- *Meeting 5* (before the first phase of the teaching experiments): Formative assessment and technologies: presentation of the technology we have identified and of its potentials for formative assessment. Examples of the possible use of connected classroom technologies to support formative assessment (adaptation of two activities from the ArAl project)
- *Meeting 6* (before the first phase of the teaching experiments): Analysis of the activities on time-distance graphs: our adaptation.
- *Meeting 7* (before the first phase of the teaching experiments): Training in the use of the IDM-Tclass software; examples of its use to support formative assessment.
- *Meeting 8* (before the beginning of the second phase of the teaching experiments): Analysis of the re-design of some of the activities, carried out starting from the a-posteriori reflections developed after the first phase of the teaching experiments.

We also organised:

- two cluster meetings (the first one on the 9th March 2015, the second one on the 15th September 2015), that involved the teachers of the three clusters of schools;
- one semi-cluster meeting (on the 23rd June 2015), that involved the two clusters of schools from the Torino's area;
- three semi-cluster meetings (on the 3rd June 2015, on the 29th September 2015 and on the 24th of November) organized in the school of Carcare.

These were the contents discussed during the ***first cluster meeting*** (9th March 2015):

- Brief excursus of the different activities presented in the previous meetings;
- Presentation of our adaptation of the “common activity” on functions and graphs that will be experimented in all the FaSMEd countries;
- Analysis of a possible paths within which the common activity could be presented;
- The different data we were going to collect;
- Presentation of our version of the teacher report;
- Planning of the future activities.

These were the contents discussed during the ***semi-cluster meeting*** organised with the schools in the Torino's area (23rd June 2015):

- Brief excursus of the activities carried out by the different teachers in their classes;
- Small group activity on the analysis of the worksheets used during the teaching experiments and discussion;
- The use of digital technologies to support formative assessment: analysis of some videos from the teaching experiments;
- Planning of the future steps of the experimentations.

These were the contents discussed during the ***second cluster meeting*** (15th September 2015):

- Sharing of the results arisen from the reflections developed during the semi-cluster meeting: about the activities in the classes (focus on the worksheets) and about the support provided by the technology during the activities;
- Presentation of the FaSMEd three-dimensional framework as a theoretical tool that could support the analysis of the role played by technology during FA processes;
- Analysis of a class discussion, developed during the first phase of the teaching experiments, through the lenses of the FaSMEd three-dimensional framework;
- Presentation of the motion sensor as a tool to introduce time-distance graphs;
- Planning of the second phase of the teaching experiments.

These were the contents discussed during the ***semi-cluster meetings*** organised in the school of Carcare:

- Analyses of video recordings from the class experimentations
- Planning for the tasks to be experimented.

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 “ <i>Interpreting Distance-Time Graphs</i> ”, 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; 31-40; 41-50; 51-60; over 60)	51-60
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* 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	<p>Two teachers works with the class 5A. The teacher DV teaches Mathematics, Science and Arts.</p> <p>As teacher DV also stated in the final interview on her teaching experience, this class has always worked well together.</p> <p>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:</p> <p>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.</p> <p>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</p>

	<p>initiative. Both these students are sometimes able to construct argumentations.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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</p>
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	<p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>11) Andromeda and Noé Their performances are usually at a low-medium level.</p>
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	<p>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.</p> <p>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.</p> <p>Usually he is interested and he participates to class discussions. But, sometimes, he displays inadequate logical skills.</p> <p>Both the students are not able to construct argumentations to justify their choices.</p> <p>12) Valeria, Rodolfo and Marianna</p> <p>Their performances are usually at a medium level.</p> <p>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.</p> <p>Marianna works harder than Valeria, but, during group activities, she is usually passive.</p> <p>Both these students are not able to construct argumentations.</p> <p>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.</p>
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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

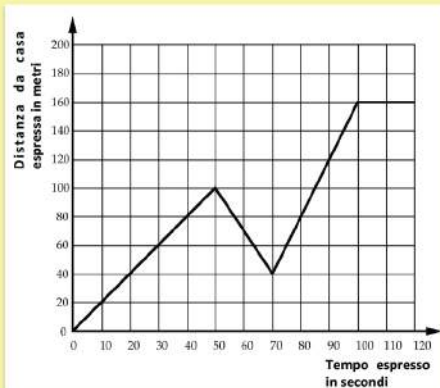
<i>Length of lessons, date & time</i>	29 October 2015, 2 hours (10.30-12.30)
<i>Year group & class size</i>	5A (grade 5) – 27 students
<i>Objectives & lesson theme</i>	<p>1) Guiding the students in the interpretation of a time-distance graph:</p> <ul style="list-style-type: none"> - interpretation an ascending/descending line within the graph; - interpretation of an horizontal line within the graph. <p>2) Make the students focus on the reasons supporting the correct interpretation of a time-distance graph.</p> <p>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.</p>
<i>Tasks used</i>	Worksheets 1 – 1A – 2
<i>Resources used</i>	<ul style="list-style-type: none"> • 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.

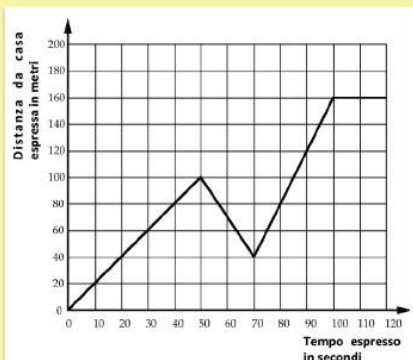
During the activity, students can receive the “helping worksheet” 1A. The teacher and the researchers initially walk around the class to see if some students need some clarifications, then work at the computer, waiting for students’ answers.

The teacher and the researcher select some of the students’ answers, in order to 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

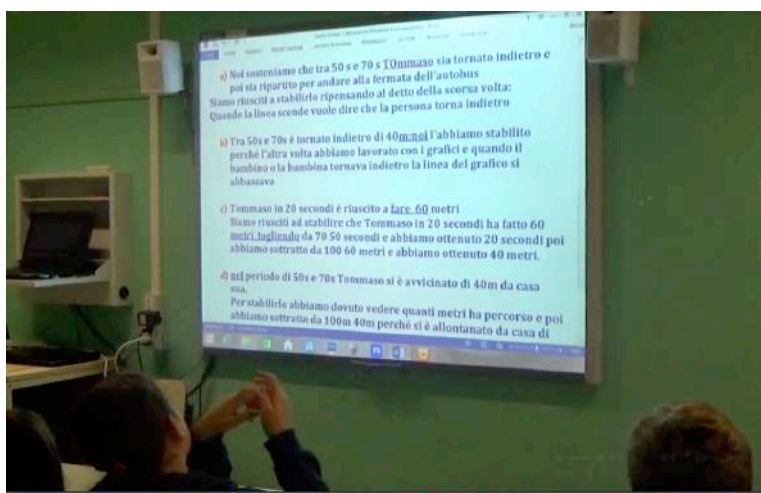
Siamo riusciti a stabilirlo ripensando al detto della scorsa volta:
Quando la linea scende vuole dire che la persona torna indietro

- 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.

<i>Transcript</i>	<i>Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback</i>
<p>140) Teacher DV: Let’s listen to what Arturo has to say on answer C, that, according to him, is right.</p> <p>141) Arturo: I think that it is right because, if you look at the graph...from 50s to 70s there are, actually, 20 seconds.</p> <p>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?</p> <p>143) Arturo: 70 minus 50.</p> <p>144) Teacher DV: 70 minus 50. Do we all agree?</p> <p><i>The pupils nod.</i></p>	<p>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.</p> <p>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</p>

<p>145) Arturo: However, if we look at the graph, he (<i>Tommaso</i>) arrives at 100m, then he goes back.</p> <p>146) Teacher DV: Do we all agree that he goes back?</p> <p><i>A chorus of students answer "yes".</i></p> <p>147) Teacher DV: Who don't agree on the fact that he goes back?</p> <p><i>None of the pupils raises his/her hand.</i></p> <p>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 (<i>answer C</i>) is right.</p>	<p><i>learners forward</i>) is therefore activated.</p>
<p>149) Teacher DV: So is it right? Do you agree with Arturo?</p> <p><i>Silence.</i></p> <p>150) Researcher 1 (<i>speaking with Arturo</i>): Repeat the words you used, since they are very precise ... Listen to them (<i>speaking with the other students</i>).</p>	<p>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 <i>feedback about the processing of the task</i>, because she wants to make them focus on Arturo's way of interpreting the graph in order to understand what 40m represents. <i>Strategy 3</i> is, therefore, again activated.</p>

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.

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

	answer C (again, <i>feedback on the task</i>). Mirco (line 169) shows that he really has activated himself as <i>the owner of his own learning</i> ("we did not write it").
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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 (<i>to the whole class</i>). Here, especially in the first and second answer (<i>answer A and B</i>), 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.	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 <i>strategy 1</i> because she aims at sharing with students the criteria for success.
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<p>188) Researcher 1: He is going toward his home. So I ask you: why, when a line is descending, does it mean that he is going back? We saw that, if (<i>the line</i>) is descending, he goes back, but we did not say why.</p>	
<p><i>Luca, Carlo and Arturo raise their hands.</i> 189) Luca: Because, if the straight line (<i>with his forefinger, he traces a hypothetical horizontal axis</i>), we may say, is the sensor, when the line approaches the sensor (<i>with his forefinger, he traces a descending line</i>), 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 (<i>to the other students that have risen their hands</i>): Do you want to add something? <i>No one answers.</i></p>	<p>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, <i>instructional resources for each other</i>. Strategy 4 is, therefore, again activated.</p>
<p>193) Researcher 1: Other pairs, for example those who wrote answer D and C, mainly focused on how much (<i>Tommaso</i>) walked. He walked for 60m. However, to give this answer, where did they look within the graph? 194) Ambra: The two lines (<i>she is referring to the two axis</i>)... 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 (<i>she indicates the point (50,100)</i>), then this (<i>she indicates the point (70,40)</i>). Does looking at these points help us to understand that he is approaching his home?</p>	<p>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 <i>providing a mathematical justification</i>. 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 <i>looked at</i> to highlight that the distance from home is decreasing (lines 196-198). Overall she provided feedbacks about the processing of the task.</p>
<p>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 (<i>she indicates the point (50,100)</i>) and I see where I am,</p>	<p>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</p>

then I read this one (*she indicates the point (70,40)*) and I see where I am – does it help 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!

(line 205).

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

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

<p>child is going back.</p> <p>216) Teacher DV: It (<i>the line</i>) is descending because the distance is decreasing.</p> <p>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 (<i>the one focused on the experience with the motion sensor</i>). Because, if I only say “I remember that, when we used the sensor, when it (<i>the line</i>) 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.</p> <p>This (<i>observation</i>) will be useful in the future lessons.</p>	<p>why the justifications constructed during this phase of the discussions could be considered “mathematical justifications” 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 <i>criteria for success (strategy 1)</i>.</p>
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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

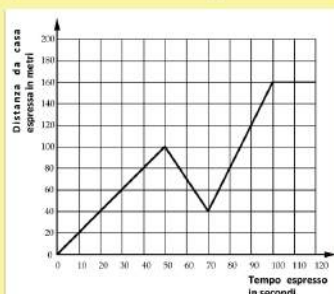
We project worksheet 1A (helping worksheet) received by some pairs/groups of students that were struck with the task.

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:

<p>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...</p> <p>221) Researcher 1: The main question to be answered is still this one (<i>she indicates question 1</i>). 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?"</p> <p>222) Teacher DV: Why do the suggestions focus on this?</p> <p>223) Researcher 1: What do these questions help to do? <i>Different students raise their hands.</i></p> <p>224) Carlo: Because they help you understand the distance in the period between 50s and 70s. Because, at 70s, he is nearer...</p> <p>225) Researcher 1: So you are saying that it enables to look at the distance. Aren't you?</p>	<p>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.</p>
226) Teacher DV: And why does it (<i>the</i>	Teacher DV (line 224) focuses on another

<p><i>help</i>) suggest that Tommaso is moving on a straight road?</p> <p>227) Carlo: Because it wants to make us reason on the fact that he is going back.</p> <p>228) Researcher 1: What mistake couldn't be done if I remember that the road is straight?</p> <p><i>Silence.</i></p> <p>229) Researcher 1: If I don't know that the road is straight, what could I think?</p> <p><i>Anna mimes a curvy road with her hands.</i></p> <p>230) Arturo: I could think that the sensor initially indicates a direction, then he goes on the right...</p> <p>231) Teacher DV: So a change in the direction.</p> <p>232) Researcher 1: That we are zigzagging, in a strange way.</p> <p>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.</p>	<p>suggestion that is given in worksheet 1A. Researcher 1 (lines 226-227) aims at making students reflect on the possible misinterpretations that this suggestion wants to prevent.</p> <p>Strategy 3 is therefore activated, since feedback about the processing of the task are given.</p> <p>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.</p> <p>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.</p>
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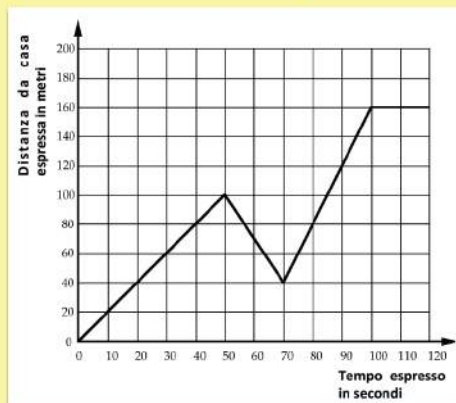
When the discussion on worksheet 1 ends, we send worksheet 2 to the students, stressing on the importance of proposing a justification that is *complete from the mathematical point of view*, a learning criterion which is once again made explicit to the students.

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.

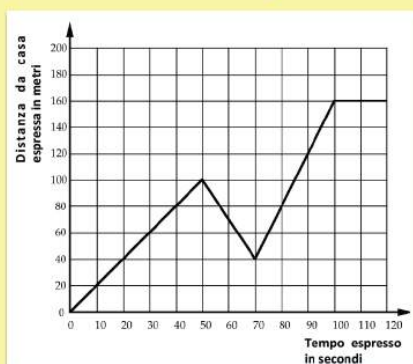
We observe that, in other classes, some students did not understand the meaning of “the last 20 seconds”. Stefano intervenes to say that it means the period of time from 100s to 120s.

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.



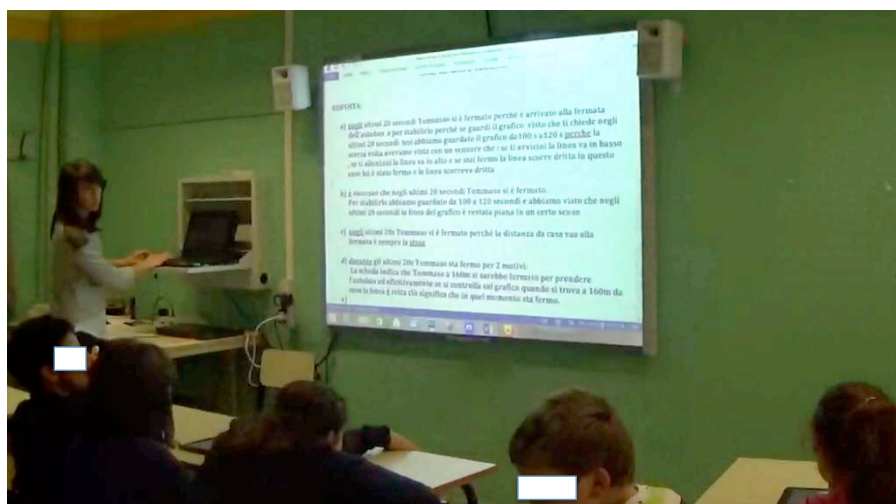
Domanda 2: Cosa è successo durante gli ultimi 20s?

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 da 100 s a 120 s perché la scorsa volta avevamo visto 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 stessa
- 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 è 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.

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

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.

<i>Transcript</i>	<i>Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback</i>
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? <i>Stefano and Sabrina raise their hands.</i> 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! <i>Sabrina speaks quietly to Stefano, indicating the IWB.</i> 299) Researcher 1: What did you want to say? <i>Stefano looks at the IWB.</i> 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.	In front of Stefano's disorientation (line 297), researcher 1 (lines 301-303-306) tries to activate Sabrina <i>as an instructional resource for her classmates (Strategy 4)</i> , asking her to widely explain the reasoning subtended to their answer.

305) Sabrina: Because, in the graph...	
306) Researcher 1: Come to the IWB. Looking at the graph, maybe, could help you.	
<p><i>Sabrina comes next to the IWB.</i></p> <p>307) Teacher DV: Now Sabrina tries to explain. Maybe someone did not understand what they (<i>Sabrina and Stefano</i>) wanted to say...</p> <p>308) Sabrina: From here (<i>she indicates the point (100,160), then she traces the segment from the point (100,160) to the point (0,160)</i>), the distance is always 160 from home.</p> <p>309) Teacher DV: Noé, did you understand what she wanted to show?</p> <p>310) Sabrina: And the line (<i>she indicated the horizontal segment from (100,160) to (120,160)</i>) is not descending, nor ascending, so the distance, in our opinion, is always the same.</p> <p>311) Teacher DV: Noé, so do you think that (<i>Sabrina</i>) is right or not?</p> <p>312) Chorus: She is right!</p> <p>313) Noé: Yes, she is right!</p> <p>314) Teacher DV: So, Noé, what is the distance from home, during those 20 seconds?</p> <p>315) Noé: 160.</p> <p>316) Teacher DV: Does it change?</p> <p>317) Noé: No.</p> <p>318) Anna: It (<i>answer C</i>) is right!</p>	<p>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.</p> <p>This excerpt highlight, therefore, that Sabrina's interventions (line 308-310) actually represented a <i>feedback about the processing of the task</i> for her classmates.</p> <p>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).</p>

Teacher DV reads answer D:

D) During the last 20s, Tommaso stopped for two reasons:

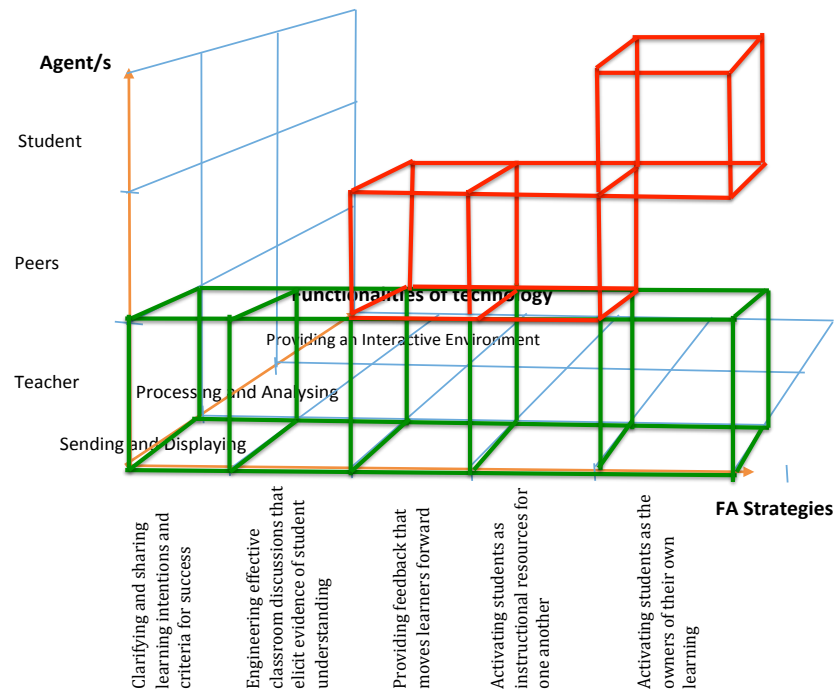
The worksheet says that Tommaso has to stop at 160m, to take the bus. Actually, if you check on the graph when Tommaso is at 160m from home, the line is straight, so it means that, in that moment, he stops.

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:



2.2 Lesson 2

<i>Length of lessons, date & time</i>	5th November 2015, 2 hours (10.30-12.30)
<i>Year group & class size</i>	5A (grade 5) – 27 students
<i>Objectives & lesson theme</i>	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”.
<i>Tasks used</i>	Worksheets 2A – 3 – 4 – 4A
<i>Resources used</i>	<ul style="list-style-type: none">• 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.

