ENSL

Case study in maths

1. Context

The school

Collège Fontreyne is a low secondary school of a small town in South-East of France (Gap). School population is summarized in the table below.

	School	Public + Private Department	Public + Private Regional education authority	Public + Private France	same sector Dpt	same sector Reg	same sector Fra
Senior managers and teachers	20,8	20,1	22,5	22,3	19,2	18,8	18,8
Middle managers	13,5	12,5	11,9	12,4	12,7	11,5	12,0
Employees, craftsmen, tradesmen and farmers	36,3	38,9	28,8	26,7	38,4	28,2	26,1
Workers and inactive workers	25,6	25,5	34,6	35,3	26,6	39,2	39,7
Not specified	3,8	3,0	2,2	3,3	3,2	2,3	3,5

Tab. 1 Distribution by professions and socio-professional categories (PSC) 2014-2015
source: https://fichetab.ac-aix-marseille.fr/index.php/etablissement?rne=0050480V

The class

Grade 9 class (students' age: 13-14), composed of 22 students with an average school level. The teachers declare that there is no difficulty in the class management. The class composition has been made with the will of creating a class with low achievers and medium students.

The teacher

Mathematics teacher since 2001, Thomas taught 4 years in different schools (high school and secondary schools) before coming in this secondary school. He is involved in different projects and is a driving force in his school. He has had an institutional position in the regional education authority since 2002 and had been inspector for one year. He has worked with technology since the beginning of his career, and he indicates that the possibility to use an IWB in his class is an important stage in his career.

2. Tasks and resources used

Session 1 (day 1)

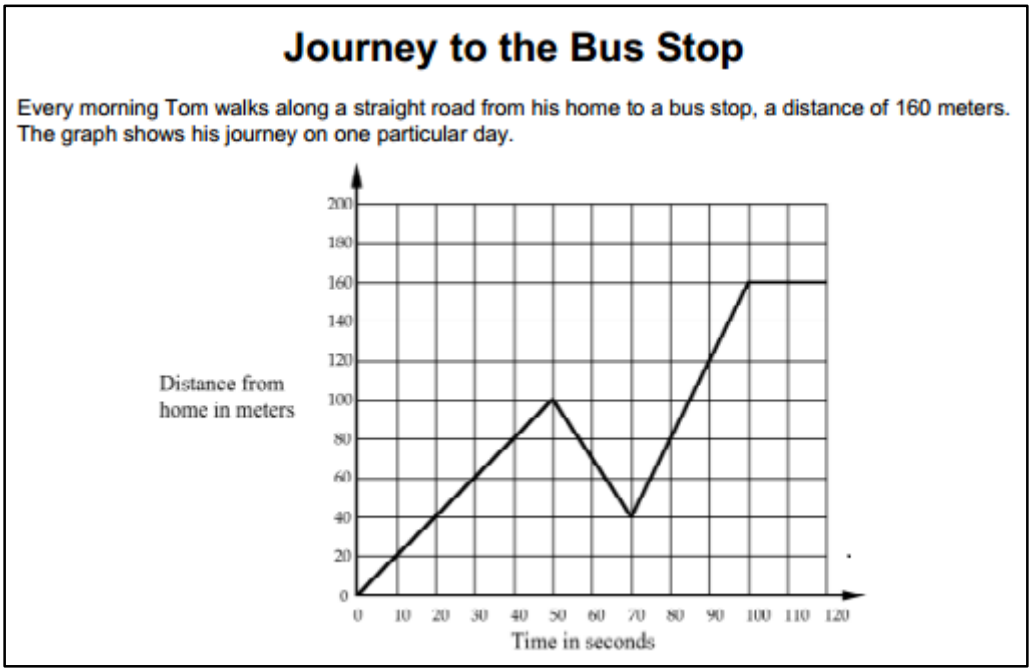


Fig. 1: Sheet of the Activity 1

Activity 1: write a story that corresponds to the graph in Fig. 1.

Activity 2: matching a graph with a story (Fig. 2). Translated in French, the task has been copied and pasted in Maple TA.