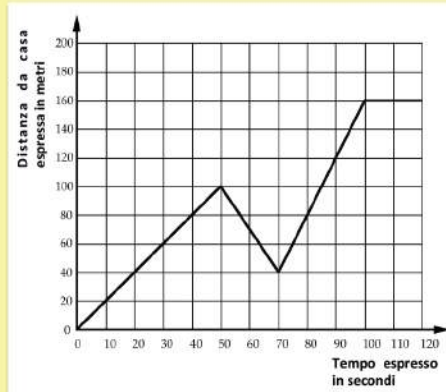
Worksheet 2 is projected on the IWB to resume what was done during the previous lesson (lesson 1). Since Elisabetta and Valeria were not present during lesson 1, Teacher DV asks to the rest of the class to explain them how they reasoned to answer the questions in the worksheets 1 and 2. Moreover, Teacher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

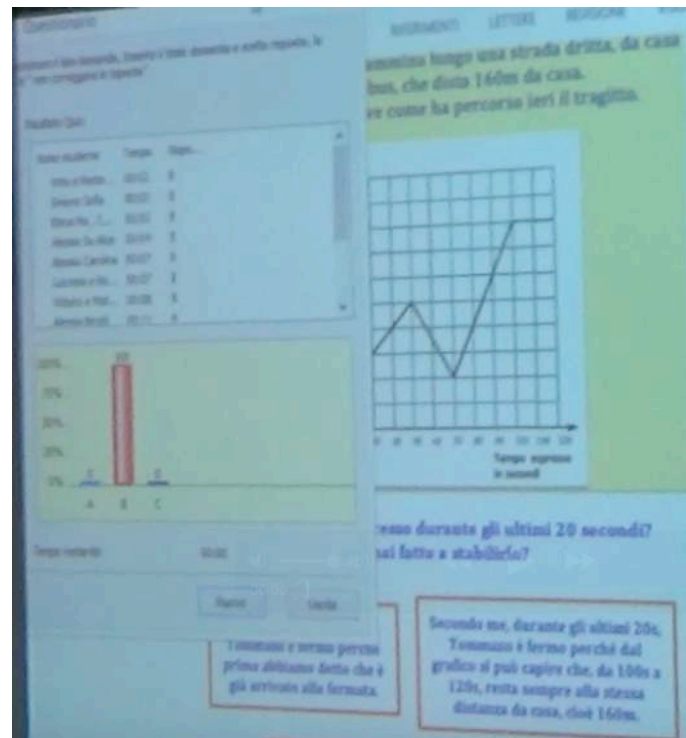
We tell students that we will denote:

- 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.

<i>Transcript</i>	<i>Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback</i>
<p>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.</p> <p>69) Researcher 1: You said: “We rejected both A and C because neither of them referred to the distance”... from where?</p> <p>70) Veronica : From Tommaso’s home.</p> <p>71) Researcher 1: From Tommaso’s home to the bus stop. Ok...</p> <p>Sabrina raises her hand.</p> <p>72) Teacher DV: What do you want to say, Sabrina?</p> <p>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"</p>	<p>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).</p> <p>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).</p> <p>In particular, Researcher 1’s intervention on the discussion developed during the previous lesson (line 74) represents both a <i>feedback about the processing of the task</i> and a <i>feedback about self-regulation</i>.</p>

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?	
<i>Anna raises her hand.</i> 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 (<i>with the hand she traces an horizontal line</i>). 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.

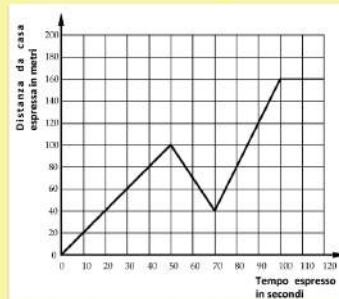
Carlo adds that answer A gives an unacceptable justification because it is based on something that was said by someone else and not on a real understanding. Elisabetta points out that answer B is more complete because it tells how far Tommaso is from home during the period from 100 to 120 seconds. Other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

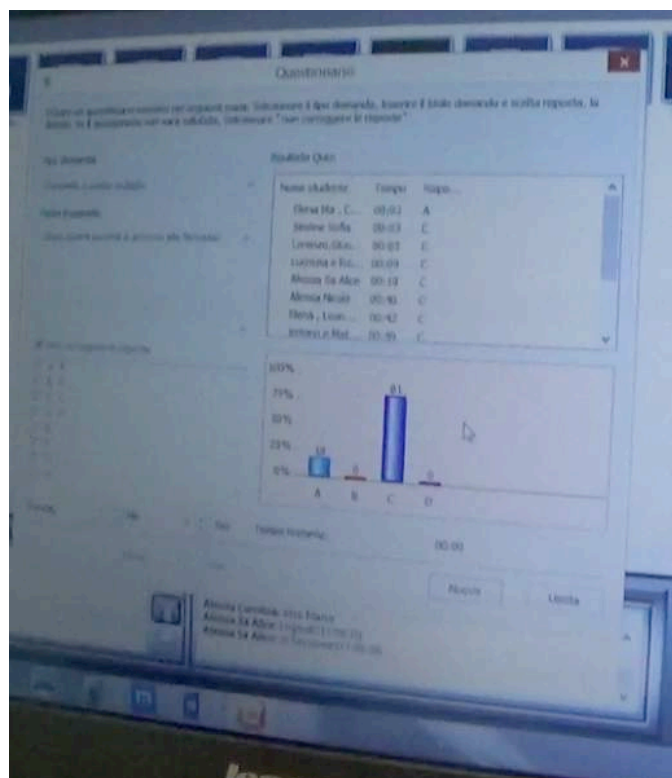
The aim is, therefore, to activate **strategies 2** (*Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding*) and **3** (*Providing feedback that moves learners forward*).

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.

<i>Transcript</i>	<i>Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback</i>
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<p>130) Rodolfo: So... he starts from 50s (<i>with his finger, he traces the segment from the point (0,0) to the point (50,100)</i>), then we add 20s (<i>with his finger, he traces the segment from the point (50,100) to the point (70, 40)</i>), that is 50 plus 20 equals 70. Then he moves and you arrive at 100 (<i>with his finger, he traces the segment from the point (70,40) to the point (100, 160)</i>), so we add other 30s. 70 plus 30 is 100. And then he stops.</p> <p>131) Researcher 1: So you split the time ... You say: to complete the first part it takes him 50s (<i>she points, with two fingers, at the two ends of the segment (0,0)-(50,0)</i>), to complete the second (<i>part</i>) (<i>she points, with two fingers, at the two ends of the segment (50.0)-(70.0)</i>), it takes him...</p> <p>132) Rodolfo: 20</p> <p>133) Researcher 1: And we get to 70 ... To complete the third (<i>she points, with two fingers, at the two ends of the segment (70,0)-(100,0)</i>) it takes him ...</p> <p>134) Rodolfo: 30</p> <p>135) Researcher 1: ...and I get to 100.</p> <p>136) Researcher 1: Ad why are you sure that ... (<i>indicating the point (100,160)</i>)</p> <p>137) Rodolfo: Because then he stops and does not walk anymore.</p> <p>138) Researcher 1: So, you say: if he stops, it means that he has reached the bus stop for sure ...</p>	<p>This brief excerpt highlights how Rodolfo has activated himself as the owner of his own learning (strategy 5).</p> <p>In his interventions (lines 130, in particular), in fact, he clearly presents the reasoning he constructed to identify the correct answer.</p> <p>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).</p> <p>Line 137 highlights a possible source of misconception: the idea that Tommaso has reached the bus stop because, then, he stops.</p> <p>Researcher 1 is aware of this, as it will be evident in the following excerpt.</p>
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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
<p>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?</p> <p>149) Sabrina: Over there (<i>pointing at the graph</i>).</p>	<p>Researcher 1 (line 148) proposes a possible doubt to the class, in order to activate the students <i>as owners of their own learning</i> (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).</p>

<p>150) Researcher 1: Come next to the IWB to show it. <i>Sabrina goes next to the IWB.</i> 151) Sabrina: Because, here, is at 160m (<i>with her finger, she traces the segment from the point (120,160) to the point (0, 160)</i>) and, above (<i>pointing at the text of the problem</i>), 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!</p>	<p>Sabrina (line 151) shows to have 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 <i>instructional resource for her classmates (strategy 4)</i> 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).</p>
<p>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 (<i>referring to Elisabetta-Arturo-Luca</i>) 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.</p>	<p>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.</p>
<p>167) Vincenzo: However the graph could</p>	<p>Vincenzo (lines 167-170) recalls the</p>

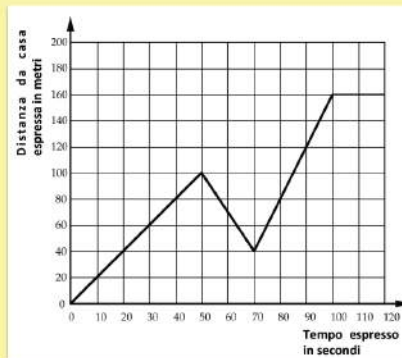
<p>also have been interrupted, for example... when the time ran out, it stopped recording... the child may also have stopped to tie his shoes, then, as he was tying his shoes, the time ran out...</p> <p>168) Anna: No, no, no!!!</p> <p>169) Teacher DV: Let him finish, then we listen to those who are saying “no”.</p> <p>170) Vincenzo: So, the rest of the path was not recorded. ... However, if he is at 160, he has arrived at the bus stop.</p> <p>171) Researcher 1: He says: It is 160 that convinces me.</p>	<p>experience with the motion sensor to 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.</p> <p>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 <i>as an instructional resource for his classmates (strategy 4)</i>.</p>
<p>172) Researcher 2: Someone said “no”. It's interesting, when someone says “no”, to find out why.</p> <p>173) Researcher 1: Why do you say “no” to what he said ...?</p> <p>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...</p> <p>175) Teacher DV: You stopped him too early. You did not give him the possibility to finish his reasoning ...</p> <p>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?</p> <p>177) Carlo: The text.</p> <p>178) Researcher 1: Don't trust the text too much, however. Sometimes...</p> <p>179) Teacher DV: In fact, he said: the text tells about the 160m...</p> <p>180) Researcher 2: There are two aspects. One tells: you read it in the text...which is a way...</p> <p>181) Researcher 1: Sometimes we should trust the text, sometimes not...</p> <p>182) Researcher 2: And then you check the graph.</p> <p>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.</p>	<p>During this part of the discussion, Teacher DV and the researchers activate strategy 3, giving two different feedbacks:</p> <ul style="list-style-type: none"> - 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:

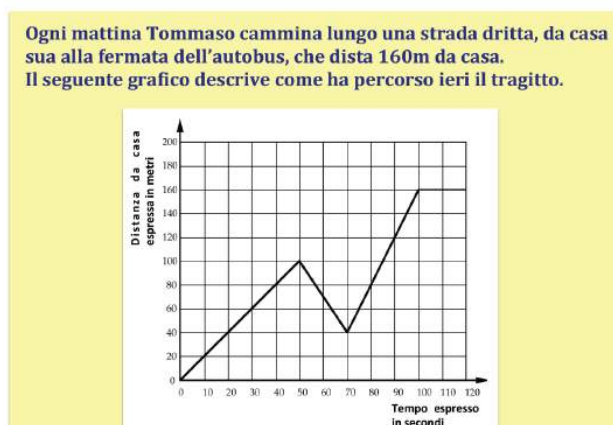
Teacher DV reads again the text of the problem and the question: "*Does he walk for 160m? Why?*"

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:

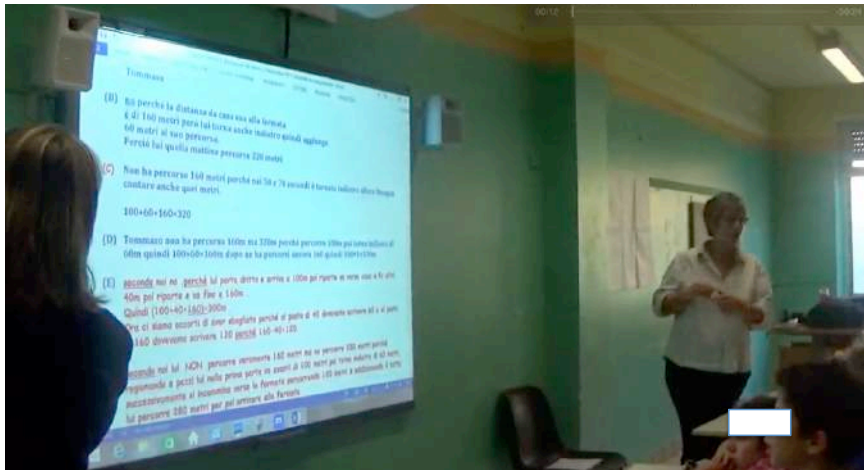
Scheda 4



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 $160 \times 2 = 320m$
- (E) secondo noi no ,perché 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 perché $160-40=120$.
- (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:

<i>Transcript</i>	<i>Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback</i>
<p>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.</p> <p>280) Carlo: This is the same reasoning we did!</p> <p>281) Stefano: However, we did it wrong. We've realized it now!</p> <p>282) Researcher 1: Ah? Have you realised it now?</p> <p>283) Stefano: Yes!</p> <p>284) Researcher 1: What did you write?</p> <p>285) Sabrina (<i>in pair with Stefano</i>): D was our answer! (<i>pointing at the IWB</i>)</p>	<p>In this excerpt it is evident that Stefano is activated as owner of his own learning (strategy 5).</p> <p>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.</p> <p>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).</p>

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 $160 \times 2=320m$.

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.

<i>Transcript</i>	<i>Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback</i>
<p>297) Researcher 1: They (<i>Stefano and Sabrina</i>) said they understood their mistake, and therefore they are going to tell us which mistake they made.</p> <p>298) Stefano: It is because we did 160 plus 160, which is 320. But it is wrong because...</p> <p>299) Researcher 1: So you have given the same answer they give. Haven't you? (<i>pointing at Vincenzo and Mirco</i>)</p> <p>300) Stefano: Yes, because we wrote 320. But... he walks, at the beginning, for 160 meters...</p> <p>301) Researcher 1: Wait. I'll show you the graph (<i>she projects the graph on the IWB</i>).</p>	<p>Two main FA strategies are activated:</p> <ul style="list-style-type: none"> - 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.

<p>302) Stefano: Initially, he walks for 160 meters (<i>with the finger he quickly traces, the segment from the point (50,100) to the point (70,40), then the segment from the point (70,40) to the point (100,160)</i>). However, from 40 to 160, there is 120, then 160 plus ...</p> <p><i>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:</i></p>	
<p>332) Teacher DV: Why? How do you know this? Explain it to Vincenzo! What calculation have you done?</p> <p>333) Sabrina: Because, from 100 (<i>indicating 100 on the vertical axis</i>), he walked for 60 meters (<i>with her finger, she traces, on the vertical axis, the segment from 100 to 40</i>) and arrived at... (<i>she indicates 40 on the vertical axis and then she traces, with her finger, the segment between (0,40) and (70,40)</i>).</p> <p>334) Teacher DV: Where does he arrive...? You see it on the graph.</p> <p>335) Sabrina (<i>pointing at 40, on the vertical axis</i>): At 40 metres.</p> <p>336) Teacher DV: From 40 to... (<i>Sabrina indicates the point (70,40)</i>)</p> <p>337) Sabrina and Stefano: To 160 (<i>Sabrina indicates 160 on the vertical axis</i>).</p> <p>338) Teacher DV: So, how many meters has he walked through? What calculation do you have to do?</p> <p>339) Stefano: It is 120 metres.</p> <p>340) Sabrina: It is 160 minus 40.</p> <p>341) Teacher DV: That is 120. Ok?</p> <p>342) Stefano: So, then you have to do...</p> <p>343) Teacher DV: During the last 20 secondi, then, what does he do?</p> <p><i>Sabrina indicates the segment between the point (100,160) and the point (120, 160).</i></p> <p>344) Vincenzo: He stops!</p> <p>345) Stefano: He stops!</p> <p>346) Teacher DV: He stops. ...so ...the sum is...?</p> <p>347) Stefano: 160 plus 120 ... that is 280. ... so we got wrong, but now we have understood.</p>	<p>Also in this phase of the discussion, Sabrina and Stefano are activated as instructional resources for the other students (strategy 4).</p> <p>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).</p>

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 $(100+40+160)=300\text{m}$

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.

<i>Transcript</i>	<i>Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback</i>
<p>362) Marianna: Because the first piece (<i>with her finger, she traces the segment between the point (0,0) and the point (50,100)</i>) is till 100 (<i>indicating the point (50,100)</i>), then he goes back (<i>with her finger, she traces the segment between the point (50,100) and the point (70,40)</i>) and reaches 40 (<i>with her finger, she points the segment between (70,40) and (0,40)</i>). And then he starts again (<i>she moves her finger on the segment between the point (70,40) and the point (100,160)</i>) and gets to 160 (<i>with her finger, she traces the segment from the point (100,160) to the point (0,160)</i>). We did like this...</p> <p>363) Researcher 1: Is it why you wrote those three numbers over there? (<i>She is referring to 100, 60 and 160</i>)</p> <p>364) Marianna: Yes.</p> <p>365) Researcher 1: 100, I read it here (<i>she traces, with her finger, the segment from (50,100) to (0,100)</i>); 40, I read it here (<i>she traces, with her finger, the segment from (70,40) to (0,40)</i>) and 160, I read it here (<i>she traces, with her finger, the segment from (100,160) to (0,160)</i>).</p> <p>366) Researcher 1: Why did you later change your mind?</p> <p>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.</p> <p>368) Researcher 1: This is why, at the beginning, instead of writing the distance Tommaso walked</p>	<p>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.</p> <p>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).</p>

<p>through, ... what did you write?</p> <p>369) Researcher 1: What is 40? (<i>pointing at 40 on the vertical axis</i>)</p> <p>370) Teacher DV: The distance...</p> <p>371) Marianna: The distance from home.</p> <p>372) Researcher 1: Instead of the distance Tommaso walked through, you wrote the distance from home.</p> <p>373) Researcher 1: Even here (<i>she first indicates the point (100,160), then she traces, with her finger, the segment from (100,160) to (0,160)</i>), what 160 represents?</p> <p>374) Marianna: It is the distance from home.</p>	
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We read the last two 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

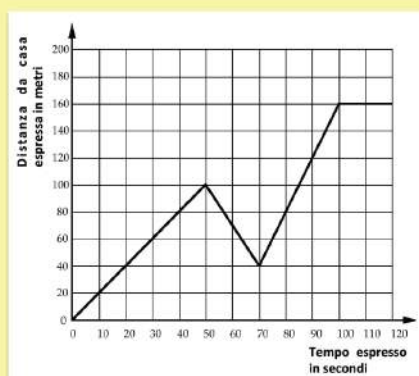
We project worksheet 4A, in particular Anna and Claudia's worksheet:

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**).

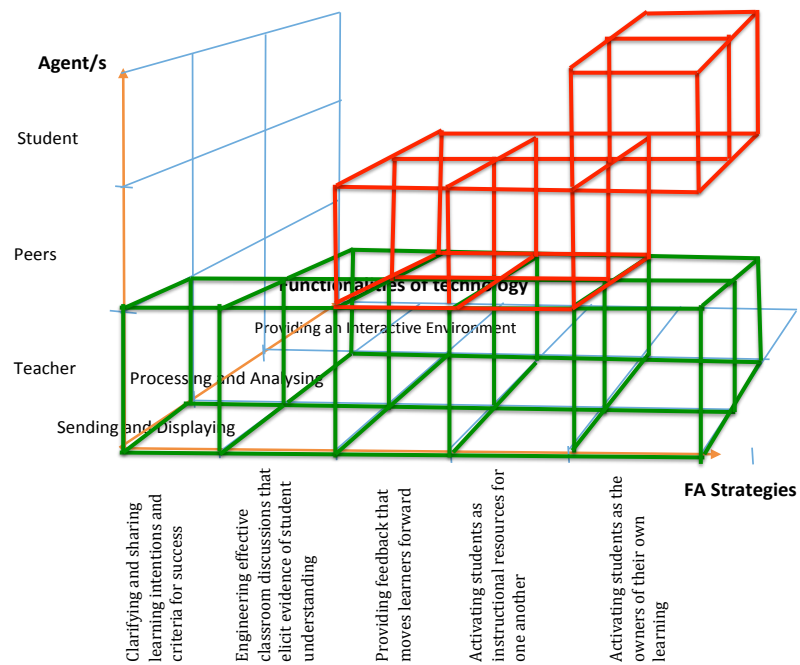
Carlo asks to approach the IWB to explain why he considers this helping worksheet effective.

Transcript	Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback
<p>453) Carlo: Maybe someone...could say that (Tommaso) walks for 160m (<i>with his finger, he traces the segment from the point (0,160) to (100,160)</i>) ... 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 (<i>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)</i>) and then you calculate...</p> <p>454) Teacher DV: The sum.</p> <p>455) Carlo: The sum.</p> <p>456) Researcher 1: He says: these questions enables you to split your reasoning.</p> <p>457) Carlo: Yes.</p> <p>458) Researcher 1: Do those who raised their hands before want to add something?</p> <p>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...</p>	<p>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.</p> <p>Since feedback about self-regulation are given, strategy 3 is activated.</p> <p>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”.</p>

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.



2.3 Lesson 3

<i>Length of lessons, date & time</i>	9th November 2015, 2 hours (14.15-16.15)
<i>Year group & class size</i>	5A (grade 5) – 27 students
<i>Objectives & lesson theme</i>	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”.
<i>Tasks used</i>	Worksheets 5 – 6
<i>Resources used</i>	<ul style="list-style-type: none">• 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.

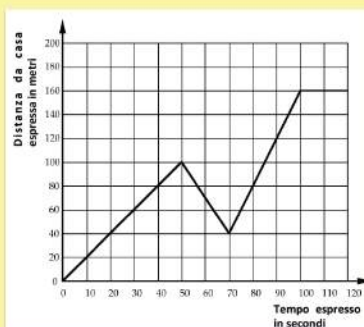
At the beginning of lesson 3, the worksheet 5 is projected on the IWB.

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:

<p>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 delle merende aperta allora intuì che si indietreggiò aveva perso la merenda allora tornò indietro recuperò la merenda, chiuse la tasca e si ziazzò verso la fermata dell'autobus, arrivò alla fermata Tommaso si sedette su una panchina e per aspettare l'autobus chiacchiò con gli amici.</p>	<p>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.</p>
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Transcript	Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback
<p>11) Researcher 1: Before telling other stories, tell me if this story can be ok. 12) Chorus: Yes.</p>	<p>Researcher 1's intervention (line 11) is aimed at activating students as instructional resources for one</p>

<p>13) Valeria: Yes, but at the beginning she didn't say that...she's soon jumped at the piece (<i>of the graph</i>) in which he (<i>Tommaso</i>) came back. <i>Voices</i>.</p> <p>14) Researcher 1: So what did she have to add?</p> <p>15) Valeria: That he walked from home...</p> <p>16) Researcher 1: That he went out from home, maybe? That he has walked? <i>Valeria nods</i>.</p> <p>17) Researcher 1: And the accident that happened to Tommaso? Did he lose his snack, come back, take it, close his pocket... (<i>miming the scene with gestures</i>)?</p> <p>18) Vincenzo: Eh, no!</p> <p>19) Sabrina: Because...</p> <p>20) Researcher 1: Let's listen to Sabrina.</p> <p>21) Sabrina: Because, if not, there would be a line... (<i>gestures with her finger an horizontal segment</i>) horizontal.</p> <p>22) Researcher 1: Where would it be? Come and show us. <i>Sabrina come to the IWB.</i></p>	<p>another (strategy 5).</p> <p>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).</p> <p>This leads Sabrina to activate herself as an <i>instructional resource for her classmates</i>. 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.</p>
<p>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)).</p> <p>24) Chorus: No!!!</p> <p>25) Researcher 1: Where would it be? Would it be here? ...(tracing an horizontal segment with her finger, from the point (50,100) to the point (70,100)). <i>Some students answer "yes".</i></p> <p>26) Chorus: No, no! Below!!!</p> <p>27) Researcher 1: They say below...but below where? <i>Livio raises his hand.</i></p> <p>28) Researcher 1: Livio? <i>Livio comes at the IWB.</i></p> <p>29) Livio: Here... (<i>tracing an horizontal segment with his finger, from the point (70,40) to the point (90,40)</i>).</p> <p>30) Researcher 1: Why do you say that it should be there?</p> <p>31) Livio: Because here (<i>indicating the point (70, 40)</i>) he took up his snack, then he closed his pocket ...(tracing an horizontal segment with his finger, from the point (70,40) to the point (90,40)) and then (<i>tracing a vertical segment with his finger, from the point (100,40) to the point (100,160)</i>).</p> <p><i>Anna suggests that, maybe, Tommaso closes his bag while he is walking.</i></p>	<p>This excerpt highlights that strategies 4 and 5 are effectively activated:</p> <ul style="list-style-type: none"> - 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.

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

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

<p>RISPOSTA: Tommaso cammina verso la fermata dell'autobus e non si accorge che gli è caduto il portapenne, dopo controlla se ha tutto nello zaino e si accorge che non ha il portapenne e ritornerà indietro pensando che l'aveva dimenticato a casa però si accorge che era sul marciapiedi lo prende, va verso la fermata, correndo per non perdere l'autobus.</p> <p>Giacca con il fiatore e si ferma per allacciarsi scarpe e va nell'autobus.</p>	<p>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 his pencil case at home, but he finds it on the pavement. He takes it, he runs toward the bus stop, otherwise he can lose the bus. He arrives at the bus stop, stops to tie his shoes and gets on the bus.</p>
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Transcript	Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback
<p>99) Noé: Our mistake was that, when he (Tommaso) checks in his backpack, ... he cannot check while he is walking.</p> <p>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?</p> <p>Noé goes next to the IWB.</p> <p>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.</p> <p>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)).</p>	<p>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.</p> <p>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.</p>

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

<p>RISPOSTA: È PARTITO DA CASA SUA E SI È ALLONTANATO DI 100M. POI È RITORNATO INDIETRO DI 60M PERCHÉ SI È ACCORTO DI AVER LASCIATO SU UNA PANCHINA LA MERENDA. POI SI È 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.</p>	<p>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.</p>
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- 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.

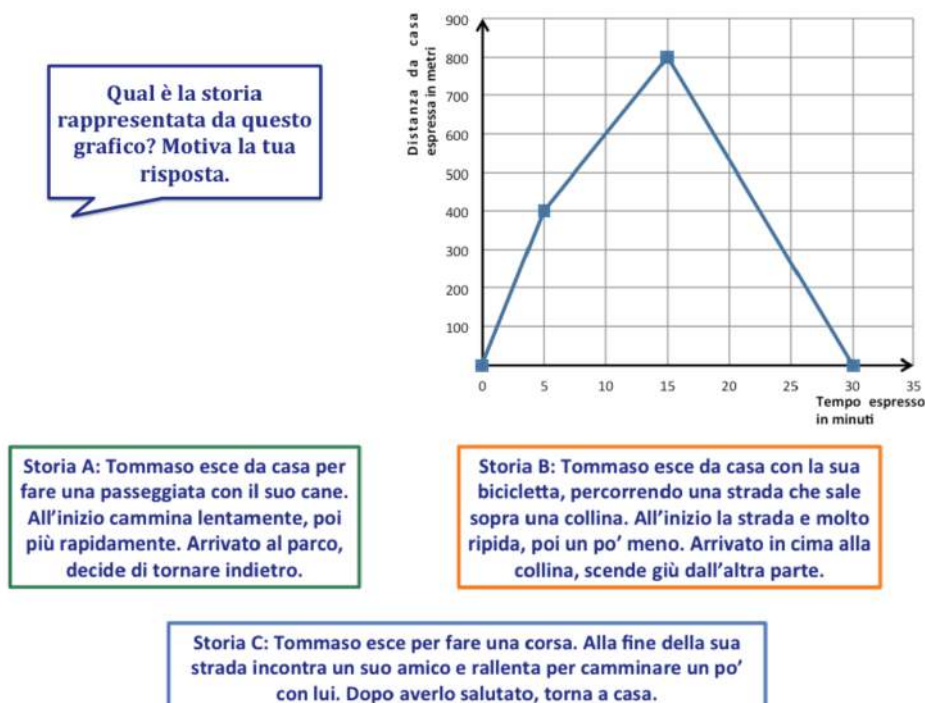
We also discuss if we can be sure that, after 120s, the bus arrives.

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



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 your 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).

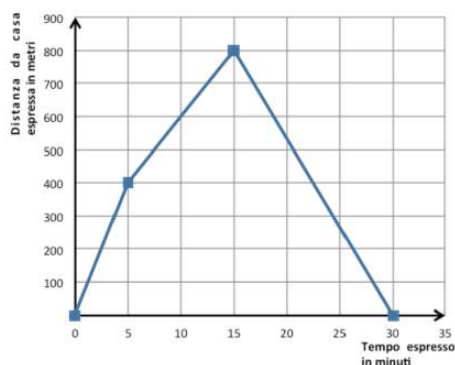
We read the three stories and tell the students to think about the possible matching and to justify their answers. We also remind them that, if they face some difficulties, they can ask for the "helping worksheets".

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
<p><i>Sabrina raises her hand.</i> 347) Sabrina: (<i>The story</i>) 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".</p>	<p>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.</p>
<p>349) Researcher 1: There is also another reason why (<i>the story</i>) B is not right... Let's look at the graph for a while. Let's see if you can find it (<i>the other reason</i>) looking at the graph. Why B is not right? <i>Many pupils raise their hands.</i> 350) Researcher 1: A lot of hand have been risen. Who can start (<i>speaking</i>)? 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 (<i>he is referring to story B</i>)... <i>Voices.</i> 352) Researcher 1: Wait (<i>speaking to the other students</i>). Maybe I understood what Giacomo wants to say. He says: here we can read "he walked home" (<i>she indicates this sentence in the story C</i>). Here you can read "he goes back" (<i>she indicates the sentence in the story A</i>). Here (<i>she indicates the story B</i>) you cannot find it. ...Why is it not correct that "he goes back home" is not written in this story? (<i>speaking to Giacomo</i>) <i>Giacomo remains silent.</i> 353) Researcher 1: Why do you say that it is not correct that here we cannot find the sentence "he goes back home"? (<i>to Giacomo</i>) 354) Giacomo: Because, over there, we can find that (<i>the line</i>), then, goes down (<i>he</i></p>	<p>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.</p>

<p><i>indicates the graph on the IWB).</i></p> <p>355) Researcher 1: You say: here, the graph is going down (<i>she moves her finger along the last part of the graph, that is the segment from the point (15,800) to the point (30,0)</i>), it goes down toward the horizontal axis. What does it tell us?</p> <p><i>Giacomo remains silent.</i></p> <p>356) Researcher 1: What is Tommaso doing?</p> <p>357) Giacomo: He is going back...</p> <p>358) Teacher DV: Good!</p>	
<p>359) Researcher 1: Let's listen to other observations.</p> <p>360) Teacher DV: Did you listen to what Giacomo said? ...I don't know. Someone, in my opinion, lost himself.</p> <p>361) Carlo: Can I explain it?</p> <p>362) Researcher 1: Carlo is going to explain what Giacomo said.</p> <p>363) Carlo (<i>speaking with his classmates</i>): Because Giacomo said that, in the answers (<i>he means the stories</i>) 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.</p> <p>364) Teacher DV: Instead of "It doesn't specify"...</p> <p>365) Researcher 1: Doesn't B only specify it? It tells something that contradicts...</p> <p><i>Livio, Adriana, Ambra raise their hands. We let Ambra speak.</i></p> <p>366) Ambra: It tells that ...that it goes down to the other side. It seems a hill (<i>she is referring to the graph</i>), so it goes down to the other side. But ...</p> <p>367) Noé: It is a graph, not a hill!</p> <p>368) Researcher 1: Noé says: "it is a graph, not a hill".</p> <p>369) Noé: Because...</p> <p>370) Researcher 1: Then, if Tommaso went down to the other side, ...?</p> <p>371) Ambra: He wouldn't come...</p> <p>372) Arturo: He wouldn't be at home.</p> <p>373) Valeria: Yes! ... and, in C, you can read "he goes back home".</p> <p>Eh, yes! ...and then, in C, it's written "he comes back home".</p>	<p>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 <i>an instructional resource for the other students (strategy 4)</i>. This enables the rest of the class to take the responsibility of their own learning (<i>strategy 5</i>), as Ambra (line 366), Noé (lines 367), Arturo's (line 372) and Valeria's (line 373) interventions testify.</p>

374) Researcher 1: He (<i>indicating Arturo</i>) says: “he wouldn’t be at home”.	
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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.

<i>Transcript</i>	<i>Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback</i>
468) Noé: Now I have noticed that, the last part ... at the park, Tommaso decides to go back home” (<i>he indicates the story A</i>). ...Also here (<i>indicating C</i>): “When Tommaso left his friend, he walked back home”. 469) Researcher 1: And what justification did you (<i>Noé and Andromeda</i>) write? (<i>She looks through the file projected one the IWB, until she finds and projects Noé and Andromeda’s answer</i>)	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.

<i>Transcript</i>	<i>Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback</i>
<p><i>We let Adriana start speaking.</i></p> <p>488) Adriana: In my opinion, C is right because...</p> <p>489) Researcher 1: Come and show it.</p> <p><i>Adriana goes next to the IWB.</i></p> <p>490) Adriana: In my opinion, he (Tommaso) initially goes faster (<i>she indicates the segment from the point (0,0) to the point (5,400)</i>), then he goes slower (<i>she indicates the segment from the point (5,400) to the point (15,800)</i>), because here it takes him 5 minutes (<i>indicating 5 on the horizontal axis</i>) to walk for 400m (<i>indicating 400 on the vertical axis</i>). Then it takes him 10 minutes (<i>indicating the segment from the point (5,0) to the point (15,0)</i>) to walk, again, for 400m.</p> <p>So he initially goes faster, then he slows down because he meets his friend.</p> <p>491) Researcher 1: Have you understood what she said? (<i>to Noé</i>)</p> <p>492) Noé: Yes.</p> <p>493) Researcher 1: Do you agree with her? (<i>to Noé</i>)</p> <p>494) Noé: Yes.</p> <p>495) Researcher 1: So, what is the period of time in which Tommaso walk faster? (<i>to Noé</i>)</p> <p>496) Noé: The period from 0 to 5 minutes.</p> <p>497) Researcher 1: From 0 to 5 minutes.</p>	<p>This excerpt testifies how the reflections developed during the discussion enable the students, the teacher and the researchers to provide important <i>feedback to one another (strategy 3)</i>.</p> <p>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).</p>

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 he goes back for 800m in 15 minutes, running.

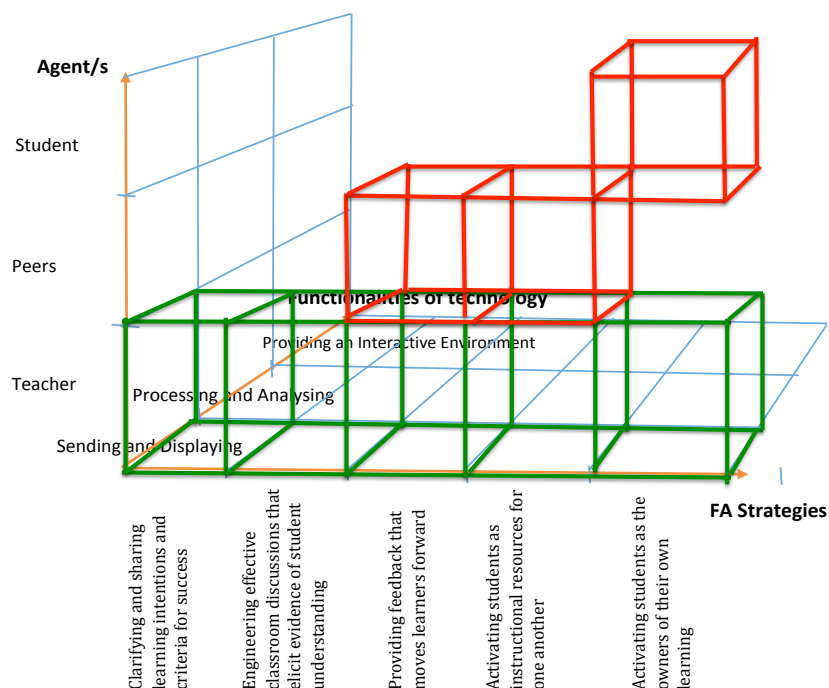
We say that Livio and Giacomo sent us their answer very soon, so, for this reason, we suggested them to check it again. Livio and Giacomo explain to the other pupils what part of their answers they corrected after they re-checked it. Livio observes that they initially erroneously interpreted the meaning 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 network¹. 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 required 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 student 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:

<i>View on mathematics</i>	<i>View on technology</i>
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 (<i>our adaptation of "For me, the technology does not work, or help"</i>) Using IDM-TClass during mathematics lessons helps to understand what the teacher wants us to learn. [<i>for grade 7, it was phrased as: Using IDM-TClass during mathematics lessons helps me to better understand the objectives of the activities</i>]

<p>I am good at mathematics.</p> <p>When I work on my own I learn better mathematics</p>	
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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:

<i>Completely agree</i>		<i>Not completely agree</i>		<i>Completely disagree</i>	
<i>Mathematics</i>	<i>Technology</i>	<i>Mathematics</i>	<i>Technology</i>	<i>Mathematics</i>	<i>Technology</i>
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	Only few people can understand mathematics	Using IDM-TClass during mathematics lessons is useless

			she uses IDM-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:

<i>Completely agree</i>	<i>Not completely agree</i>	<i>Completely disagree</i>
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 of 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:

<i>Completely agree</i>	<i>Not completely agree</i>	<i>Completely disagree</i>
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.

CASE STUDY 2 - Istituto comprensivo di Carcare

REPORT OF THE ACTIVITIES

This part consists of 4 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

1.1 School Context – Scuola Secondaria di I Grado “G. Mameli”

School name	Istituto Comprensivo di Carcare – Scuola Secondaria di I Grado (lower secondary school) “Goffredo Mameli”
Subject (Maths/physics/biology/chemistry)	Mathematics
Activities used	Our adaptation of the activity “ <i>Interpreting Distance-Time Graphs</i> ”, from the Mathematics Assessment Project
Technology/tools used	The networked classroom technology IDM-TClass
School Context	
School Roll (number of pupils)	Approximately 1100 students in all the Istituto Comprensivo.
Staff Roll (number of teaching staff)	4 mathematics and science teachers in the lower secondary school “Mameli”
Geographical location (urban/rural, etc.)	Rural
Relationship to other schools (e.g. cluster/Feeder/Part of a group of schools)	Cluster of kindergarten, primary and lower secondary schools. It is an Istituto Comprensivo, this

	means that it is organized in different school levels, from kindergarten to primary school (grade 1-5) to lower secondary school (grades 6-8), all under the same school Head. Due to the nature of the municipality, which is located in small mountains, the Institute is organized in 12 schools, located also in the nearby (municipalities of Altare, Cosseria, Mallare, Pallare, Bormida, Plodio).
Age range	3-14
Single or mixed gender	Mixed gender
Ethnicity	There are children of immigrant families (from Eastern Europe, Africa and South America).
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)	In the past, the area was developed due to some industries, but now it suffers the economic crisis. The lower secondary school is the only one in the area; there are students from different social classes.
How the school is judged to be performing in local context	The school is the only one in the area. The school is judged a good quality one in the region.
Past experience of using formative assessment	No specific project concerning formative assessment.
Past experience of using technologies/tools	All the classes of the lower secondary school are equipped with an interactive whiteboard and all lessons are performed using it. All the mathematics teachers followed teacher training programs on the use of new technologies. The school was one of the centers for teacher professional development (projects <u>M@t.abel</u> and project ISS for mathematics and science); it hosted the main project on the use of interactive whiteboard and connected classroom technologies in Italian schools (projects LIM and

	Cl@ssi 2.0).
Previous experience of working within other research projects	The Institute is currently collaborating with the University of Genoa on a long-term project on argumentation and mathematical proof titled “Language and argumentation”.

1.2 Teacher demographic (Monica Testera - MT)

Subject area (science or mathematics)	Science and Mathematics
Role (e.g. Head of Department/Teacher, etc.)	Teacher; Assistant of the Head of the Istituto Comprensivo, with responsibility for the lower secondary school “Goffredo Mameli”; Head of the mathematics and Science Department of the school “Goffredo Mameli”
Gender	Female
Age range (under 20; 21-30; 31-40; 41-50; 51-60; over 60)	51-60
How long has he/she been teaching	Since 1986
How long has/she been working at this school	Since 2005
Past experience of using formative assessment within lessons	No specific project, but formative assessment characterizes her way of teaching (see the interview to the teacher in paragraph 3).
Past experience of using technologies/tools within lessons	She regularly uses interactive whiteboard. She was involved in the project “Classi 2.0”, funded by the Ministry of Education. She planned and implemented activities with the use of new technologies in mathematics.
Past experience of working in a research project	She is currently involved in the “Language and argumentation” project with the University of Genoa, aimed at planning, implementing and

	analysing teaching activities with a focus on argumentation.
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1.3 Class demographic

Class	2A – IC Carcare
Age range	11-12
Number of students in the class	22
Gender split within class (male/female)	12 males, 10 females
Ethnicity	One student comes from South America.
Mixed ability or ability set	Mixed ability class
Any relevant contextual information	<p>The students work well together, there is a good climate.</p> <p>They are used to discuss and to group-work.</p> <p>Here are some information on the groups of students, as outlined by the teacher during the preparation and implementation of the activities.</p> <p>Group 1: Anita and Tina, Alice and Debby The first two students recently received a diagnosis of dyslexia. They work regularly with the other students; the teacher provides them help, when required, and proposes adapted tasks for individual assessment. They took part to all the FaSMEd activities. Alice is low achieving. Debby is intuitive and involved, but she suffers from frequent absences from school. They were put in the same group because of the frequent absences of Debby and the difficulties of Anita and Tina.</p> <p>Group 2: Mil and Pon. Low achieving students.</p> <p>Group 3: Olaf and Remo. Medium-achieving students.</p> <p>Group 4: Mark and Mario. Mark is medium-</p>

	<p>achieving, Mario is high-achieving but a very “traditional” student, he likes solving exercises by his own rather than taking part into the discussions. When the activity is less traditional, he is less involved and less brilliant.</p> <p>Group 5: Rob and Cate. High achieving students, they like taking part into discussion and argumentation activities.</p> <p>Group 7: Brown and Paul. Medium-high achieving students, they like taking part into discussion and argumentation activities.</p> <p>Group 8: Ur and Mary. Low achieving students, they get lost when faced to non procedural activities. Mary is very involved, and she produced interesting power presentation summarizing the experience with sensor detectors.</p> <p>Group 9: Lea and Em. Low-medium achieving students.</p> <p>Group 10: Lol and Lola. Medium achievers. Lola is good at maths but she doesn’t intervene very much.</p> <p>Group 11: Flo and Carlo. The two students have special needs. They are helped by a dedicated teacher, who assists them during the lesson. They took part to the FaSMEd activities with the help of their teacher, working willingly during group work. Their productions were not selected for discussion. They did not intervene into the discussions but listened to the discussions.</p>
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2. Report and analysis of three lessons

The case intervention under analysis refers to the second cycle of experimentation performed by the teacher MT.