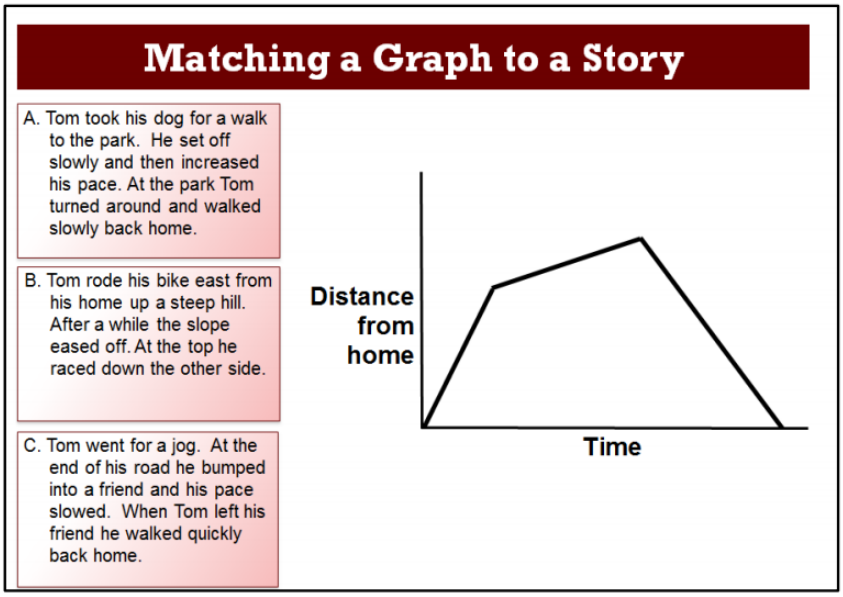


Fig. 2: Question entered in Maple TA

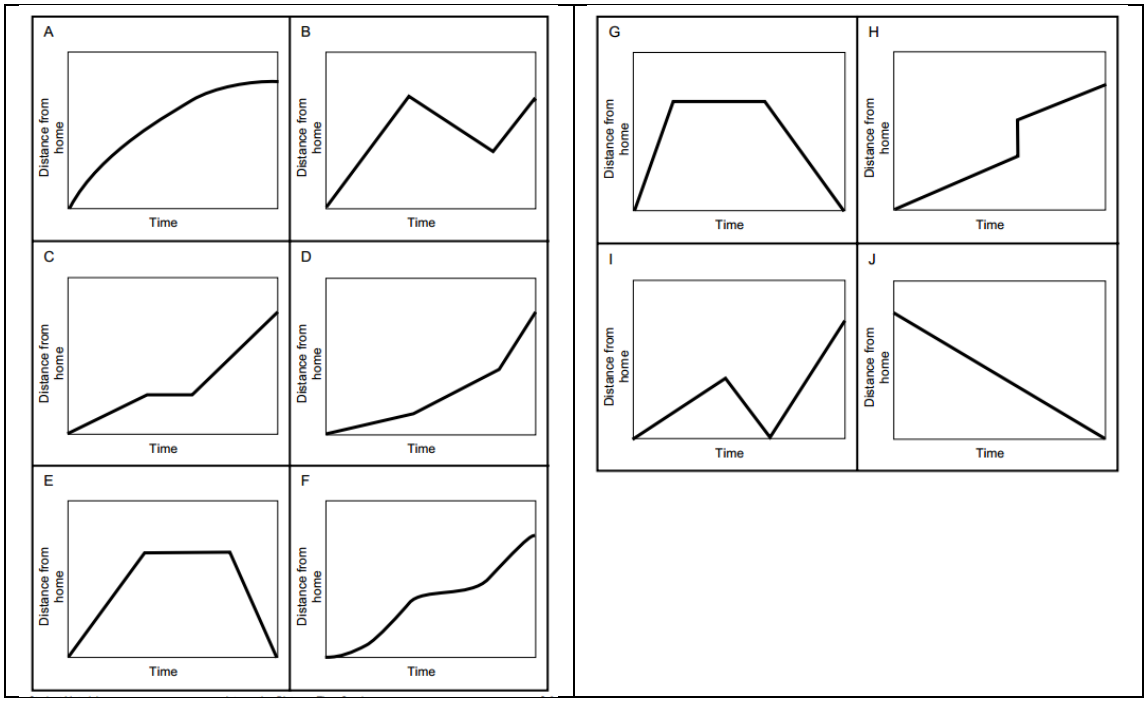
Session 2 (day 2)

Feedback on the classroom's scores regarding the Activity 2 (Fig. 2).

Sharing and discussion about the students' stories concerning the Activity 1 (Fig. 1).

Session 3 (day 2)

Activity 3: Matching ten graphs to ten stories (Fig. 3) on Maple TA.



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!

Fig. 3: Activity 3 entered in Maple TA

Session 4 (day 3)

Feedback on the classroom's scores regarding the Activity 3 (Fig. 3).

Sharing and discussion about the students' answers.

Session 5 (day 4)

Individual assessment (paper and pencil) on the base of the Activity 1 (Fig. 1).

Copies of other tasks used

The will of the teacher was to insert the particular FaSMEd lesson within his actual progression. Therefore, he chose to begin the lesson by solving equation exercises. Students used their tablets and shared with the teacher their results.

Technology used:

- By the students: tablets with
    - One Note 2013 as a text editor
    - Maple TA as an online quiz platform

- By the teacher: computer
    - linked to the IWB and to the tablets network (NetSupport School);
    - with Maple TA as a quiz editor and platform to send questions, to collect and analyze students' answers.

Type of formative assessment used:

"Ritualized" questions on Maple TA with feedback to the students about the classroom's results that allow to motivate learning and to inform the students on their progress, with complete or partial correction in the notebook.

Class tests

Some weeks later, T proposed to his students an activity called "breathe like a graph" where he asked students to interpret a graph that gives the volume of air in the lungs as a function of time and finally to breathe like the graph.

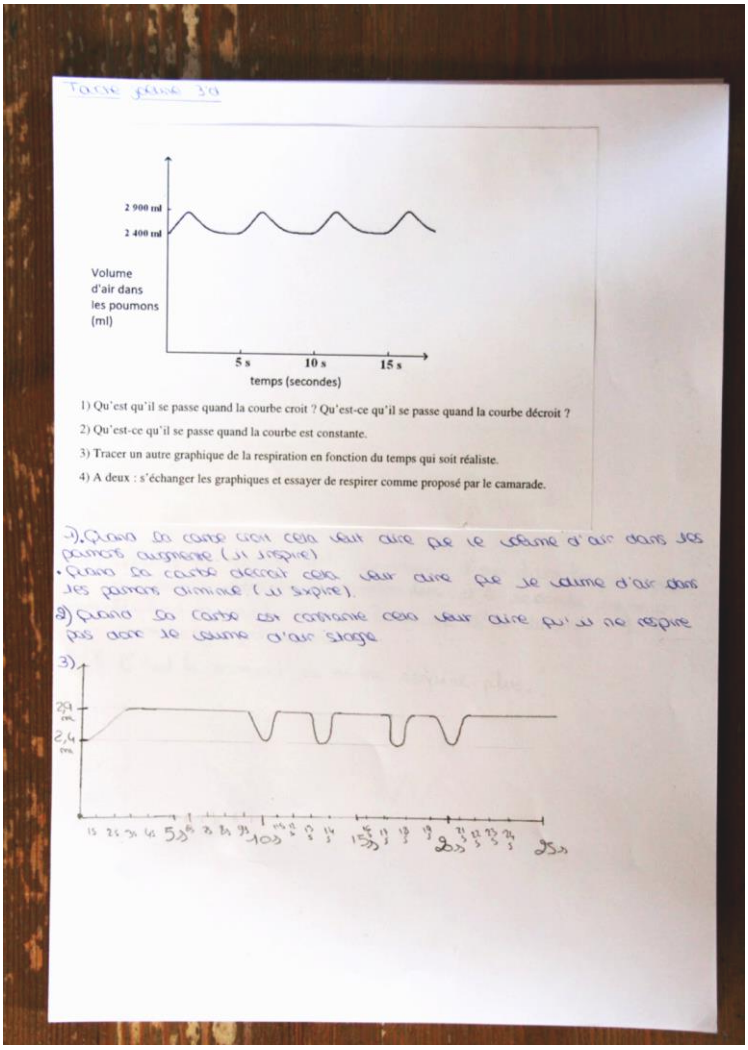


Fig. 4 Breathe like a graph

The questions:

1) What happens when the curve grows? What happens when the curve decreases?
2) What happens when the curve is constant?
3) Draw a graph of breathing as a function of time which is realistic.
4) By two: share your graphs and try to breathe like the graph of your mate.

On the example shown Fig. 4, the student wrote:

1) when the curve grows, it means that the volume of air in the lungs increases (he/she inhales) when the curve decreases, it means that the volume of air in the lungs reduces (he or she breathes out) .
2) when the curve is constant it means that he/she doesn't breathe any more and the volume of air in the lungs stagnates.

3. Work with teachers

The French research team has worked since the beginning of the school year 2014-2015 with the teachers team of the "tablet classroom". More particularly with the teachers of literature, English, Spanish, History and Geography, Physics and Mathematics. The case study we are presenting has been implemented in the maths classroom. Therefore, we focus more on interactions with the maths teacher which was organized in different ways:

- at distance
  - the teacher filling in a diary
  - by email
  - using google drive
- in the presence of the teacher
  - cluster meetings
  - days of observation: the school is relatively far from Lyon and we arranged two to four days observations where we followed the students in their school timetable and took time to discuss with the teachers' team and more particularly with the maths and science teachers.

The work between the maths teacher and researchers was essentially organized around the lessons contents, the FA philosophy and the potentialities of technology in terms of FA.
During the school year 2014-2015 and the first trimester of school year 2015-2016, we met teachers seven times:

- During the cluster meetings (December 2014, 10th, July 2015, 1st)
  - **December 2014**: (17 participants, meeting led by researchers) general presentation of the FaSMEd project and reflections about the pair "FA-technology". Discussion about the different solutions that schools have chosen: connected classrooms, students response systems, tablets classrooms,...
  - **July 2015**: (12 participants, meeting led by researchers) work with teachers about FA process. Probation of the theoretical framework of FaSMEd (three-dimensional model) in relation with the different experiments in the classes. Discussion with teachers showed the effectiveness of the model and its potentialities for analysing a class situation.

- During the school visits[31]:
  - **November 2014 (3 days)**: first observations in the classroom. It was the very beginning of the connected classroom and students had had tablets at their disposal for 15 days when we visited the school. We noticed that even if students seemed to be confident with tablets, the technical difficulties that teachers encountered needed a very important work by teachers in order to keep a (almost) fluent operating in the classroom. FA was at that moment an external component of teachers' teaching conceptions. This meeting with teachers (8 participants teaching in this class) was the occasion of presenting the whole project and working on FA as a process in relation to the potentialities of connected tablets.

Fig. 5: The maths classroom

  - **February 2015 (2 days)**: first intervention cases in mathematics where the teacher began to use Net Support School to share data with students but also to ask questions. At the end of the week, the maths teacher wrote: "*I was astonished by the encountered difficulties of some of my students, particularly coming from students that I have already detected as struggling students. It is an obstacle that I had clearly minimised in my teaching practice until now. The work in the FaSMEd project as well as the use of tablets in classroom helped me to better grasp this obstacle*". In this occasion, we met the teachers' team (8 participants) to discuss about the managing of tablets in the classroom and formative assessment.