Since in the first cycle of experimentation, performed with three classes of grade 7, we had observed that the students had worked mainly adopting a holistic view of the graph, rather than focusing on specific parts or points, in this second cycle the teachers proposed to anticipate worksheet 5, further modifying it (*“Every morning Tommaso walks along a straight road from home to a bus stop, a distance of 160 meters. The graph shows his journey on one particular day. Describe how Tommaso has walked on the road from his home to the bus stop. What could have happened to him?”*), so as to work primarily on a holistic comprehension of the graph.

Totally, 9 lessons were performed, and the following table provides an overview:

Lesson 0	October 13th, 2 hours		Activity with the motion sensor
Lesson 1	October 20th, 1 hour	Worksheet 5 and discussion	The students are given the graph, they are asked to reconstruct the story of Tommaso from a global point of view.
Lesson 2	October 27th, 2 hours	Worksheets 2A, 3 and 4 (each one followed by a discussion)	Specific questions on some parts of the graph representing Tommaso's journey
Lesson 3	November 3rd, 2 hours	End of discussion on worksheet 4. Worksheet 6 and discussion. Worksheet 6A assigned as homework	Students have to choose the corresponding story to a given graph.
Lesson 4	November 9th, 2 hours	Discussion on Worksheet 6A.	
Lesson 5	November 10th, 2 hours	Worksheet 7 and discussion	Students are required to match a set of cards of time-distance graphs with a set of cards with their possible interpretations
Lesson 6	November 16th, 2 hours	Discussion on worksheet 7	
Lesson 7	November 23rd, 2 hours	Individual written class test	The text of the class test contains also worksheet 8 (see below)*
Lesson 8	November 30th, 2 hours.	Discussion on the written test (including worksheet 8)	

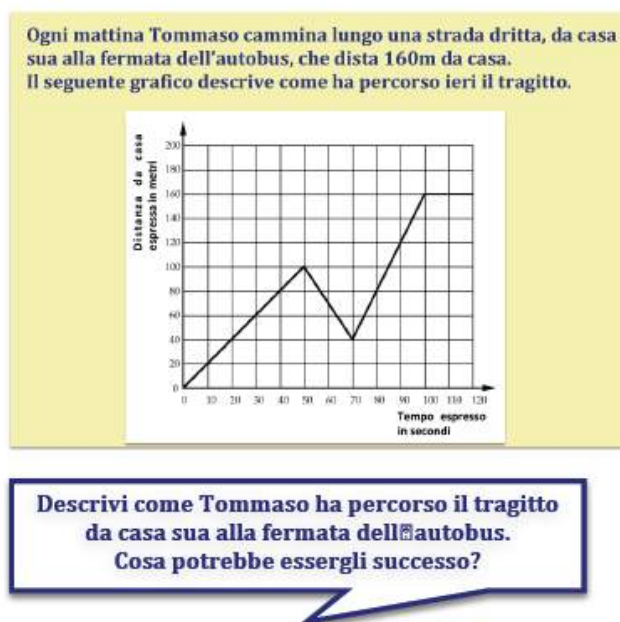
* After the task sequence on time-distance graphs, the teacher proposed an individual written class test containing three tasks inspired by the task sequence.

For this case study, we focus on the analysis of lesson 1, 2 and 3.

2.1 Lesson 1

The first episodes we analyze come from the lesson 1 (October, 20th). The students worked in small groups on the first worksheet (that corresponds to worksheet 5 of the task sequence described in the general part) for about 18 minutes. Here is the original worksheet 5 (adapted) as was sent to the groups, and the English translation of the text.

Scheda 1



“Every morning Tommaso walks along a straight road from home to a bus stop, a distance of 160 meters. The graph shows his journey on one particular day. Describe how Tommaso has walked on the road from his home to the bus stop. What could have happened to him?”

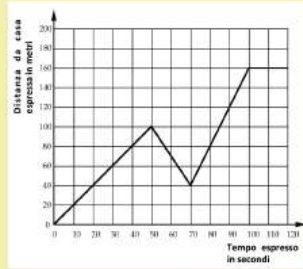
While the students were facing the task, the teacher and the two researchers monitored the groupwork through the IDM-TClass software, but also going directly to the groups' desks. Once produced a written answer, each group sent the document containing the answer to the teacher's laptop. In this way, the teacher could quickly read the answer and select some productions to start the discussion.

After all the groups have sent their work, the teacher shows to the whole class, using the **sending & displaying functionality of the technology**, some written productions. 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. Such productions are read and discussed by the whole class.

As a starting point, the teacher displays the written answer produced by Mil and Pon:

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.



Descrivi come Tommaso ha percorso il tragitto da casa sua alla fermata dell'autobus. Cosa potrebbe essergli successo?

RISPOSTA: Tommaso camminava lungo la strada fino a quando ha incontrato i suoi amici che gli hanno chiesto di andare con loro a scuola (allungando il tragitto). Quindi ha percorso più di 160 metri per andare alla fermata dell'autobus.

"Tommaso was walking on the street, until he met his friends who asked him to go to school with him (making the journey longer). Then he did more than 160 meters to get to the bus stop".

At first, Mil clarifies that they thought about a meeting with friends to give meaning to the second part of the graph:

7. Mil: We wanted to add that he was walking to the bus but he saw his friends then he went back to his friends and after they went all together to the bus stop, because that segment that went down... to say that... following his friends.

From Mil's sentence and other students' interventions, we may say that students are making reference to the former experience with motion sensors in order to interpret the new graph. More precisely, they interpret the increasing parts of the graphs as movements towards the bus stop and decreasing parts of the graph as movements back home.

Cate asks for clarification about the way of interpreting the second segment of the graph:

21. Cate: But nobody knows that the graph... I mean, it is not like the one of the last lesson, that when you got ahead it went straight and... we followed a straight line and instead when you got back it went down, but nobody knows it now.

22. Researcher: what do you mean by "nobody knows it"?

23. Teacher MT: nobody knows what?

24. Cate: that the graph changes direction when... for instance, if Tommaso gets farther the graph goes on and up, if he gets closer the graph gets down.

Two issues emerge as relevant for the discussion. At first, it is important to assess whether students understood the new situation and thought about the possibility of applying what was understood in the former experience with motion sensors. For instance, it is important to make the students reflect on the fact that Tommaso walks on a straight street (and this information makes the situation similar to what they experienced with motion sensors). Furthermore, it is important to move students to a deeper level of justification: from one side, it

is important that students are able to link the new graph to the previous experience; from the other side, it is important that they approach a more theoretical level, moving from an interpretation based on the memory of the former experience to an interpretation based on the meaning of the graph.

Cate's intervention is caught and used to pursue these goals.

<i>Transcript</i>	<i>Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback</i>
33) Cate: but for me, I mean, we wrote something like that, that he does many meters, but... it is not that... it is not written that the graph changes direction when he gets farther or closer...	Cate expresses her doubt concerning the written answer that is displayed on the interactive whiteboard. In this way, she provides a feedback about the task , commenting the classmates' written production.
34) Researcher: wait, you are saying: we said this because we remember what we saw last time, but is it true that also here we can interpret it in this way? Was this your doubt?	The researcher reformulates Cate's doubt, so as to establish <i>where the learner is in her learning</i> and also to involve all the classmates in the subsequent discussion. Her aim is therefore to activate strategy 2 (<i>Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding</i>). We may also say that Cate is <i>activated as resource for her classmates</i> (strategy 4).
35) Cate: yes, that's it.	
36) Researcher: ok, did you all understand the doubt of...	The researcher involves the classmates in the discussion, so as to <i>activate them as resources</i> for Cate (strategy 4).
37) Cate: Cate.	
38) Researcher: of Cate? Who tells that we can say that when the graph goes up it means that he is going farther and when it goes down...	By rephrasing Cate's doubt, the researcher is giving in implicit way a positive feedback to the girl (feedback about the processing of the task), recognizing the legitimacy and the importance of her question.
39) Cate: is it because it is getting closer again?	
40) Researcher: can we say this or not? What do you think? (<i>to all the students</i>)	The researcher involves the classmates in the discussion, so as to activate them as resources for Cate (strategy 4).
41) Rob: for me yes. Yes, because it is written, there is exactly...	Rob answers, trying to clarify to Cate how to interpret the graph.
42) Teacher MT: it is written where?	The teacher encourages Rob to make explicit his explanation to Cate, and also pushes him to clarify what he is saying, so helping him to properly be an <i>instructional resource for his mates</i> (strategy 4).

43) Rob: in the y axis.	
44) Teacher MT: what is written on the y axis?	The teacher is near the interactive whiteboard, where the graph is displayed. All the students can look at the y-axis.
45) Rob: the distance from home expressed in meters	
46) Teacher MT: then?	
47) Rob: then the distance from home and... the closeness, then... looking at the graph you can understand that he gets farther and you see that also time, I mean, in 50 seconds... in 50 seconds he gets farther of 100 meters and then in 70 seconds, from 50... in 20 seconds he gets closer of 60 meters...	Rob explains to Cate in which way to interpret the graph, focusing no more on the former experience with motion sensor but on the meaning of the two axes. Rob <i>activates himself as a resource</i> for Cate (strategy 4).

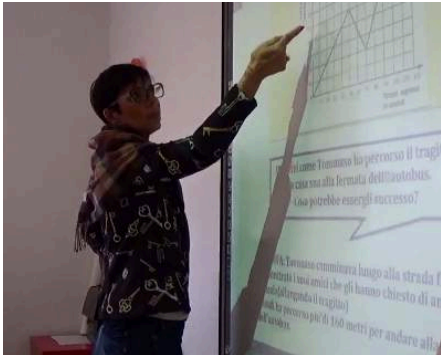
In this short excerpt we see the use of the technology in its **sending and displaying** functionality: the teacher, once received the files from the students, selects and displays to all the class, thanks to the interactive whiteboard, some written answers. The excerpt refers to a short episode of discussion starting from the analysis of one written answer. During the discussion, the answer and the original task (text and graph) are always **displayed**, allowing the teacher, the researcher and the students to make reference to them.

The FA process “*establishing where the learners are in their learning*” is at issue. Cate is encouraged to express her doubt, which is reformulated by the researcher so as to involve all the class into the discussion. The FA strategies employed by the teacher and the researcher are **strategy 2** (*engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding*) and **strategy 4** (*activating students as instructional resources for one another*). The student Rob intervenes to explain Cate how to look at the graph in order to understand the link between the shape of the graph and the journey of Tommaso. Rob activates as resource for Cate, under the guidance and encouragement of the teacher and the researcher.

Concerning the agents of the FA strategies, we may say that Rob acts as a resource for Cate, then the “**peers**” dimension is present. Moreover, Rob is encouraged to explicit his explanation by the researcher and the teacher, then also the **teacher** dimension is present.

The discussion goes on with the analysis of the same written production. Paul expresses a new doubt, still connected with the link between Tommaso’s movement and the graph.

Transcript	Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback
68) Paul: at the beginning he (<i>referring to Rob</i>) also said: when he went back, it (<i>referring to the graph</i>) went... it went back to 40, but in order to get back shouldn’t it go towards the... y axis?	Paul expresses his doubt concerning the link between the backward movement (towards home) and direction of the graph. He asks whether the graph should not go towards the y-axis. Paul expresses his doubt, thus acting as <i>owner of his own learning</i> (FA strategy 5).
69) Teacher MT: well, that is the time that goes on...	The teacher gives an immediate feedback to Paul. Focusing on time, she addresses the fact that a movement towards the y axis would be a

	movement on the x axis and gives an important feedback about the processing the task .
70) Paul: eh, indeed, if this is the nearness (<i>he indicates the distance from the y axis</i>)... the closeness to home, this is the home (<i>he indicates the y axis on his notebook, where he has copied the worksheet</i>), it must get back to the y axis and not go down... not go...	Paul makes his doubt more explicit.
71) Teacher MT: but if I get back here... you say, in this drawing it should get back.	The teacher reformulates Paul's doubt, with the aim of <i>establishing where the learner is</i> and involving all the class into the discussion (strategy 2).
72) Researcher: shall we let someone speak? Who wants to help him? Did you understand his doubt?	The researcher involves all the class into the discussion, encouraging the other students to understand Paul's doubt and help him. Reformulation and direct question are two key strategies to involve all the students. FA strategies are: Strategy 2 (Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding); Strategy 4 (Activating students as instructional resources for one another).
73) Teacher MT: did you understand? He says: "if he gets closer to home, for me, it (<i>the graph</i>) should get closer to the y axis" (<i>she does the gesture of a horizontal line from point (50, 100) to the y axis</i>).	The teacher reformulates Paul's doubt, using also her gestures to better make clear the reference to the y axis in Paul's interpretation (line 70).
	
74) Cate: for me no, because the graph in this way means that he (<i>Tommaso</i>) turned himself and he goes back... it does not have to get back... to make understand that he get back, it (<i>the graph</i>) goes down (<i>she simulates with her finger the movement from up to down</i>), without getting back this way (<i>she simulates with her finger the horizontal direction from right to left</i>)	Cate intervenes and explicitates the link between the movement of Tommaso and the direction of the graph. We may note that Cate had expressed doubts about the link between movement and graph (see previous excerpt). In this episode Cate is able to <i>activate herself as resource for another student</i> (FA strategy 4).
75) Researcher: why does it (the graph) doesn't have to get back to the y axis?	The researcher relaunches the question to all the class, with double aim of involving other students and obtaining a more theoretical explanation. Also, through this question she gives a

	feedback on the task , by confirming in implicit way that the graph has <i>not</i> to get back to the y axis
76) Teacher MT: Ur?	
77) Ur: instead, for me, I don't know but I think that he did not really get back home, he got back for a part of the path because it (<i>the graph</i>) did not really get the bottom.	
78) Teacher MT: but do we know how much...	The teacher intervenes and asks directly how much meters Tommaso went back.
79) Rob: 60 meters, that is to say he went back for 60 meters to 40 meters.	
80) Teacher MT: he (<i>Tommaso</i>) got closer up to 40 meters, what you say is right, but let's answer to the fact that, who was saying this, that it (<i>the graph</i>) goes back. Brown?	The teacher gives a quick feedback to Rob (feedback about the task) and relaunches Paul's doubt.
81) Brown: it cannot... the graph can not get back, because, how could we know how much time did it take? 82) Paul: well, we would go back in time. 83) Teacher MT: what would mean if I would ... 84) Paul: we would go back in time! 85) Teacher MT: going back in time!	Brown activates <i>as a resource for another student</i> (FA strategy 4). Such an intervention is efficient, as evidenced by Paul's answer. The teacher repeats Paul's answer, to give him a <i>feedback</i> about the rightness of the explanation.

The second excerpt refers to another moment when, starting from the analysis of a **displayed written production**, one student expresses a doubt concerning the link between Tommaso's journey and the graph.

We may say that Paul, expressing his doubt spontaneously (he is not questioned by the teacher, and the discusses written production is not the one produced by his group), activates himself *as the owner of his own learning* (FA **strategy 5**).

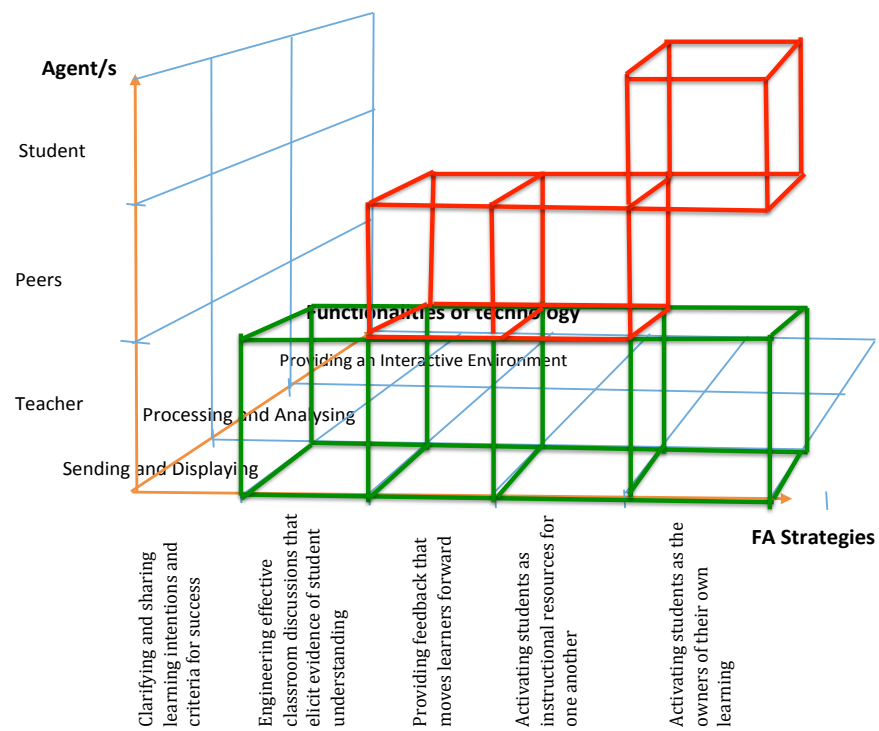
The functionality of technology at issue is **sending and displaying**, since the students, the teacher and the researcher refer to what is displayed on the interactive whiteboard (a written answer, the text of the task, the graph).

The agents involved are the **student** (Paul), **the teacher and the researcher**, the **peers**.

The teacher and the researcher have the goal of establishing where the learner (the student Paul, who expresses his doubt) is and helping him to move forward. In order to accomplish this aim, they adopt two FA strategies: **strategy 2** (*engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding*); **strategy 4** (*activating students as instructional resources for one another*). Reformulation of Paul's doubts and direct questions to the audience (*Who wants to help him? Did you understand his doubt? ...*) are used in order to activate such FA strategies.

The students Rob, Cate and Brown intervene and help Paul to understand the link between the movements and the graph. We highlight Cate's intervention: while in the former excerpt Cate had expressed her doubts, in this excerpt she turns herself as responsible of her own learning. We may say that the previous *feedback about the processing of the task* helped her to understand the way of addressing the task.

The following diagram highlights how the sending and displaying functionality of the technology enabled the teacher and the other agents to activate a wide range of formative assessment strategies during lesson 1.



2.2 Lesson 2

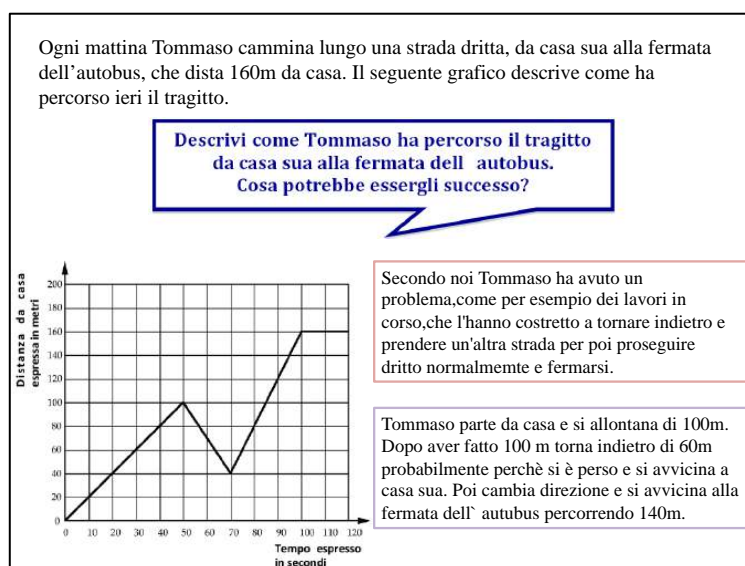
The subsequent selected episodes refer to lesson 2 (October 27th). Lesson 2 starts with a short summary of what was done in the previous lesson, afterwards a new selection of group answers to worksheet 5 is displayed to the whole class. It is worth mentioning that, while in the previous lesson the group productions had been selected on the spot, in this lesson the teacher displays some productions that she selected in a quiet moment between the two lessons. As outlined in the former lesson, 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 functionality of technology is **sending and displaying**, since the discussion concerns the analysis and comparison between two group productions that are displayed.