[31] The complete report of these observations and meeting with teachers is available in :

Aldon, G., Panero, M. (2015). *Classe tablette au collège Fontreyne de Gap. Une étude didactique.* DOI 10.13140/RG.2.1.2495.5606, https://ife.ens-lyon.fr/fasmed/IMG/pdf/rapport.compressed.pdf

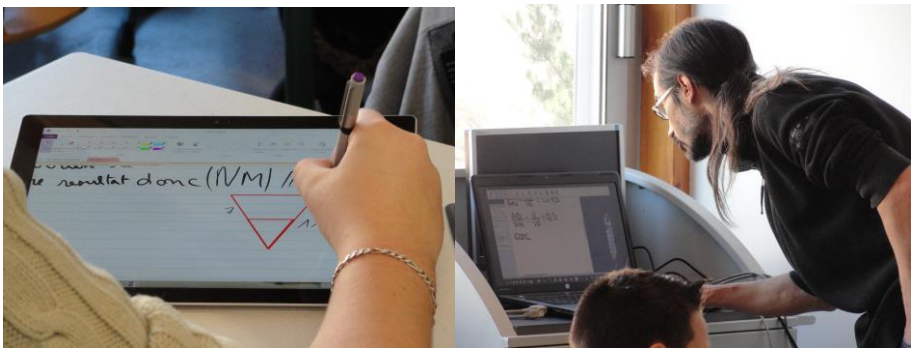


Fig. 6: Teachers and students working with a network of tablets

- **April 2015 (3 days)**: second intervention cases in mathematics where the teacher used the potentialities of the network to share, display, process and analyse data from students. More generally, relatively to FA strategies, the maths teacher orchestrated the different functionalities of technology in direction of individual students, of the whole classroom or even of himself. Instrumental orchestration helped him in refining his FA strategies. Indeed, moving from 'processing and analysing' data to 'sending and sharing' results or new learning tasks allowed him to choose the most powerful FA strategy according to students' mastering of the competences at stake. The maths teacher wrote: "*the positive aspects: […] high enhancement of struggling students with positive incidence on their learning capabilities. […] awareness of every students, due to the use of FA*".

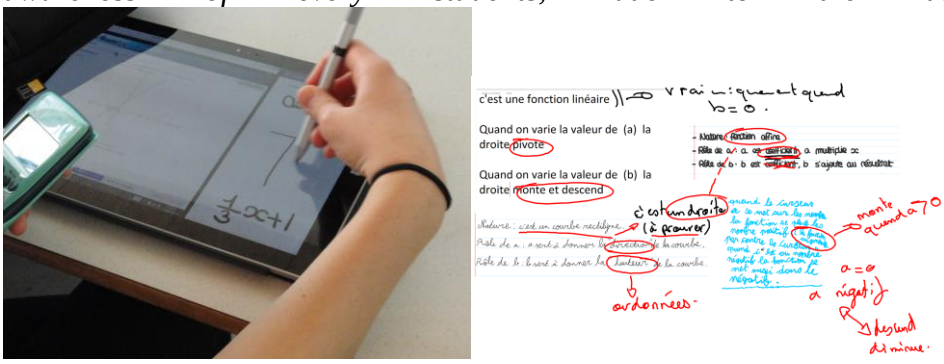


Fig. 7: Lesson about linear functions

- **June 2015 (1 day)**: presentation of the results of the first year experiment and discussion with teachers, headmaster and students' parents (25 participants). Meeting with students and q-sorting activity.

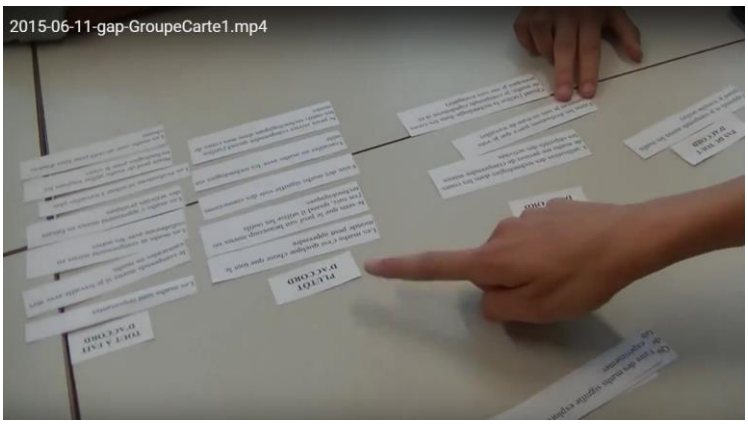


Fig. 8: Q-sorting activity

- **October 2015 (4 days)**: the case study experiment that is more developed below: use of the FaSMEd resource "Time-distance activity"; Q-sorting activity with the students before and after the intervention. In addition, we had a meeting with the new teachers' team, composed of four teachers of the previous experiment and two new teachers, the headmaster and two researchers. In this meeting led by researchers, teachers having an experience from the previous year played a role of facilitator by sharing their practices with the tablets.

In the first year of experiments, the main difficulties that teachers mentioned are due to the technical aspects of networking and managing the tablets in an effective pedagogical way. In the second year of experiments, these difficulties seem to regress and the main difficulties that were mentioned in the discussions with teachers were the management of the students learning tracks. In October 2015, when we met the teachers' team, the teacher of history and geography stresses that the passage to the notebook is artificial: "*This year I juggle the notebook and the tablet at once, but I haven't found a satisfactory solution yet.* [...] *There is the aspect digital activities, that we cannot always integrate in the notebook in terms of written track* [...] *so there is often a rupture: we work with technology and then we close the tablet and we move on to the notebook for getting a written mark on paper. Up to now, I'm not satisfied.*" The question of managing students' learning tracks remained to discuss, but teachers decided to adopt shared decisions in the classroom.

Concerning the time-distance activity, the difficulties that the maths teacher mentioned when using FaSMEd material are linked to the very new ways of thinking a mathematics lesson on a topic that is not easy to teach: relationships of distance and time and representation on a graphic. Commenting the experience during the lesson, he shared his feelings with the students: "*If it seems difficult, it is also because it is a chapter that I always skipped before.* [...] *So I try, but if I have some difficulties in explaining you this topic it is because it's hard for me too... Not being wrong, remaining correct... It's not something evident.*"

4. Classroom teaching (based on teacher interviews)

This section corresponds to the report written by the teacher starting from the questions here written in bold characters.

Your experience on the use of technology in the classroom before FaSMEd.

- I have been using systematically a computer associated with a video projector and an IWB for five years. I have a good command of these tools, technically as well as pedagogically.
- I worked in the computer room with my students occasionally (spreadsheet, DGS)
- I was used to send work to students by email. I provided to students the written notes taken at the IWB.

Your experience on the use of formative assessment in the classroom before FaSMEd.

The use of formative assessment was implicit. I had very low awareness of it. No specific tool was constructed or used for this purpose. The collection of information was done through conventional controls, activities at the beginning of the lesson, oral exchanges, observations of students in their activities. The quality and consistency of the treatment of such information varied widely.

What is now for you formative assessment?

Gathering information at all steps of the teaching act.

Treatment may result in:

- an oral return to individual students enabling them to appreciate the value of their work (with the possible consequences: inflection or relaunch of work in progress, boosting of already done student's work),
- a collective feedback to class enabling it to assess the value of students' work (with the possible consequences: inflection or relaunch of work in progress, boosting of already done class work),
- accumulating and analysing data by the teacher (for further feedback to students written and oral with argumentation. For evolution and rewriting of upcoming courses),
- having discovered the formative assessment in the FaSMEd project and a working group called "technology", it has also become closely associated for me with new digital tools uses:
    - tablets, instant collection for exploitation with IWB, written records of students, interactive quizzes (Netsupport school, MapleTA)
- it is for the first time in my teaching career that:
    - I can have valid and comprehensive information on the status of my students' knowledge acquisitions,
    - I can process this information effectively in order to improve students' skills (that I think is partially achieved).

What are the advantages and disadvantages of using technology for the formative evaluation? (difficulties, inputs, constraints ...)

There were some technical difficulties related to the handling of the material, during the first two months of FaSMEd project. Today I see only advantages of using digital technologies for formative assessment. Some of the reasons are the following:

- increased student motivation for all new types of assessments available on digital media. Students especially appreciate to have instant feedback (feedback which can be individual or collective)
- ease of collecting and processing information (for some assessments there may be corrections and statistics or automatic exhaustive results)
- facilitated exploitation of students' written work with the interactive whiteboard.

More specifically in this class sequence: what are the difficulties you had planned that students would encounter?

- The misunderstanding of the information carried by the graphic
- The confusion between graphic and map
- Difficulty in manipulating the speed as a measure
- Difficulty to interpret the relation between two quantities

What types of student activity are especially important in this sequence?

The production of free texts linked to the graphics (for the creative aspect induced by this approach. Creativity in term of literature that comes in a dialectic relation with the"mathematical" creativity. The oral and written exchanges between students within groups (for the knowledge and individual skills construction with peers)

The collective syntheses based on students' work and presentations.

5. Lessons

During the cluster meeting of July, the time-distance activity has been presented and commented. The maths teacher of college Fontreyne decided to implement this activity in his grade 9 class in the first trimester of the school year 2015-2016.

In September 2015, we (two researchers) and the maths teacher exchanged by email about this implementation of the FaSMEd material concerning the time-distance activity. The choice of the activities (see Fig. 1, 2 and 3) and the mode of implementation, as well as the organisation of the work in the classroom, were planned by the teacher. We both observed and videotaped the mathematics classroom during a whole week :

- day 1: session 1 and 2;
- day 2: session 3;
- day 3: session 4.

One camera was focused on the teacher, the other one on the students' activity. We both met seven voluntary students on day 1 and all the students on day 3 for discussing about the experience and proposing the Q-sorting activity.

We met the teacher on day 2 to organise together the session 4 (day 3) according to the students' productions and the emerging difficulties.

The teacher documented the session 5 (day 4) where researchers were no more present.

A PRIORI ANALYSIS OF THE LESSON

Having observed the teacher during some lessons about linear functions in April 2015, we know the learning objectives he considers important to achieve concerning this topic, working with different register of representation:

a. Calculating and detecting images.
b. Calculating and detecting inverse images.
c. Recognising a linear function.
d. Shifting from the graphical frame to the algebraic frame and vice versa.

These are the mathematical competences he wanted the students to achieve during the last year of low secondary school in relation with high level competencies about problem solving and modelling. Time-distance activity fits these didactic intentions, because it can prepare the mathematical background to deal with these competencies.

Time-distance activity comes after two learning sequences implemented in the classroom and in parallel with a third one. The different sequences overlapped throughout the lessons.

First sequence: introduction of the notion of function (modelling; optimisation; different forms of representation: algebraic, table of values, graph; use of paper and pencil; use of excel and GeoGebra).

Second sequence: mobilisation of grade 8 geometrical notions and introduction of the Intercept Theorem.

Third sequence (in parallel with time-distance activity): problem solving with equations of first order.

In order to support his didactic choices, the teacher has developed a scheme of action relatively to the formative assessment process that he has implemented in different situations:

- making the students work in group for fostering discussion and argumentation among students;
- collecting one production for each group (one student writes on her tablet the proposal agreed in the group while the others take note either on their notebook or their tablets);
- showing the different production at the interactive whiteboard (IWB) and commenting them with the students;
- using the Net Support School for managing the groups' work and the Maple TA for managing the individual work;
- providing feedback both individually and about the class' progression.