The two productions are:

1. *For us, Tommaso had some problem, for instance some men at work that made him go back and take another road and after go on normally and stop.*
2. *Tommaso leaves home and goes on for 100 meters. After having done 100 meters he goes back of 60 meters, probably because he got lost, and he gets closer to his house. Afterwards he changes direction and he gets closer to the bus stop, walking for 140 meters.*

Here is the original power point slide that was displayed to the students, with the two answers reported at the right of the graph:



One author of the second answer, Rob, immediately amends the last part, recognizing that Tommaso walks for 120 meters.

Afterwards, the students highlight that, in both answers, Tommaso is said to return closer to home, but only the first answer mentions also the last part of the journey (when Tommaso doesn't walk anymore).

Afterwards, the discussion focuses on the decreasing part of the graph, that the students interpret in terms of returning closer to home. In the first production Tommaso is said to have changed his way, while in the second one Tommaso is said to have gone back, still on the same road. The student Brown observes that Tommaso did not change his way, only the direction:

74. Brown: For me, anyway, he (*Tommaso*) did not take another road, he could have... I don't know... forgotten something... he lost his pencilcase in the middle of the street, he just went back, there he changed his direction, for this reason there is a peak, but he did not necessarily change the road... take another road, because maybe it (*the graph*) would have noted more distance.

Brown *activates herself as a resource for the other students* (FA **strategy 4**), because she points out something that doesn't work in the second answer, giving a **feedback about the task** to the classmates. Brown is efficient in explaining that Tommaso did not change his road, but only direction. Anyway, for the teacher it is important to make clear that this is the only possible interpretation, since the text of the task reports that Tommaso moves along a straight line.

The discussion on this crucial issue is illustrated in the following excerpt:

<i>Transcript</i>	<i>Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback</i>
94) Teacher MT: but, the information, does only the graph give us information? Was the task made up only by the graph? 95) Paul: there was also the text. 96) Teacher MT: ah, there was also the text, shall we read again the text? Go on, Rob. 97) Rob <i>reads again the text of the task</i> . 98) Teacher MT: have we got some more information? 99) Cate: ah, but Tommaso walks along a straight road. 100) Student: yes, indeed	<p>The teacher brings to the fore that, in order to fill the task, it is important to take into account both the graph and the text. Apart from strategy 2 (<i>Engineering effective classroom discussions</i>), she activates two FA strategies:</p> <p>Strategy 1 (<i>Clarifying and sharing learning intentions and criteria for success</i>);</p> <p>Strategy 3 (<i>Providing feedback that moves learners forward</i>).</p> <p>The teacher involves the students in a careful reading of the text. In this way, she pursues a double goal: working on the task (feedback on the task) and promoting a careful reading of the text as an efficient strategy for solving any problem (feedback about the processing of the task).</p>
101) Teacher MT: that is to say? 102) Mark: Then, yes, he changed his way necessarily... then.. 103) Teacher MT: did he change his way? 104) Student: no! 105) Teacher MT: Brown? 106) Brown: I wanted to say that he did not change his way, because, the road is straight, if the road were straight and after there were a little road here, the motion sensor would not have caught him...	

<p>107) Teacher MT: yes, let's imagine to observe him, not that there is a motion sensor, we take the times and we measure his distance from home, but the text gives you another information: that he was walking on a straight road. Then, in reality, I know the...that he was walking on a straight road. This fact, that he was walking on a straight road, can I understand it from the graph or not?</p> <p>108) Rob: not.</p> <p>109) Teacher MT: because the graph just tells me... what?</p> <p>110) Rob: the distance and time.</p>	<p>The teacher gives a quick feedback to Brown (feedback about the processing of the task), and encourages her and all the students to focus on the text (feedback about the processing of the task).</p> <p>FA strategy 3 is activated.</p>
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In the former excerpt the teacher has two goals: at the task-level, she wants to clarify that only one interpretation (Tommaso changes his direction, going back towards home) is possible, since the text explicits that Tommaso is walking on a straight road; at meta-level, she wants to highlight the careful reading of the text as an efficient problem solving strategy. This means that she wants to give **feedback about the processing of the task**.

In order to pursue this double goal, she activates the following strategies:

Strategy 1 (*Clarifying and sharing learning intentions and criteria for success*);

Strategy 2 (*Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding*);

Strategy 3 (*Providing feedback that moves learners forward*).

Also the peers are agents of the formative assessment process: Brown and Rob intervene, thus *acting as resources for one another* (**strategy 4**).

The functionality of technology is that of **sending and displaying**, since the discussion starts from the analysis and comparison of some written answers, which are displayed via the interactive whiteboard.

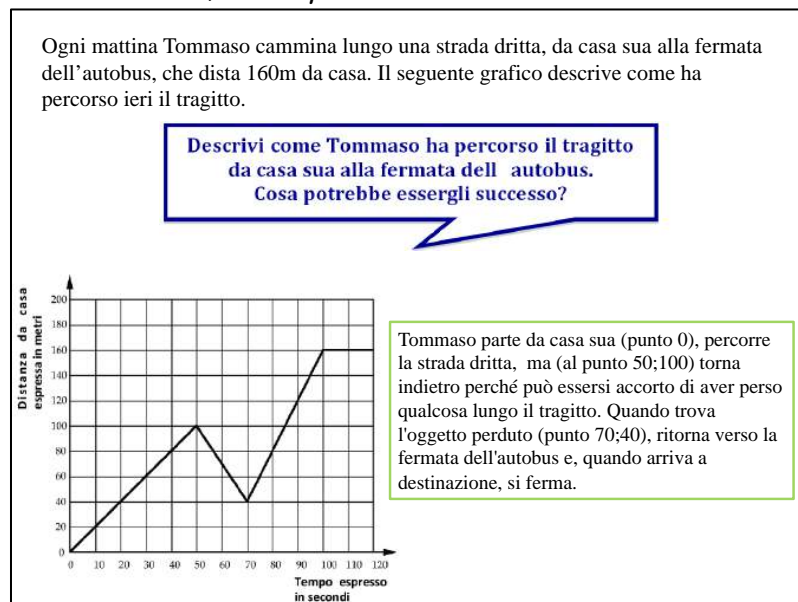
Afterwards, some students observe that, in the experience with the motion sensor, if one student moved away from the straight line, the sensor was no more able to detect him and the graph resulted with some gaps. They use this experience as an argument for the fact that Tommaso moves along a straight line: since the graph is like the graph they obtained with the motion sensor, they infer that Tommaso walked along a straight road.

The teacher clarifies that in principle, just looking at the graph, Tommaso could also have moved to another road. Indeed, without using the motion sensor but measuring the distance from home second after second, it would have been possible to have a graph without gaps even in that situation. Only the information given by the text warrants that Tommaso moved along a straight road.

119. Teacher MT: [...] anyway, why did they write "along a straight road"?
120. Debby: To make us understand that Tommaso did not change his way.
121. Teacher MT: but is it important to know that he did not change his way?
122. Debby: yes, because anyway if we have to describe the journey it is important to know whether he changed his way or not.
123. Researcher: at least there is only one interpretation.
124. Teacher MT: there is only one interpretation.

Once established that the first written production is not correct (because it reported about men at work and changing the road), the teacher invites to read and discuss another selected answer:

3. Tommaso starts from his house, point zero, he goes on a straight road, but at point (50,100) he goes back because he might have forgotten something along the path. When he finds the lost object, point (70,40), he goes back to the bus stop and, when he arrives to the destination, he stops.



The analysis of the selected answer is a good occasion for the teacher to check whether the students understood the previous issue concerning the information on the straight road and the fact that Tommaso in the second trait comes back. The process at issue is “*establishing where the learners are in their learning*”.

The functionality of technology is still **sending and displaying**, and the first activated **strategy** is **2** (*Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding*).

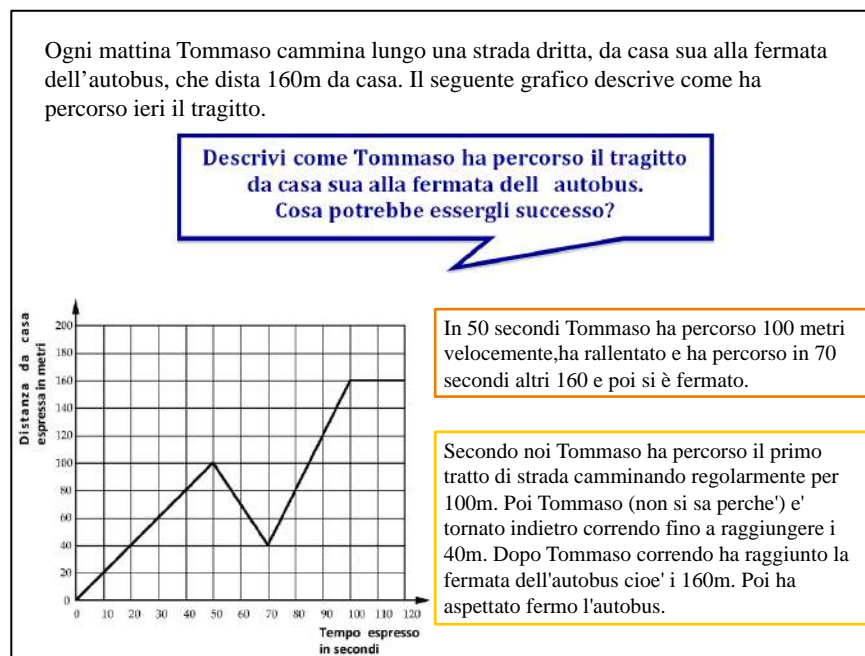
<i>Transcript</i>	<i>Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback</i>
141) Researcher: does this story tell us something different, in comparison to the ones we read before? 142) Paul: it tells that the road is straight.	
143) Teacher MT: it reports that the road is straight, an information from the text.	The teacher reformulates Paul's intervention, so as to underline the importance of taking into account all the information from the text. The activated strategy is 1 (<i>Clarifying and sharing learning intentions and criteria for success</i>).

<p>144) Mark: then, that he doesn't go back, that he doesn't change his way.</p> <p>145) Teacher MT: that he doesn't change his way but...?</p> <p>146) Debby: he comes back.</p> <p>147) Teacher MT: he comes back.</p> <p>148) Debby: but for another reason.</p> <p>149) Teacher MT: for another reason.</p> <p>150) Mark: he could have lost something.</p>	<p>Mark and Debby intervene, showing that they understood the previous discussion on the road that does not change.</p>
<p>151) Rob: but I did not understand why he wrote "at the point (50,100)".</p> <p>152) Teacher MT: what is that? What does it mean?</p> <p>153) Pon: those are the coordinates.</p> <p>154) Teacher MT: those are the coordinates.. of the point (50,100)</p> <p>155) Rob: ah, yes!</p> <p>156) Teacher MT: then the 50 is...</p> <p>157) Voices: the time.</p> <p>158) Teacher MT: and 100?</p> <p>159) Voices: the distance from home.</p> <p>160) Teacher MT: then those are the coordinates of the point. Then they (the authors of the answer) imagine that he (Tommaso) lost something, from that point he goes back, and then?</p>	<p>Rob asks for clarification for the presence of the coordinates on the written answer. The teacher encourages other students to intervene as resources for Rob (strategy 4). Pon intervenes, activating himself as resource for Rob.</p>
<p>161) Cate: then he says that "he comes back" and not that "he changes his way".</p>	<p>Cate points out that the written text correctly says that Tommaso comes back, not that the road changes.</p>
<p>162) Teacher MT: he comes back... and after?</p> <p>163) Ur: he comes back because when he finds the object he had lost he goes back to the bus stop, walking again on the same road and when he comes to the bus stop he stops.</p> <p>164) Teacher MT: he stops, ok? I would say that... are you all ok with this? May we take this as a complete description, for you? Exhaustive?</p>	<p>The teacher concludes by a series of questions, to make sure that the students understood; in this way, she implicitly gives a feedback about the task.</p>

The work goes on with the analysis and comparison of the last two selected written answers:

4. In 50 seconds Tommaso walked along 100 meters quickly, he got slower and did in 70 seconds 160 more meters, after he stopped.

5. For us, Tommaso did the first part of the path walking regularly for 100 meters. After, Tommaso (we don't know why) went back running until he reached 40 meters. After, Tommaso, running, reached the bus stop that is to say the 160 meters. After he waited for the bus without moving.



<i>Transcript</i>	
203. Teacher MT:	OK. Which further information do these two answers give us?
204. Cate:	that he (<i>Tommaso</i>) ran and got slower and got faster.
205. Brown:	the speed.
206. Teacher MT:	The speed: some information on the speed, on the way of moving, something we had not yet seen.

From the last two short excerpts we may observe that the activity of analysis and comparison of written production is efficient for the work at content level (***feedback on the task***) and also at meta level (***feedback about the processing of the task***), since the students may grasp a better insight into the task and at the same time reflect on the possible ways of addressing the task. Answer 3 exemplifies the way of dealing with coordinates to give a more detailed description of Tommaso's journey, answers 4 and 5 bring to the fore that Tommaso's movement may be described also in terms of speed, not only in terms of time and distance.

Once again, a crucial point is to move from the interpretation of the graph in reference to the former experience with the motion sensor to a more theoretical explanation for the interpretation in terms of speed. Such a goal is pursued in the following excerpt. The functionality of technology is ***sending and displaying***, since the class discusses the written answers that are displayed on the IWB.

The agents are the teacher and the researcher, but also the peers, that intervene, thus *activating themselves as instructional resources for the mates*.

Relevant FA strategies are: ***strategy 1*** (*Clarifying and sharing learning intentions and criteria for success*); ***strategy 2*** (*Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding*); ***strategy 3*** (*Providing feedback that moves learners forward*).

<i>Transcript</i>	<i>Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback</i>
215) Researcher: and... I ask you two questions,	The researcher encourages all the class to

	you already said it, but why when we look at the third trait we say that Tommaso run, that is to say, why do we link this to an increased speed?	explain the link between the graph and the speed, activating strategy 2 (<i>Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding</i>).
216)	Mark: because you see the difference between the first and third trait: the first trait is more towards the horizontal line, instead the third trait is more towards the vertical line.	The first explanation, proposed by Mark, relies on the comparison between the traits and, implicitly, to the former experiences with the motion sensor.
217)	Mario: no, for me in the last part he (Tommaso) goes faster because maybe he was late and then he run.	Mario seems to focus on the story (Tommaso was late because he had to go back to recover the pencilcase, then he probably run in the last part of the path) rather than on the interpretation of the graph.
218)	Teacher MT: yes, but from the graph, besides this inclination...	The teacher encourages the students to focus on the graph, activating strategy 3 (<i>providing feedback that moves learners forward</i>).
219)	Lola: you see also that in the first trait he (Tommaso) spent a “tot” of seconds while in the third one he spent less seconds.	Lola proposes another kind of explanation, based on the amount of time spent to walk in the two traits.
220)	Teacher MT: then, should we look at the time he spends to do what...?	The teacher encourages the students to develop Lola’s proposal, thus giving in an implicit way a positive feedback on it.
221)	Mark: because going up to 100 meters he spent 50 meters, and then he spent 50 more seconds to go to 40 meters and to go to 160 meters.	Mark works on the graph, but, differently from Lola, he focuses on the amount of meters walked in the same amount of time (50 seconds).
222)	Teacher MT: then...	
223)	Researcher: can you show us?	The researcher encourages Mark to show his reasoning at the whiteboard, so as to involve all the students and then activating mark as a real <i>instructional resource for the other students</i> (strategy 4)
224)	Teacher MT: come here. So, your classmate says: “He spent...”	The teacher’s intervention is aimed at involving all the students in understanding Mark’s explanation.

225)	Mark: to go to 100 meters he spent 50 seconds because the coordinates are (50,100).	
226)	Teacher MT: OK	
227)	Mark: but after, going 40 meters he spent 20 seconds and then he went back up to 100 meters and then he spent 30 seconds. To get back and get back to 160 meters he spent 50 seconds.	
228)	Teacher MT: can we understand how many meters he walked in those 50 seconds?	
229)	Mark: from 40... 120! 120 meters.	
230)	Teacher MT: 120 here (<i>she indicates the whiteboard</i>).	
231)	Mark: yes.	
232)	Teacher MT: and this little trait?	
233)	Mark: ah, he did ... 180!	
234)	Teacher MT: 180... then in 50 seconds...	
235)	Mark: he did 180 meters running and instead...	
236)	Teacher MT: how do I understand that he is running? Or that anyway he is going faster than before? Because in the first 50 seconds how many meters did he do?	The teacher encourages Mark to synthesize and conclude his reasoning, making explicit the comparison between the amount of meters walked in the same amount of time. She therefore activates strategy 3 (<i>providing feedback that moves learners forward</i>).
237)	Mark: only 100.	
238)	Teacher MT: only 100. Ok.	
239)	Researcher: ok, is it all right?	
240)	Teacher MT: did you understand? He (<i>Mark</i>) says: "in the first 50 meters he did 100 meters because he gets away from home until 100 meters, in the subsequent 100 meters actually he (<i>Mark</i>) does 60 meters to come back, get what had been lost, and then he does 120 more meters to reach the 160 meters of distance from the house, which is the bus stop, then totally it gives 180 meters... in 50 seconds, in the same 50 seconds, then the time is the same, but the walked meters are more in the second trait, then it is clear that he goes...?"	The teacher reformulates to give feedback on the task and also on the processing of the task .
241)	Rob: faster	
242)	Teacher MT: really faster.	
243)	Researcher: I wanted to say that it is important to link our evaluation of the speed to the numbers that we can get from the graph, because let's imagine somebody who did not do the experience with the motion sensor, you can not just tell him "yes, that's because we saw with the motion sensor that the more we run the	The final comment of the researcher gives a feedback about the processing of the task , underlining the importance of producing "theoretical", rather than empirical, explanations. She also gives some feedback about self, because she points that referring to the former experience with the motion sensor is

more the line moved"; it must be something that somebody finds looking at the graph, without having done the experience with the motion sensor, ok? Then, a first explanation is to say "because we saw it last time", and it is good that you refer to that experience, but furthermore you can explain it with the data.

anyway a very good starting point. We may say that the researcher activates the FA **strategy 1** (*Clarifying and sharing learning intentions and criteria for success*).

Once finished the discussion on the selected written productions, the work on a new task (worksheet 2) starts. The teacher, as planned a priori with the researcher, chooses to propose an instant poll:

In this poll three justifications, given by fictitious students, are proposed, with the request of identifying the most complete one among them:

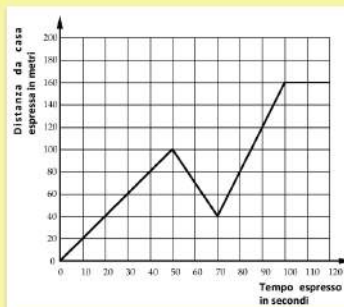
(a) *During the last 20s, Tommaso is not walking because we have already said that he has reached the bus stop.*

(b) *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.*

(c) *I understood that, during the last 20s, Tommaso is not walking because the line of the graph is horizontal.*

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.

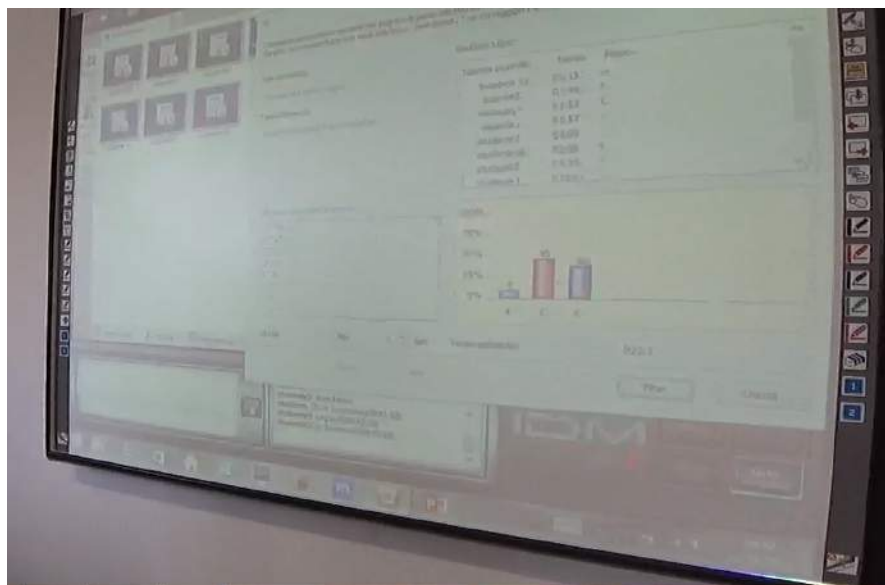
Secondo me, durante gli ultimi 20s, Tommaso è fermo perché dal grafico si può capire che, da 100s a 120s, resta sempre alla stessa distanza da casa, cioè 160m.