ORGANISATION OF THE LESSONS

In this section, we explain the organisation of the lessons in a very descriptive way. In the next section, each of this session are analysed.

Session 1 (day 1)

Objective: understanding students' interpretations of a time-distance graph.

Activity 1 (30 minutes): Working in groups of three or four, the students had to write a story that corresponds to the graph in Fig. 4: "Tell what could have happened (using maths)". Everyone had to note down the proposal shared in his/her group, one student per group had to write the story on his/her tablet using One Note 2013.

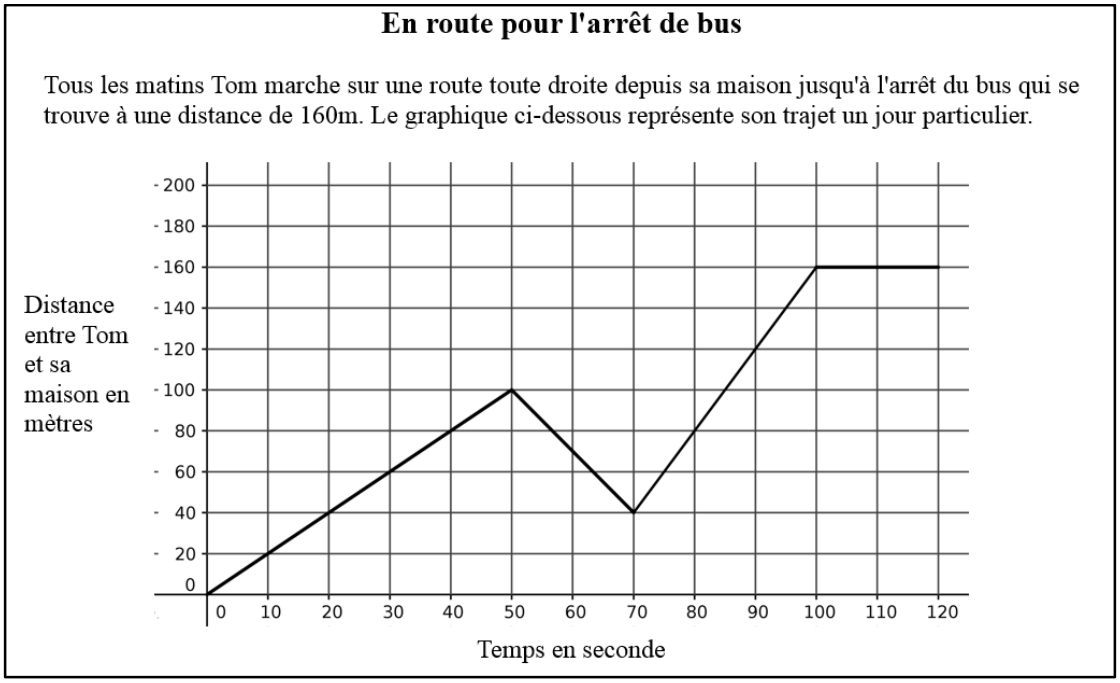


Fig. 9 : Student's sheet of the activity 1.

The teacher collected the production of each group. For doing so, he accessed the students' tablets from his computer through the Net Support network, made screenshots of the students' proposals, pasted them on a document shown on the whiteboard.

In this way, the different groups' productions were shared in the classroom. The teacher read all of them with no validation, and he asked to students to note down any element they find interesting or different from what they had done.

Session 2 (day 1)

Objective: understanding students' interpretations of a time-distance graph.

Activity 2 (10 minutes): An individual question was proposed on the platform Maple TA. The picture in Fig. 5 had been copied and pasted to create a Maple TA question and the students had to enter A, B or C

as an answer.

Students worked individually: they accessed the platform from their tablets using their personal account, they found the question in the quiz to be done, reflected a while on the problem and then submited their answer.