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?

RISPOSTA:

The students worked in small groups. All the groups answered in less than 8 minutes. The picture shows the distribution of answers, as displayed to the class at the end of the groupwork.



All the subsequent part refers to the **functionality of technology “processing and analyzing”**, since results from the instant poll are processed and the results of such a processing are displayed to all students and used as a starting point for the discussion.

The FA process “*establishing where the learners are in their learning*” is at issue. Furthermore, the teacher aims at giving feedback at content level (**feedback about the task**) and also at meta level (**feedback about the processing of the task**), namely about the way of providing an explanation that is not only correct but also complete.

The FA strategies that the teacher activates are: **strategy 1** (*Clarifying and sharing learning intentions and criteria for success*); **strategy 2** (*Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding*); **strategy 3** (*Providing feedback that moves learners forward*). Moreover, students intervene, thus turning themselves as *instructional resources for the peers* (**strategy 4**).

After a brief analysis of A, justifications B and C are compared.

Transcript	Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback
353) Teacher MT: let's look at B and C. Let's hear some motivation of those who chose C, why did they chose C, and some motivation of those who chose B.	The teacher encourages the students to discuss the reasons behind the choices of the poll. Brown suggests that answer B gives more information on the last trait. Another student, echoing Brown, affirms that B is the most complete.
354) Brown: we chose B because B specifies also that he (<i>Tommaso</i>) stayed still from 100 to 120 seconds, while C doesn't say this, saying that they were only 20 seconds they could have been 150, 170, 180 and so on...	
355) Student: B is the most complete.	
356) Teacher MT: B is the most complete.	
357) Mario: for me the B is not right	Mario challenges the former evaluation: in

<p>because, we understood that, when we used the motion sensor, let's say, you understand that a person stops when the line is horizontal, and there (<i>justification B</i>) it doesn't say this, then it is not the most complete.</p> <p>358) Researcher: could you say it again, please?</p> <p>359) Teacher MT: yes, please.</p> <p>360) Mario: for me the B is wrong, because when we did the experience with the motion sensor we discovered that, let's say, staying still we did a horizontal line, and that is not written there.</p> <p>361) Teacher MT: he says "we loose the information of the horizontal line".</p>	<p>his opinion, answer B is not complete because it does not refer to the experience with sensor detectors.</p> <p>This is a good occasion to discuss again the role and value of the empirical experience with sensors. This issue is discussed in the subsequent hour of lesson (see below).</p>
<p>The lesson is interrupted because time (one hour) is finished. The students attend to two hours of lesson of technology; afterwards they continue their mathematics lesson (one more hour). The teacher displays again the different options A, B, C.</p>	
<p>388) Brown: well, looking at the question now I would say that also C is right, maybe B is more complete because it explains everything, but, "How do you know it?", it is C that answers because the line of the graph is horizontal, then in this case it would be C.</p>	<p>Brown comes back to her former observation. Influenced by Mario's former intervention, she says that C is the most complete. Mario's intervention acted as a feedback for her.</p>
<p>389) Teacher: OK, but the question was "What is the most complete?", then actually they are both correct, we wonder which is the most complete.</p> <p>390) Lollo: but if we had not done that activity before...</p> <p>391) Teacher MT: the activity with the motion sensor.</p> <p>392) Lollo: we could not have known that if you are still the line is horizontal</p> <p>393) Teacher MT: Could not we have known it? Let's think about that.</p> <p>394) Researcher: then are you saying that maybe the justification C, the third one, requires the fact that one has done the experience with the motion sensor?</p> <p>395) Lollo: yes.</p> <p>396) Teacher MT: then, we know from the experience with the motion sensor that if the line is horizontal it means that the person does not move.</p>	<p>The teacher's aim is to promote a discussion on the role and value of the activity with sensors. She also wants to focus on the completeness of the two options (Strategy 1: Clarifying and sharing learning intentions and criteria for success).</p> <p>Lollo intervenes, suggesting that one cannot refer to the experience with sensors, since the answer should be intelligible also by a reader who did not do such an experience. Lollo seems to have taken advantage from the previous discussion on speed (the interpretation in terms of speed can not be justified in reference to the experience with sensors, it should be justified in a more theoretical way). This suggests that he got from the previous discussion a fruitful feedback about the processing of the task.</p> <p>The teacher reformulates Lollo's intervention so as to involve the other students. In this way she also activates Strategy 3 (Providing feedback that moves learners forward).</p>

<p>397) Cate: but teacher, if... we told that if the person goes on the line goes on straight and goes up, and if instead the person changes direction and gets closer to the motion sensor the line goes down; then one can say "if the line is horizontal it means that anyway the person doesn't move, doesn't change direction".</p> <p>398) Teacher MT: Ok, all right.</p> <p>399) Rob: and anyway from the graph you can understand why the distance is always the same but the seconds, let's say, go on...</p> <p>400) Teacher MT: ok... then, even if we had not had the experience with the motion sensor, that made you understand in an experimental way that if I stay still the line is horizontal, your classmate (Rob) says: "from the graph I can understand it anyway". Why? Rob, could you please repeat it?</p> <p>401) Rob: because from the graph you can understand that when you don't move, that is to say when there is the horizontal line...</p> <p>402) Teacher MT: what doesn't it mean?</p> <p>403) Rob: the meters remain the same but the seconds go on, let's say.</p> <p>404) Teacher MT: Ok, then the seconds go on, but the meters that indicate... what? The...</p> <p>405) Cate: distance from home.</p> <p>406) Teacher MT: from home. They remain...</p> <p>407) Cate: the same.</p> <p>408) Teacher MT: the same. Then, what does it mean?</p> <p>409) Cate: that Tommaso does not move.</p> <p>410) Rob: instead, before, when the person goes farther or closer... let's say that both seconds and meters are moving.</p>	<p>Cate suggests an explanation based on the empirical experience with sensors.</p> <p>Rob intervenes, affirming that in the horizontal trait the distance from home is always the same. This is a shift from an explanation based on the experience with sensors to a theoretical explanation, based on the meaning of the graph.</p> <p>Rob provides Cate (and the other students) a feedback to move forward (strategy 3), turning himself as an <i>instructional resource for his classmates (strategy 4)</i>.</p> <p>The teacher reformulates Rob's intervention, giving him a feedback about the processing of the task and to all the students a <i>feedback that moves them forward</i>. Reformulation is also a means to activate Rob as <i>resource for the others (strategy 4)</i>.</p>
<p>411) Teacher MT: ok, that both meters and seconds change, while he (Rob) says "from the graph I see that horizontal line, it explains me that the meters remain the same while the time goes on", then the time goes on, my distance from home is always the same, and this means... that I don't move, is it clear? Then, what is the most complete, after this observation? Those who chose C agree that B maybe is less linked to the experience with the motion sensor?</p>	<p>The teacher asks again the question concerning completeness. Cate answers that B is more complete, thus showing that Rob's feedback was really helpful for her.</p>

<p>That is to say, does it explain me why the graph is horizontal, the line is horizontal, does B explain why the line is horizontal?</p> <p>412) Cate: yes, B does.</p>	
<p>413) Teacher MT: B explains why the line is horizontal, while C just says “the line is horizontal”; B instead explains why the line is horizontal, because the meters remain the same, even if time goes on, isn't it?</p> <p>414) It says “from the graph you can understand that from 100 to 120 seconds”, then time goes on, “he (Tommaso) is always at the same distance from home”, that is to say 160 meters.</p> <p>415) If I stay for 20 seconds always at the same distance from home it means that I do not move, because if I moved I would get farther or closer, is it clear? Then it gives me some information, it explains me why... what does it mean to have the horizontal trait, are you ok? Then, the fact that if I don't move the segment is horizontal is right, justification B explains me why, it is more complete, because the question was “Which is the most complete?”.</p>	<p>As a final intervention, the teacher rephrases the result of the discussion, pointing out what makes answer B more complete.</p> <p>In this way she activates strategy 1 (<i>Clarifying and sharing learning intentions and criteria for success</i>).</p>

In the last part of the lesson, a new worksheet (worksheet 3) is proposed in form of instant poll:

After how many seconds does Tommaso reach the bus stop?

(a) After 120s;

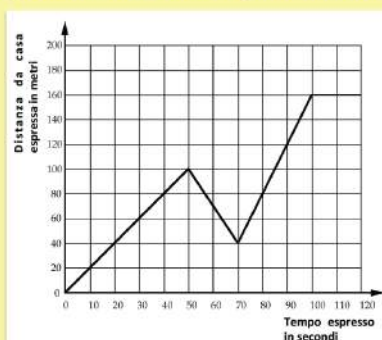
(b) After $50+70+100+120$ seconds, that is after 340 seconds;

(c) After 100 seconds;

(d) After 50 seconds.

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?

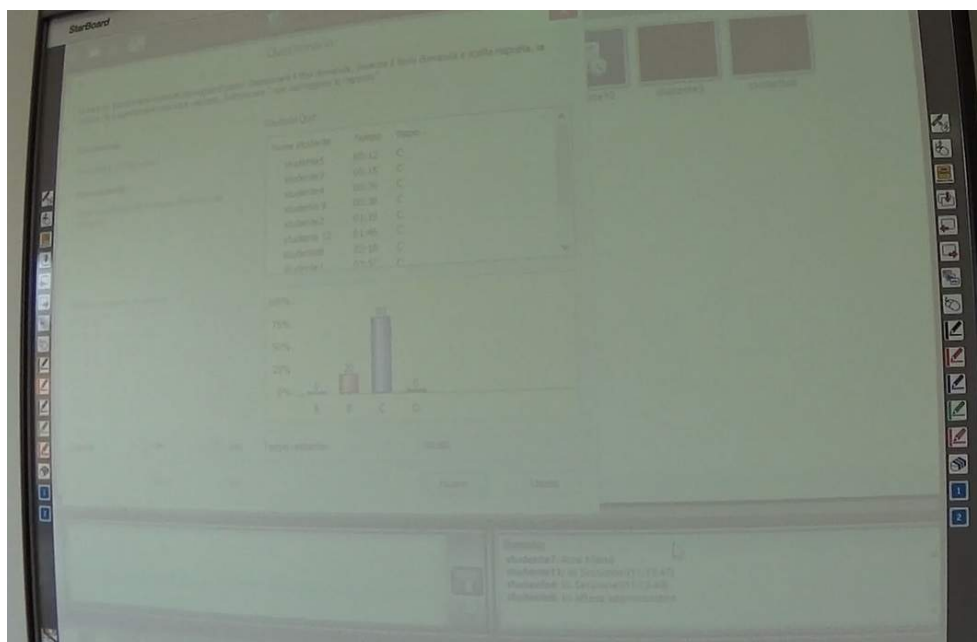
- A) Dopo 120 secondi
- B) Dopo 50+70+100+120 secondi, cioè dopo 340 secondi
- C) Dopo 100 secondi
- D) Dopo 50 secondi

Students work in groups for about 6 minutes, afterwards the result of the poll is displayed on the whiteboard and all the students discuss the results.

Two groups chose option A. Another group could not answer within the fixed time for technical problems, but declare that they would have chosen option B.

In the subsequent discussion, the teacher encourages students who answered C to help their mates to understand which was the good reasoning to do. The teacher, together with the involved students, provides to the class a **feedback about the processing of the task**. The double aim of the teacher is to make students who chose the options understand their mistake (*Providing feedback that moves learners forward, Strategy 3*), and to establish the careful reading of data from the graph as an efficient way of answer the question, without any calculation.

The functionality of technology is **processing and analysing**, since the results of the poll are the starting point for the discussion. The prevailing activated strategies are **strategy 2** (*Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding*) and **strategy 4** (*Activating students as instructional resources for one another*).



Transcript	Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback
428) Teacher MT: option B said “after 50+70+100+120 s”. Yes, Rob.	
429) Rob: for me no because, first of all you see immediately that... it can not be that because the graph does not even arrive to 340s, and after I saw... because... at 100s Tommaso comes to the bus stop and after at 110s and 120s he is already at the bus stop.	Rob <i>activates himself as resource for the peers (strategy 4)</i> , since he provides a feedback about the processing of the task . He points out that 340 is too much, and explains how to interpret the graph to answer the question.
430) Debby: or you can simply do the calculation that, here you can do that Tommaso comes to 50... 431) Researcher: please come to the blackboard. 432) Debby: you can do this calculation: here Tommaso comes to 50, then you keep in mind 50, then from 50 to 70 you keep in mind 20, from 70 to 100 you keep in mind 30, you do 50+20+30 and you get 100. 454) Researcher: but, listen, going back to what Debby was saying, one could do 50+30 and so on, but was it really necessary to do all those passages? How could we do to get the answer? I would let them answer, since they had chosen B, it now it is ok for you...	Debby proposes to calculate the time spent in each part of the journey. The researcher lets her expose, afterwards she points out that doing all the calculation was not necessary. She poses the question to the class, so as to give a <i>feedback that moves forward (strategy 2)</i> , turning the peers as resources for Debby.

455)	Remo: for me it was sufficient to see that 160 meters correspond to 100 s...	Remo intervenes, <i>activating himself as a resource</i> for Debby (strategy 4). He points out that a careful reading of the graph gives all the required information, without any calculation. The teacher synthesizes Remo's answer, thus giving him a positive feedback and turning him as a <i>resource for the class</i> .
456)	Researcher: it is reached...	
457)	Remo: then it was sufficient to see what was corresponding to 160 meters and you got the answer.	
458)	Researcher: ok.	
459)	Teacher MT: then it was sufficient to read how much seconds correspond to 160 meters.	

The lesson goes on with the group work on worksheet 4, where this question is posed: “Does he walk for 160m? Why?”.

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:

Students work in groups for about 10 minutes. Afterwards, a first round of discussion is carried out. The following productions, selected on the spot by the teacher and the researchers, are displayed on the interactive whiteboard:

1. No, because we said that maybe he went back or he lost something and he walked for more than 160 meters.
2. No, he did not walked for exactly 160 meters because in the point where he went back he did 60 meters then totally Tommaso did 280 meters.
3. For us he did not walked for exactly 160 meters, because going back he did 40 more meters, that is to say 10 meters for each little square. Afterwards he went back in direction of the bus stop and he did 60 more meters up to the bus stop. Totally Tommaso did 200 meters.

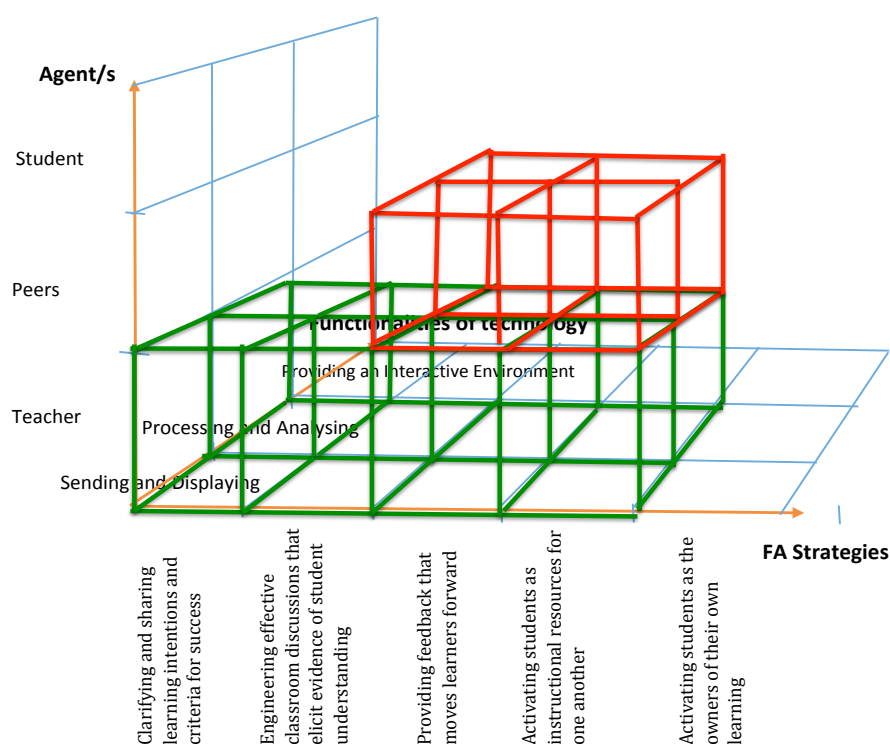
4. No because at the point (50;100) Tommaso went back of 60 meters walking then for 220 meters.

The students and the teacher observe that the first answer is qualitatively different, since it only recalls that Tommaso went back to recover something then he walked more than 160 meters, while the other three productions also try to establish how much meters Tommaso walked, but propose three different results. The last part of the discussion, strongly led by the teacher, focuses on the way of calculating how much meters Tommaso walked, getting data from the graph.

In terms of formative assessment, the teacher gives to the authors of the answers a **feedback about the processing of the task** (the good way of reading data from the graph). The activated strategies are: **strategy 1** (*Clarifying and sharing learning intentions and criteria for success*); **strategy 2** (*Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding*); **strategy 3** (*Providing feedback that moves learners forward*).

Since the lesson is almost over, the teacher decides to go on with the discussion in the subsequent lesson.

Lesson 2 is an example of the combination of the use of two functionalities of the technology (**sending & displaying** and **processing & analysing**) to foster the activation of different formative assessment strategies, as this diagram highlights:



2.3 Lesson 3

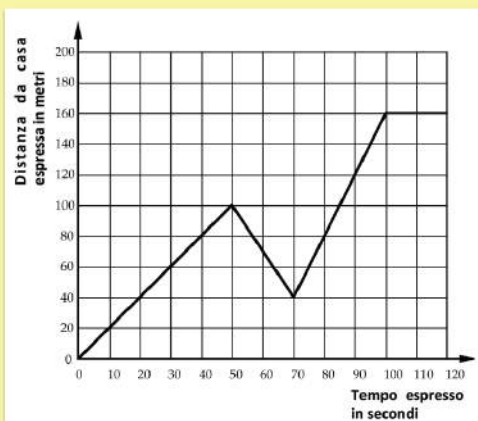
The last episodes refer to lesson n. 4 (november, the 3rd). The lesson starts with the final part of discussion on worksheet 4 (the discussed had started in the previous lesson).

Here we recall the text of worksheet 4:

Does he walk for 160m? Why?

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.



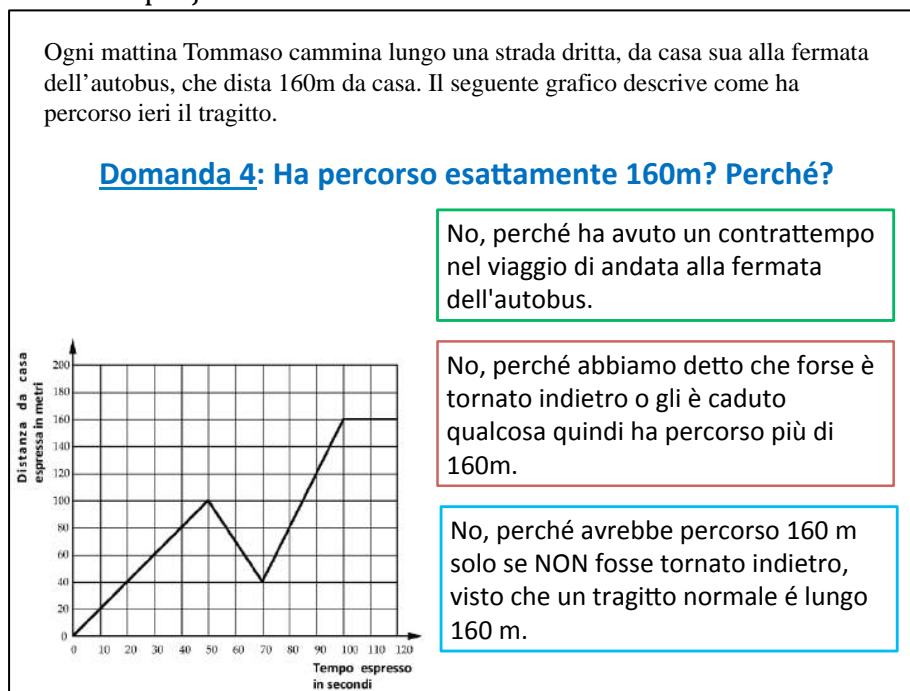
Domanda 4: Ha percorso esattamente 160m? Perché?