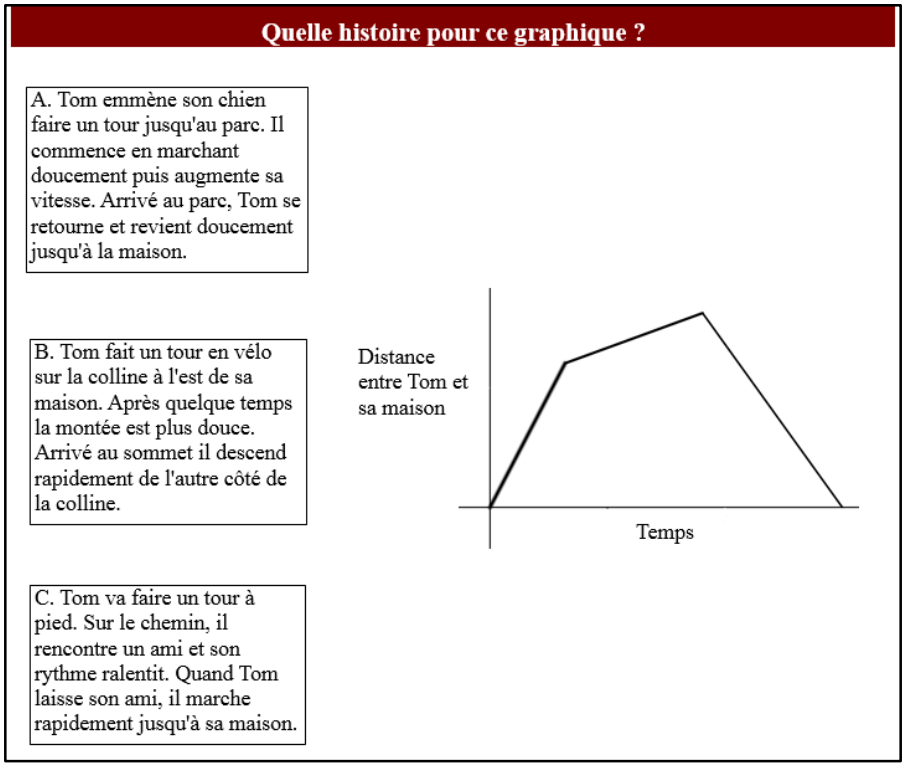


Fig. 10: Student's sheet of the activity 2.

Session 3 (day 2)

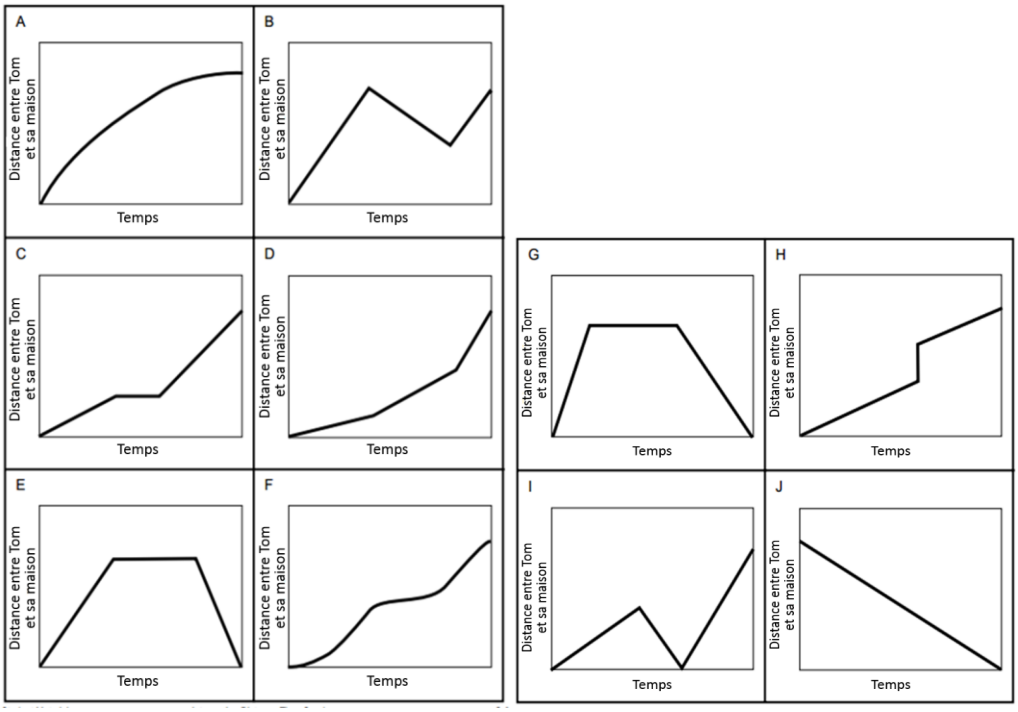
Objective: coming to an agreement about the interpretation of a time-distance graph.

The teacher commented on the classroom's scores regarding the Activity 2 (Fig. 2). While doing so, he displayed the scores and the classroom's percentage of success on the interactive whiteboard.

The teacher then displayed the graph in Fig. 1 and asked to two students to come and tell their story to the classmates, showing the different moments at the whiteboard. The story telling made come up two students' difficulties/misconceptions: the graph as a map and the misinterpretation of the constant part of the curve.

The teacher didn't validate the stories and invited the classmates to ask questions to the students at the whiteboard. Then, he introduced the activity 3.

Activity 3 (15 minutes): Matching ten graphs to ten stories (Fig. 6) on Maple TA.



1 Tom a couru de sa maison à l'arrêt du bus et il a attendu. Il s'est rendu compte qu'il avait raté le bus et donc il est retourné à la maison en marchant.	**2** En face de la maison de Tom il y a une colline. Tom a monté doucement la colline, il a marché au sommet de la colline, puis il a descendu rapidement l'autre versant.
3 Tom a fait du skate à partir de sa maison, en augmentant sa vitesse graduellement. Il a ralenti pour éviter des trous, mais après il a accéléré à nouveau.	**4** Tom a marché doucement dans la rue, il s'est arrêté pour regarder sa montre, il s'est aperçu qu'il était en retard, et donc il a commencé à courir.
5 Tom est parti de sa maison pour aller courir, mais il n'était pas assez entraîné et il a dû ralentir puis s'arrêter.	**6** Tom a marché vers le magasin du bout de la rue, il a acheté un magazine puis il a refait toute la route pour rentrer à la maison en courant.
7 Tom est sorti pour se promener avec des amis. Soudain il s'est rendu compte qu'il avait laissé son porte-monnaie chez lui. Il a couru à la maison pour le récupérer puis il a dû courir encore pour rejoindre les autres.	**8** Ce graphique est complètement faux. Comment Tom peut être à deux endroits en même temps ?
9 Après la fête, Tom a marché doucement pour rentrer chez lui.	**10** Écrivez votre propre histoire !