RISPOSTA:

Three productions, previously selected by the teacher and the researchers, are displayed at the whiteboard and the teacher involves the students in comparing them:

1. *No, because he had some unforeseen difficulty when going to the bus stop.*
2. *No, because we said that maybe he went back or he lost something and he walked for more than 160 meters.*
3. *No, because he would have walked for 160 meters only if he had not gone back, since the normal path is 160 meters.*

This is the file that was projected on the IWB:



The teacher promotes a comparison between the three answers. The students analyze them in terms of correctness and completeness of the information given.

The teacher in this way provides a **feedback about the task** and also the way of processing the task (how to justify the answer). The functionality of technology is **sending and displaying**, since the discussion is performed on the displayed answers. The prevailing activated **formative assessment strategies** are **2** (*Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding*), **1** (*Clarifying and sharing learning intentions and criteria for success*), **3** (*Providing feedback that moves learners forward*). The **teacher** is the prevalent agent, but also the **peers** intervene to give feedback to their classmates.

Transcript	Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback Transcript
7) Teacher MT: OK, well, let's see... analogies or differences between these answers? If they are alike, if some of them says something more than the others, if you agree with them... Let's go! Do they all say the same? Yes, Paul?	The teacher promotes a comparison between the three selected answers, with the aim of fostering a reflection on what is a correct and complete justification. She poses a series of questions so as to involve all the students in a fruitful discussion (strategy 2: engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding).
8) Paul: The last one says that the normal path is 160 meters.	
9) Teacher MT: What does it mean?	
10) Paul: That, if he had done the normal path without going back, he would have done 160 meters.	Paul points out that the last answer is more complete than the previous ones, because it compares the "normal" path to the actual path followed by Tommaso (feedback about the task, given by a peer).

11) Teacher MT: Because in the text, you remember what was written? That the bus stop...	
12) Paul: It is 160 meters far from home.	
13) Teacher MT: Then, if he had not come back, the last answer says “he would have done 160 meters”; the other answers instead, does the last one answer confirm what the other two say?	The teacher promotes a comparison between answers, in order to highlight what is the most complete.
14) Paul: It says something different.	
15) Teacher MT: Yes, Ur?	
16) Ur: It adds that anyway... it specifies that he (Tommaso) would have done 160 meters only in a normal path, if he had not had some unforeseen difficulty.	Ur is able to reformulate what Paul had already pointed out. We may say that Paul’ feedback on the task was efficiently caught by Ur.
17) Teacher MT: OK, anyway it says that, it confirms that he had some difficulty and then, having come back, does it give exactly 160 meters or not?	
18) Mary: No.	
19) Teacher MT: No, because he (Tommaso) went back, then he walks more, for the fact that he went back. In the second answer there is a “maybe”, do you think that “maybe” is necessary?	The teacher points out that the answer n.2 should not contain “maybe”, since the fact that Tommaso went back is a sure information. Pointing out the use of the expression “maybe” she teacher gives a feedback about the task but also the processing of the task , that is to say the way of organizing and presenting an explanation. The activated strategies are 1 (<i>Clarifying and sharing learning intentions and criteria for success</i>) and 3 (<i>Providing feedback that moves learners forward</i>).
20) Student: No, because we confirmed that he goes back.	
21) Teacher MT: we are sure about that, because it is the graph to tell us this, then that “maybe” should be taken away.	

Afterwards, two other sets of selected answers are displayed, compared and analyzed. The discussion focuses on the way of reading data from the graph and using them to calculate how much meters Tommaso actually walked. Rob observes that in the second trait Tommaso walks faster, since the segment is more inclined. Cate is not convinced and asks for clarification. The discussion moves to the comparison between the first and third trait. Rob and Paul, supported by the teacher, intervene to clarify this issue to Cate.

In this excerpt the functionality of technology at issue is **sending and displaying**, since the discussion takes place in reference to the displayed answer (and text of the task). The peers are the prevailing agents, with the support of the teacher. The activated **formative assessment strategies** are **2** (*Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding*), **4** (*Activating students as instructional resources for one another*), **5** (*Activating students as the owners of their own learning*).

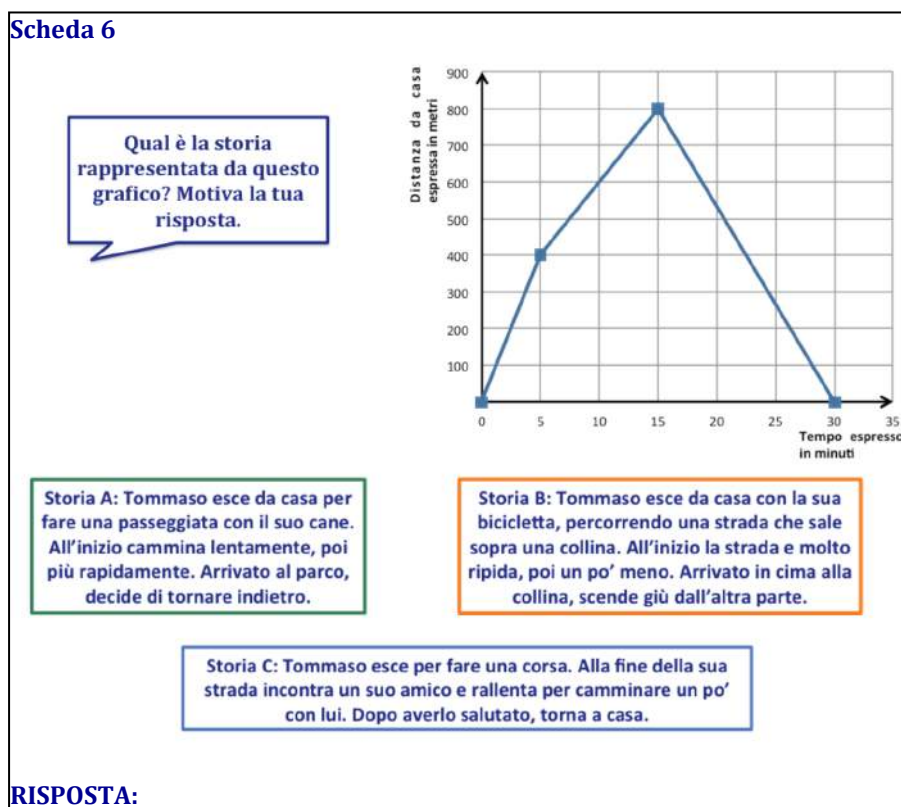
Transcript	Analysis according to the FaSMEd three-dimensional framework and the four
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	<i>levels of feedback Transcript</i>
134) Rob: At (50; 100) he goes faster.	
135) Teacher MT: After, he goes faster. Why, did we say? From what do we understand it?	
136) Rob: From the inclination.	
137) Teacher MT: From the inclination of the segment. OK, let's reason more on this point, those are things that we will use these observations: the inclination and the way of walking, OK? That is to say, how much space I do in how much time. Yes?	The teacher reformulates, so as to promote a reflection on the way of interpreting inclination in terms of speed. She gives a feedback on the task .
138) Cate: But, teacher, I don't agree so much on the inclination, because for me if that graph represents, it represents that, at (50,100), 50 seconds are passed and he did 100 meters, of course the... line of the graph must be in that way, otherwise it doesn't get the point, and when Tommaso comes...	Cate expresses some doubts on Rob's answer. Cate activates herself as <i>owner of her own learning</i> , calling for a deeper understanding (strategy 5).
139) Teacher MT: It is when Tommaso comes back.	
140) Cate: And, if when he goes from 100 to 40, of course after it (the graph) must ascend in that way, because if he climbed more inclined to the right...	
141) Teacher MT (to Cate): Do you agree on the fact that Tommaso goes faster?	
142) Cate: Yes, but...	
143) Teacher MT: Are you saying that it is necessary that Tommaso goes faster?	
144) Cate: No, I don't agree on the fact that the line, that line represents the fact that he goes faster, because...	
145) Teacher MT: This trait? (<i>Pointing to the second trait</i>)	
146) Cate: The other one (<i>pointing the third trait</i>)	
147) Teacher MT: This one?	
148) Cate: Yes, because... Tommaso... for me the line must necessarily come... it comes to that point, 160... it comes to 160 meters and to 100 seconds, and then it must come to that point and it changes direction.	Cate is reconstructing the last part of the journey, looking at the graph. She points out that, since the bus stop is 160 meters far from home, once reached the distance of 160 meters, Tommaso must necessarily change his movement, and the graph changes the direction. Cate is struggling to make sense of the graph, disentangling the journey of Tommaso and the shape of the graph. Sometimes she seems to mix up the two issues, for instance in the last sentence it is not clear whether it is Tommaso or the graph to change direction.
149) Teacher MT: But your classmate... go on (to Rob)	

150) Rob: But they could, in order to show that Tommaso went slower, rather than making him arrive earlier and draw the straight line, to draw a oblique line that ended...	Rob, taking into account Cate's comment, explicitates that the graph could have had another shape, in correspondence to another journey. Rob is <i>activating himself as instructional resource</i> for Cate (strategy 4), but he is also taking advantage from Cate's comment to deepen his reflection on the graph (strategy 5).
151) Teacher MT: To make it to arrive exactly, you say? That is to say to come exactly at this point (<i>she points (120; 160)</i>), without stopping... But... Cate, you do not agree on the fact that this segment represents a greater speed.. let's try to answer, to convince you: Rob, what did you say?	The teacher encourages Rob, who had spoken about the inclination, to clarify this issue to Cate (Strategy 4: Activating students as instructional resources for one another).
152) Rob: Because maybe they had to do... in order to show that Tommaso stopped... they also could have drawn the graph to the last square.	Rob goes on with Cate's comment on alternative drawings, rather than clarifying the issue of inclination.
153) Teacher MT: Yes, and we understood this, but now try to convince your classmate that this segment, having a different inclination from the first one, represents the fact that Tommaso went faster.	
154) Paul: In 10 seconds he does 40 meters.	
155) Teacher MT: In 10 seconds he does 40 meters? This? Please come to show it. Then...	The teacher encourages Paul to <i>activate himself as instructional resource</i> for Cate (strategy 4)
156) From 70 to 80 seconds there are 20+20 meters.	Paul <i>activates himself as an instructional resource</i> for Cate and maybe also for Rob (strategy 4).
157) Teacher MT: Are you convinced by this, Cate?	
158) Cate: Yes.	
159) Teacher MT: In 10 seconds in the last trait he does 40 meters while before, Paul, in 10 seconds...	
160) Paul: In 10 seconds he does 20 meters.	
161) Teacher MT: Then, does it mean that I run, that I go faster than before, my speed changed, ok? Are you convinced?	
162) Cate: Yes.	

After the discussion, the students are invited to work on worksheet 6.

In Worksheet 6 the graph and the three corresponding stories are presented, with the following question: "What is the story that this graph represents? Justify your answer."



The students work in group for about 22 minutes. Afterwards, there is a first discussion on some selected answers.

The first selected answer is the one by the group of Mil and Pon (two low achieving students).

For us the answer is B for two reasons:

A. *You cannot do 1600 meters by foot in half an hour*

B. *The graph represents precisely the information given by the story. Then Tommaso climbs the hills, the first trait is the climb, the second is still a climb but less steep. When he comes to the top, then Tommaso climbs down and goes back home.*

They provide two reasons for the choice of story B: the first one is based on everyday life experience (they point out that it is not possible to walk for 1600 meters in half an hour), the second one is based on a wrong interpretation of the graph: they interpret the graph as the drawing of the hill, that Tommaso climbs and descends. For the teacher, the discussion of their production is the occasion for *establishing where the group and all the other students are, giving feedback about the task* (clarifying that the graph is a modellization of the journey and not the drawing of the hill) and *about the way of processing the task* (pointing out that the justification must be based on the analysis of the information provided by the text and the graph, and not by everyday life experiences).

To this aim, the teacher promotes a discussion (**strategy 2**: Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding). More precisely, she encourages the other students to give Mil and Pon feedback (**strategy 4**:

activating students as instructional resources for one another). The other students, namely Rob, Lollo, Ur, Mark, Cate provide feedback that moves learners forward (**strategy 3**).

The functionality of technology is **sending and displaying**, since the discussion takes place by starting from the analysis of the displayed written production of the group of Mil and Pon. The **teacher** is one agent of the formative assessment process, but also the **peers** activate themselves as agents.

Mario is asked to read the production of Mil and Pon; then the discussion starts.

Transcript	Analysis according to the FaSMEd three-dimensional framework and the four levels of feedback Transcript
217) Teacher MT: Then, answer B for two reasons. Ok, Lollo?	The teacher encourages the students to <i>activate themselves as resources</i> for Mil and Pon (strategy 4).
218) Lollo: We did, because... we did the experience with the motion sensor... that if the line was more oblique the... the line, if it was more oblique, it meant that he (Tommaso) went faster, it did not mean that the road was steeper, because if the road is steeper you go slower...	Lollo gives a feedback about the task , suggesting that the different inclination of the segments should be interpreted in terms of different speed. To warrant his statement, he refers to the experience with the sensors. Lollo <i>activates himself as resource</i> for Mil and Pon (strategy 4). Lollo also adds that, when the road is steeper, usually one goes slower, and not faster, referring to everyday experience.
219) Teacher MT: Rob?	
220) Rob: This is a graph, it is not the drawing of the hill.	Rob explicitates that the graph does not represent the drawing of the hill, giving a feedback about the task to Mil and Pon. He <i>activates himself as instructional resource</i> for his classmates (strategy 4), <i>providing feedback that moves learners forward</i> (strategy 3).
221) Teacher MT: It is not the drawing of the hill, it is the graph that represents what?	
222) Rob: The... the journey of one boy, and anyway they told that it is not possible to do 1600 meters in half an hour, we already said it last time, it is a graph, it doesn't have to be really real... really near to reality.	Rob also gives a feedback about the processing of the task , pointing out that the justification must not rely on empirical arguments.
223) Researcher: Do you understand what he is saying?	
224) Mario: For me you can do it easily, you can even do 2 or 3 kilometers...	Mario challenges Mil and Pon's justification A, but on the basis of empirical experience.
225) Rob: For me yes...	
226) Teacher MT: Then, the fact of 1600 meters in half an hour, your classmate says that actually you can do it in half an hour, then that is not a good motivation. Somebody else was talking about the second motivation, motivation B, the fact that the graph explains us that Tommaso climbs the hill and so on. Lollo said: "No, because when we did the experience with the sensor we went on a oblique line, but the path we were doing was not on a hill, it was not steep".	The teacher synthesizes the interventions of Lollo, Mario and Rob, focusing in particular on justification B. She reformulates the intervention of Lollo, so as to give Mil and Pon a <i>feedback that moves them forward</i> (strategy 3).

227) Ur: Teacher, but I agree with what Lollo said. I thought that if it is steep you walk slowly, while after, when it becomes less steep, Tommaso goes faster.	Ur intervenes, referring to Lollo's intervention (218). Ur <i>activates herself as owner of her own learning (strategy 5)</i> .
228) Teacher MT: But the fact that... you say: "the fact that the road is more or less steep can give us information on the reasons why he goes faster or slower"...	The teacher gives a quick feedback to Ur, reformulating her sentence, so that other students can intervene
229) Cate: But if the line of the graph ascends it does not mean that Tommaso climbs...	Cate <i>activates herself as resource for the others (strategy 4)</i> .
230) Researcher: Rob said before... there is a difference between the graph...	
231) Student: Normal	
232) Rob: Between the graph and the drawing of the hill	
233) Teacher MT: The drawing of the hill, he says: "actually the drawing of a hill is different from that graph".	The teacher reformulates Rob's intervention, so as to give a feedback on the task that can move the other students forwards (strategy 3).
234) Mark: Teacher, moreover with the sensor we told that if we went faster... the segment went more vertically, but here if... they say that it is on a climb and he goes too, he goes fast, and then when it becomes less steep he goes less fast... I don't know, in the descent he goes really faster than on the other two traits, but if they say that he climbs up in the first trait he goes faster and then when it starts being plane he goes less fast.	Mark intervenes making reference to the experience with sensors (thus linking the inclination to the speed) and pointing out that something doesn't work in what Mil and Pon wrote. Mark expresses his own doubts, but his intervention is also a <i>feedback</i> for Mil and Pon.
235) Teacher MT: But I... this answer really tells as if the first segment, the first two parts of segment that go up described the hill, the steep climb, the less steep climb, the top and after the descent...	
236) Student: That is wrong.	
237) Teacher: Then the idea that the segments, as Rob said... "the graph is different from the drawing of a hill", or Lollo said "when we did it with the sensors we saw this kind of segments but we were not climbing, it meant that we changed the speed"... Let's remember always that the y axis describes what? The distance from home in meters.	The teacher reformulates and synthesizes the interventions of the students, so as to give a feedback to Mil and Pon. The activated strategy is 3 (providing feedback) .
238) Rob: Moreover, teacher, problems with graphs are done in order to reasons and understand what they represent, not to connect to reality, for instance a graph could maybe indicate that in 5 minutes he did 2000 kilometers, anyway the point is not what is represented... yes, but you have to understand how it is represented, in a sense.	Rob provides a feedback about the processing on the task , pointing out that the justification must be based on the analysis of the information provided by the text and the graph, and not by everyday life experiences.
239) Researcher: You say: I cannot rely on experience, on the fact that 600 meters can not be done...	
240) Teacher MT: In half an hour maybe I could walk very slow and do just 1600 meters, there	

could be such a situation...	
241) Cate: As you said, teacher, here it is written that the y axis represents the distance from home in meters, we chose the C, but here it indicates that at the beginning, from 0 to 800 he (<i>Tommaso</i>) goes away from home and then after from 800 to 0 he goes back to home, because it descends.	Cate intervenes pointing out another (good) reason to refute story B: from the graph she sees that Tommaso finally goes back home, but the story does not say this. Cate turns herself as a resource for the mates (strategy 4), giving a fruitful feedback about the processing of the task (it is necessary to read all the information that are on the graph).
242) Rob: The sensor would be the house	
243) Teacher: Yes, the sensor would be the house. Then, what does it mean descending?	
244) Cate: Getting closer to home	
245) Teacher MT: Getting closer to home.	

In a subsequent part, the teacher goes back to the authors of the preceding answer (Mil and Pon), *to establish where they are*; in particular, she wants to check whether they understood the difference between the graph and the drawing of the hill.

308) Teacher MT: It is not the drawing of a hill. Mil, you were saying that... you are one of those who chose B.	
309) Mil: For me no option is correct because no answer says that Tommaso climbs down... the only one finally is the B, because it says "he descends on the other side".	Mili is still interpreting the graph as the drawing of the hill.
310) Researcher: Why, what do the other options say at the end?	
311) Teacher MT: He says "In the graph he does not go home". Then let's look at the graph.	The teacher intervenes, proposing to look at the information that are on the graph. She provides a <i>feedback</i> to move the students forward (strategy 3).
312) Ur: For me, on the contrary, yes, because anyway if... the line is to the bottom, it does not stop at...	Ur <i>activates herself as an instructional resource</i> for Mil and Pon (strategy 4).
313) Teacher MT: After 30 minutes, at which distance from home hoes Tommaso is?	
314) Student: Zero	
315) Teacher MT: Zero meters, and what does it mean? Where is he?	
316) Mil: At home	
317) Teacher MT: At home	
318) Rob: But maybe he (<i>Mil</i>) got confused and thought that in order to come back home it (<i>the graph</i>) had to come back to the starting point	In this intervention, Rob tries to interpret Mil's previous misunderstanding. This may be seen as a feedback about the processing of the task .
319) Researcher: Ah, you are interpreting what could have been Mil's doubt...	
320) Teacher MT: Mil's mistake. If you climb down, anyway, if you are on a hill and descend on the other side you do not come back home, but you get less close, while you were saying "he does not come back home, instead yes".	The teacher provides a direct feedback to Mil and Pon (feedback about the processing of the task).
321) Mil: Because I...	
322) Teacher MT: Ok? This point says that Tommaso is	

at zero meters from home, it means that I have to go back home, then it was already a reason for not choosing B, are you ok?	
323) Students: Yes.	

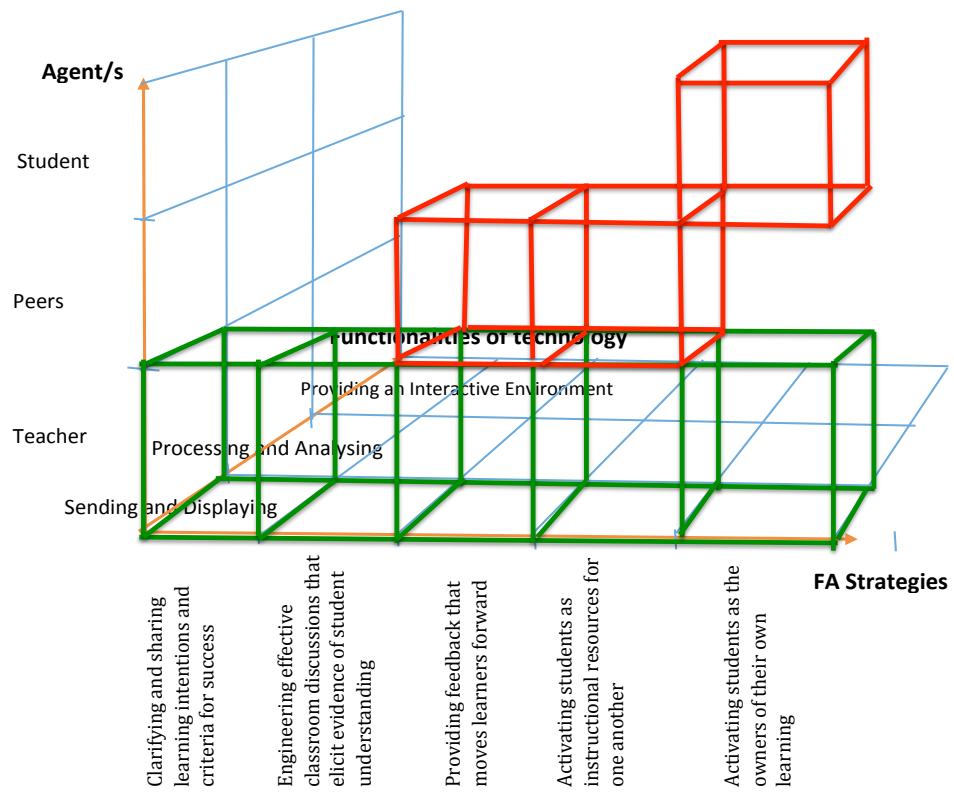
In a subsequent part, the discussion is again on the fact of referring to the experience with the sensors. Cate intervenes, calling for a more theoretical explanation. She is able to produce such an explanation by herself, drawing from the former feedback given to Mil.

330) Teacher MT: And moreover, with the experience with the sensor, Lollo says: also when we used the sensors we saw that line descending, but we were not descending or climbing, isn't it? Tommaso was getting away from home, after he was getting closer to home, did we have climbs or descents? No, he did a straight road!	The teacher proposes to the students the intervention of Lollo concerning the experiences with sensors.
331) Cate: But, teacher, I wanted to say that if somebody had not done the experience with the... the...	Cate <i>activates herself as owner of her own learning (strategy 5)</i> , calling for a clarification. She refers to the previous (see also the previous lessons) discussions on the value of the experience with sensors.
332) Teacher MT: Sensor	
333) Cate: Yes, the sensor. One could hypothesize that it was a hill, if he did not know it...	
334) Researcher: But what is that... wait, apart from the experience with the sensor, which is the information that is on the graph and that makes you surely refute B, independently from the hill?	The researcher intervenes, focusing again on the information coming from the graph that makes the story B non-acceptable. This is a <i>feedback about the task</i> .
335) Cate: That when he comes to the bottom he is home. There (<i>on the text</i>) it says that he goes down on the other side.	

The discussion continues with a quicker analysis of the answers of those groups that chose A and C.

Since no group asked or was recommended to use the additional worksheet 6A, that contained the work on the table of data, the teacher decides to assign the worksheet as a homework, to be discussed in the subsequent sessions.

The following diagram highlights the effective activation, by the three agents, of **all the formative assessment strategies**, through the use of the **sending and displaying functionality of the technology** during lesson 3:



3. Classroom teaching

In this paragraph we present teacher MT'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 lessons);
- the final interview on general aspects of classroom teaching.

3.1 Interview on this series of lessons

The interview was carried out following a semi-structured interview. The teacher knew in advance the type of questions (they were used also for the first cycle of interviews), then she gradually moved from answering the questions to speaking about her perception on the lessons in a broader sense. For this reason, we report what she declared, organized by themes.

Concerning the planned and implemented teaching sequence:

The worksheets on Tommaso's journey were carried out with more awareness than in the first experimentation (with another class, without the preliminary experience with the motion sensor).

The first worksheet (worksheet 5) was carried out by all students; from the beginning they had clear in mind that what we read on the graph was the distance from home and not the journey.

Concerning our timetable, planned times were completely over.

A difference in comparison to the former experimentation is that we performed the discussion on the subsequent lesson, if possible. It is very useful to discuss in the subsequent lesson because we do a careful selection, choosing the criterion of increasing difficulty, then at first we point out that there is the production that says nothing, after the production that uses data, after the productions that speaks also of speed, gradually.

The selection done on the spot, on the contrary, is not so... careful. And also students answer better when the discussion is carefully prepared.

Concerning the use of technology (by herself and by the students)

With technology we had no problem; the students use tablets with more and more awareness, they do not get distracted, they understand that the software is used to select their answers; if we choose their answer they declare "it is mine" immediately. They take the responsibility of their production, while when we did only discussions there were some students that were not keen to narrate what they had done. Now, on the contrary, they recognize their production and want to share it with all the class.

Concerning students' processes and interventions

Besides recognizing and taking the responsibility of their production, they are able to point out the differences among productions, in an unexpected way. They catch the differences between texts, also those students that I would not expect (to be able). Student Mil, for instance, did some good intervention, and also Debby, who is not usually... she suffers from her discontinuity in frequency, but she is very intuitive and today she came back to school and she immediately understood the task even if she had not attended to the previous session.

Anyway all the students seem involved and they seem to understand what we are doing, the use of technology, the comparison of productions, they are all in the activity.

Some students intervene very much, other students only when directly asked, with some exception. I noticed that they try to find motivations for the mistake of the classmate. In general, they listen to each other more, and they answer to each other.

I noticed an increasing care in the choice of language and reflection on the use of words.

Low achievers usually did not write very much, instead here they write more and in this way it is also possible to give them a feedback.

In the passage to worksheet 6 they encountered some difficulties because they also had to take into account some elements that were not taken into account before, such as the speed, or measure units that were missing and so on.

When necessary, they always referred to the experience with the motion sensor. But they went further.

Concerning the different modalities of work

I think they got better in the group work, during the discussions also groups that last year were very silent intervened. They also got better in data presentation. They all wrote something.

Class discussion for me is the most productive moment.

3.2 Interview on general aspects of classroom teaching

1. What is your educational background? How long have you been teaching? In this school? Why did you choose to become a teacher? What were the important steps in your professional career?

I have a Degree in Mathematics.

I have been teaching since 1986. I have been teaching in the Istituto Comprensivo di carcere (IC Carcare) since 2005.

I obtained my certificate to teach Mathematics, Mathematics and Physics, Applied Mathematics (for upper secondary school) and Mathematics and Science (lower secondary school). I obtained a permanent position as secondary school teacher in 2000. I moved to lower secondary school in 2004.

I have been tutor for national mathematics and science education projects since 2007.

I started my collaboration with university (University of Genoa) within the project "Language and argumentation in the study of mathematics" (since 2008).

I have been tutor for the national project "Interactive whiteboard" (LIM) since 2008.

I have been school responsible for the national project "Classi 2.0" since 2009.

I have been school responsible for the Mathematics and Science Department since 2006.

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

I had former experiences concerning formative assessment in the national projects I was involved and in the project on language and argumentation.

Within those projects, activities concerning basic concepts in mathematics were implemented; students' feedback was taken into account and collected, so as to promote teacher's reflective thinking and refinement of the activities themselves.

Moreover, teachers in my school have regular meetings to exchange ideas and compare what happened in their classrooms during relevant activities or new activities that were experimented for the first time. In this way, formative assessment takes place not only with students but also among teachers.

Concerning technology, I was involved in the project "Classi 2.0", funded by the Ministry of Education. My class was one of the 6 classes selected for my region. We planned and implemented activities with the use of new technologies in mathematics.

Within the project LIM, I acted as teacher educator for the use of interactive whiteboards in classroom.

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

Doing formative assessment in mathematics means to collect information on students' learning processes and development. Assessment is formative if the collected data are used by the teacher to improve his/her teaching so as to make it much effective as possible and adapted to those students in that moment.

Also the student, becoming aware of his/her learning process in comparison with that of his/her classmates, can evaluate himself/herself and the classmates, analyzing his/her process and shaping his/her reasoning in the way that is more adapted to the context.

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

The continuous discussion I promote in classroom and the feedback I collect from my students allow me to adapt my planned teaching to my students.

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

I think that formative assessment in mathematics is necessary in order to carry out teaching activities that are meaningful and effective for the learning of contents and the development of reasoning.

The use of ICT, besides proposing tools that are familiar to the social reality of students, allows us to involve in the best way those students that are less motivated.

The use of specific ICT fosters the understanding of some concepts (in geometry, in graphical representations, in the use of specific functions). Moreover, having a connected classroom at disposal for the real-time exchange of documents, it is easier and faster for the teacher to assess the processes and adapt his/her teaching, and for the students to see and reflect on their activity.

Technical difficulties, unavoidable moments of lost time, different individual abilities in the use of technology, habits linked to the everyday life use of technology may create critical moments during the lessons. Moreover, the lack of technical support at school makes the preparation and maintenance of devices more difficult.

6. What are the affordances, and the constraints?

The affordance is the fact of having at disposal for the analysis complete and exact information on processes.

The constraints are the technical difficulties.

7. What are important features of your teaching?

My teaching is based on a clear didactical contract, shared with the students and their families. At the basis there a mutual, continuous and deep respect, that engenders a quiet and ordered classroom climate.

Students are continuously encouraged to take part to the lesson and the evaluation is done on the process rather than on the product.

I try to be always helpful and I introduce the concepts starting from situations that are meaningful for the students. I encourage students to search for their own ways of learning and I try to avoid frontal lessons. I like using varied strategies and adapt my teaching to the class.

I take inspiration from y activities from various sources and modify them, trying to be innovative as much as possible every year.

8. Which way/s of teaching do you consider effective?

I consider effective ways of teaching that are varied, so as to foster different types of intelligence. In general, I consider effective the following sequence of activities: individual work; comparison in small group; classroom discussion (which is, for me, the most efficient way of working in class).

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

I do not give ready-made solutions, but I try to analyse with them the situation, to clarify what is asked and guide them in the search for the most adequate strategies.

10. What are the difficulties that students experience, in your view?

Students in general have difficulties in becoming aware of their thinking modalities. Common misconceptions concerning mathematics lead them to look for simple ways and apply routine procedures. This leads to the well-known difficulties when it is necessary to apply knowledge in different contexts.

Moreover, linguistic difficulties, that are still widespread at this age, make the communication non precise and non efficient.

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

The most important activities are those that are meaningful and motivating for the students.

In general, I consider important those activities that are adapted to their age, their background and their interest, and emotionally involving.

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

I think there is not a resource or teaching strategy that is more useful than another; rather, there is a resource or teaching strategy that is more adapt in a given moment, for a given class, for a givent content to teach.

13. What is important for students to learn in maths/science?

It is important that students learn the modalities and power of rational thinking.

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

I often organize work in small homogeneous groups (students of the same group have the same level). In this way, when difficulties emerge I can help all the students of the group, through the comparison with the mates during the collective discussion.

During individual work I try to monitor continuously the individual processes, in order to intervene in a focused way.

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

I try to understand the causes of the mistakes, in order to intervene directly on the misunderstanding the caused the mistake. I give further examples or similar situations in order to make the mistake clear and help the student to overcome it.

4. Pupils' perceptions

For the general presentation of the Q-sorting activity, see paragraph 5.1 of the Case study 1 (Garino).

4.1 Analysis of the Q-Sorting activity

The groups for the Q-sorting activities were formed keeping together the students with similar level, if possible. We present here the Q-sorting of a medium-high achieving group (group A) and of a medium-low achieving group (group B).

4.2.1 Group A (*medium-high achieving students*)

Group A is constituted by the pair Mark and Mario and the pair Paul and Brown.

They are all medium-high achievers. Mario is a high achiever but, in the teacher's words, very "scholastic": he is high performing in procedural mathematics, less brilliant (and less involved) in laboratory activities, group work and discussions. During the FaSMEd activities he performed well in groupwork, but intervened rarely (only if encouraged by the teacher). In terms of formative assessment strategies, we may say that he never turned into an instructional resource for his peers.

His groupmate Mark is a good student and did some good interventions during the activities. The students of the other group (Paul and Brown), who have a medium level, were very involved during the activities. They enjoyed the work, discussed a lot among them and intervened during class discussions.

In the first Q-sorting activity (*view on mathematics*), they organized the cards in the following way:

<i>Completely disagree</i>	<i>Not completely agree</i>	<i>Completely agree</i>
Mathematics is best learnt in collaboration with others.	I learn things quickly in mathematics.	Mathematics is something everybody can learn.
In mathematics there is no time for reflection.	Mathematics is difficult	Mathematics needs a lot of memorising.
I am nervous in mathematics lessons.	When I do not understand (in mathematics) I ask for help.	Everybody can learn mathematics if s/he works hard enough.
In mathematics there is no room for expressing one's own ideas.	Mathematics means exploring and experimenting.	Answers in mathematics are either right or wrong.
To learn mathematics it is necessary to solve many of the same tasks.	If I cannot solve a task, I become frustrated and give up.	I like mathematics

Only gifted people understand mathematics.	In mathematics there is only one right answer.	I am good at mathematics
	When I work on my own I learn better	Mathematics is fun
		Mathematics is a subject where one can be creative.

Looking at the columns, we may grasp a general positive attitude to mathematics in terms of emotional disposition and self-perception in reference to mathematics (“I like mathematics”, “I am good at mathematics”). They also agree on the fact that everybody can learn mathematics.

The view of mathematics that emerges from their choices is promising: they agree on the fact that in mathematics there is room for creativity and for expressing one’s own ideas, and recognize that doing many exercises of the same kind is not necessary. Anyway, they also agree on the fact that it is necessary to memorize timetables, formulas and so on.

There is a long discussion on the fact that in mathematics there is only one right answer (Paul: “ $1+1$ can not be 3!”).

Referring to the graph tasks, they point out that more than one answer was possible.

The “Not completely agree” column is mainly due to the fact that Mario does not agree with the other mates. For instance, he strongly affirms that he prefers working by his own.

Concerning the technology used in the FaSMEd project, the students organize the cards in the following way:

<i>Completely disagree</i>	<i>Not completely agree</i>	<i>Completely agree</i>
When I work with IDM-Tclass during mathematics lessons, I quickly understand if and why I am wrong.	Using IDM-Tclass during mathematics lessons helps me to better understand the objectives of the activities	Working with technologies in mathematics is useful.
I never remember what to do when I use IDM-Tclass during the mathematics lessons.	If I work with friends and IDM-TClass, we can find the answers.	My friends help me to work things out, or the teacher, but not IDM-TClass.
When I work with IDM-Tclass it takes me twice as long, and cannot ask the teacher directly.	Since we use IDM-Tclass I got quicker through the exercises.	
For me, the technology does not work, or help.	When I work with IDM-Tclass during mathematics lessons, I better understand what I have to do to improve my	

	understanding	
Using IDM-Tclass during mathematics lessons helps to understand what the teacher wants us to learn.	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.		

In general, they recognize that working with the software is useful and not difficult, but do not attribute to technology “per se” all the power and advantages. They even put in the “completely disagree” or “not completely agree” column many sentences referring to the link between software and formative assessment not because they do not recognize the usefulness of the software, but because they cannot ignore the other influent factors: the kind of activity and the contributions of the teacher and the peers.

For instance, Brown points out the importance of class discussions:

Brown: It is the discussion that makes you learn, not the software. Everybody explain his reasoning and you learn more.

Mark is very efficient in describing the formative assessment **strategy 3** (*providing feedback that moves learners forward*) that takes place during the class discussion:

Mark: On the tablet you get the worksheet, you solve it and you don't know whether it is right or wrong. When you do the discussion you can understand whether you did right or wrong.

Brown and Paul recognize the importance of having the peers at disposal and getting their feedback:

Paul: in order to understand you need somebody that explains you.

Brown: and the comparison with others and the moment when you listen to the other opinions are the most important because you understand what the other people think and you don't stay alone in your own logic, you can see the logic of other people and maybe put all together and understand what is right and what is wrong.

The students also appreciate very much the fact of working in group:

Brown: working in this way is useful because you understand what other people think. Even if we always quarrelled, if I did a mistake he corrected me and if he did a mistake I corrected him and even if there was a quarrel at the end we came to an answer that we felt correct.

Paul: it was the groupwork.

Amato: yes, also for me. It depends on your groupmate, he can make you understand if you did wrong or correct you or you can correct him, or your mates.

4.2.2 Group B (medium-low achieving students)

Group B is constituted by the pair Lollo-Lola and the pair Mil-Pon.

Lollo is a low-medium achiever. During the FaSMEd activities, he intervened a lot, trying also to activate as owner of his learning process and, when possible as resource for the classmate. Lola is a good student and she did some interesting interventions, although not so frequent. Mil and Pon are low achievers. Their written productions were often selected by the teacher and the researcher for the class discussion, so as to give them some feedback about the task and the way of processing it.

In the first part of the interview, the students worked on the set of cards on mathematics, producing the following categorization:

<i>Completely disagree</i>	<i>Not completely agree</i>	<i>Completely agree</i>
I am good at mathematics	When I do not understand (in mathematics) I ask for help.	Mathematics is difficult
Mathematics is a subject where one can be creative.	Mathematics is fun	I learn things quickly in mathematics.
In mathematics there is no time for reflection.	In mathematics there is only one right answer.	Mathematics is something everybody can learn.
In mathematics there is no room for expressing one's own ideas.		Only gifted people understand mathematics.
If I cannot solve a task, I become frustrated and give up.		Mathematics needs a lot of memorising.
Mathematics means exploring and experimenting.		To learn mathematics it is necessary to solve many of the same tasks.
		I like mathematics
I am nervous in mathematics lessons.		Answers in mathematics are either right or wrong.
		Mathematics is best learnt in collaboration with others.
		Everybody can learn mathematics if s/he works hard enough.
		When I work on my own I learn better

In general, a complex attitude towards mathematics emerges. Emotional disposition towards mathematics is good (they do not agree on the fact mathematics makes them nervous or frustrated; they affirm that they like mathematics), but the self-confidence is not high (they affirm they are not good at maths). They accept that in mathematics one can be creative and

express his own idea, which can be linked to the specific didactical contract of the classroom, where discussion is usually performed and argumentation is valued. Anyway, for them learning mathematics requires a lot of exercise, and this could be linked to a procedural view of mathematics.

The sentences on the “not completely agree” column are due to the fact that Lola has a better relation to mathematics (she thinks mathematics is fun) and affirms that, when in difficulty, she prefers not to give up and try to solve the problem by herself. This may be linked to formative assessment strategy 5 (activating as owner of her learning process).

Lola: for me it is better to do again by your own rather than asking for help. Because maybe the other are able to do it, and when you have a difficulty and cannot ask for help you don't know what to do.

The fact that in mathematics there is only one right answer is discussed by all the students, and they conclude that it depends on the activity.

Concerning the way of working in class, the students agree on the importance of working in collaboration:

Lollo: it depends from the classmate with whom you collaborate. If you are with somebody who is good...

Mil: also with somebody of the same level, because if you think something and the other thinks another thing...

Lola: together you understand what is right.

Interestingly, they also say that they understand better by their own.

They also report very positive comments on class discussions. This is maybe linked to the fact that low achieving groups received a lot of feedback during class discussion.

We report a short excerpt from the interview, so as to point out the way they perceive the feedback they receive from their peers (strategy 4 of formative assessment):

Researcher: Are discussions useful?

Mil: yes, because you hear the opinions of the other students and you understand what was wrong in what you did, and you come back on that point and you learn how to reason.

Lollo: Cate during the discussions was always raising her hand and saying that our answers were wrong!

Researcher: did she say simply that you did wrong?

Lola: well, maybe for her something of what we did was right and something was wrong, and she corrected us.

Researcher: but when she raised her hand what did you feel? “Oh my god, Cate is going to say something more” or “thanks god cate is going to help us”?

Lola and Lollo: she is going to help us!

Researcher: was there some occasions when you thought: “I'm going to intervene to help somebody to understand... “

Lollo: yes, to Cate!

Researcher: and the contrary, I don't intervene because I'm not sure...

Lollo: no.

Concerning the use of the software during FaSMEd activities, this is the way they organized the cards. We point out that there were no cards in the “not completely agree” column. The categorization was very quick. They did not agree with all the sentences referring to the difficulty or lack of utility of technology. In comparison to the first Q-sorting group of students, they tended to attribute a larger importance to the software.

<i>Completely disagree</i>	<i>Not completely agree</i>	<i>Completely agree</i>
When I work with IDM-Tclass during mathematics lessons, I better understand what I have to do to improve my understanding		Working with technologies in mathematics is useful
Using IDM-Tclass during mathematics lessons helps to understand what the teacher wants us to learn		If I work with friends and IDM-TClass, we can find the answers
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
When I work with IDM-Tclass it takes me twice as long, and cannot ask the teacher directly		Using IDM-Tclass during mathematics lessons helps me to better understand the objectives of the activities
I never remember what to do when I use IDM-Tclass during the mathematics lessons		