Fig. 11 : Student's sheet of the activity 3

Work in group, the students had to discuss about the graph-story matching on individual sheets provided by the teacher. After that, they had to insert their answer on Maple TA. They accessed the platform, opened the form prepared and sent by the teacher, filled it in and submit their answers.

Thus, the teacher expected answers from the students in two ways:

- Individually on Maple TA in the submitted forms;
- Collective answer on One Note 2013, on the notebook or on the provided sheets.

Session 4 (day 3)

Objectives: formalising the interpretation of a graph as the representation of a certain quantity as a function of another one; focusing the attention on what each axis represents.

The teacher came back on the graph of the Activity 1 (Fig. 1), he displayed it at the whiteboard and sent it as a pdf on the students' tablets through the Net Support network. He asked the students to detect on the graph where is Tom's home.

Students worked individually on the pdf file on their tablets. The teacher collected the production of some students through the following usual procedure: he accessed students' tablets from his computer through the Net Support network, made screenshots of the students' proposals, pasted them on a document shown on the whiteboard.

The teacher commented the students' proposals at the whiteboard, noticing that many of them had placed the home at the origin. He detected a particular point on the graph (the first pick) and asked the following questions : which are its coordinates? what does it represent?

The students worked alone or in group and the teacher walked through the classroom. After 3 minutes, they answered together to the first question, giving the coordinates of the point. Then, the teacher reformulated the second question in : what information does this point give to us?

The students work alone or in group and the teacher walked through the classroom. They finally shared the meaning of the two coordinates of the given point (distance to home and time). Then, the teacher asked where is Tom's home at that point. Several students come to the interactive whiteboard for detecting the home on the graph. They finally got to place the home on the axis of abscissas and the bus stop on an horizontal line where the distance to home is constantly equal to 160 m.

The teacher institutionalised an important methodological indication for reading a graph: every point contains two pieces of information: read carefully the meaning of each axis.

The teacher read again one of the stories proposed by the students on Fig. 1 which made confusion between distance to home and walked distance. Basing on this, he gave to the students a new task: drawing the graph of the walked distance as a function of the time.

The students discussed in group and each of them gets to an individual answer (on tablet or on notebook) that he/she gave or sent to the teacher.

Finally, students had to individually write a story for the "orphan" graph (B in figure 6) on their notebook or their tablets. The teacher collected the students' production before the the end of the lesson.

Session 5 (a week later)

Assessment on the interpretation of a graph: "breathe like a graph".

Analysis of sessions

Session 1

Clearly the teacher tried to find the state of knowledge of students: "where the students are"; he let students discussed together about this first task: "write a story" and used technology as a communication tool. But he wanted that the students talk together to reach a common answer and it's the reason why he asked that each group works with only one tablet. Two groups (Group 1 and 2) have been observed while working on the Activity 1 (Fig. 4).

Group 1

The teacher's interventions turned out to be very important for promoting the work in this group. Concerning the FA strategies, this is an example of the relationship between the teacher's strategy of "providing feedback that move the learner forward" and the students' strategy to be "activated as the owner of his own learning". If we refer to the three-dimensional model, it is possible to say that there is a dynamics between the cuboids (teacher, sending and sharing, providing feedback that move the learner forward) and (student, sending and sharing, activate students as the owner of their own learning). Let us analyse some examples of this interaction.

The four students observe the graph for about 5 minutes, retrace it with their pen, observing what it happens separately in the different intervals, without thinking of a possible story. S1, who uses her tablet as the tablet of the group, writes

160m = 2 min

100m = 50 sec

We can notice that the students are a little bit lost about the given task, thinking that they need to produce a calculation. S2 calls the teacher.

1- S3 (to S1): *Did you write the story?*
2- S1 (to S3): *No. What are we telling now?*
3- S2 (to the teacher): *We have to tell a story?*
4- Teacher: *What happened?*
5- S1: *Well, he walked!*
6- Teacher: *Why it does so?* (he retraces the graph with his finger)
7- S2: *Because he does something.*
8- Teacher (to the group): *Well, explain this something! Explain what happened.* (To the class): *Something happened. You have to get to an explanation!*

This is an occasion for the teacher for intervening in the group and for encouraging the whole classroom's work (8). The teacher prompts the students with specific questions (4 and 6). Starting from this interaction with the teacher, the four students begin to interpret the graph in terms of what Tom could have done. Each student proposes his/her interpretation in the group, without actually discussing them.
The first pick is interpreted as: "*he takes a break*" (S3).
The decreasing part and the constant one are interpreted as:

- "*he is tired, he slows down*" (S3, S1)
- "*he has to go down the street, then he goes faster*" (S4).

The increasing parts as

- "*he runs because he is late*" (S1)
- "*he has to go up the street, then he slows down*" (S4).

Another story (proposed by S3 and S2), introducing a river to run along and a bridge to cross, seems more appealing to the students. The story they finally write on the group's tablet and send to the teacher is based on the misconception of the graph as a map. S2 calls the teacher:

9- S2: *Sir, we have a story!*
10- Teacher: *Super! When you finish I'll take it. We're going to tell stories to each other*.
11- S2: *That's cool!*

Through his words (10) the teacher engages the students in the work they are doing and motivates them to keep focused on it. The fact that their production, with their own handwriting, will be displayed at the IWB motivates the students to work at best they can (9 and 11).

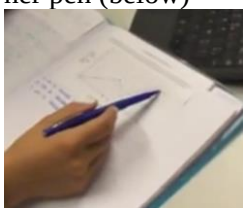
Group 2

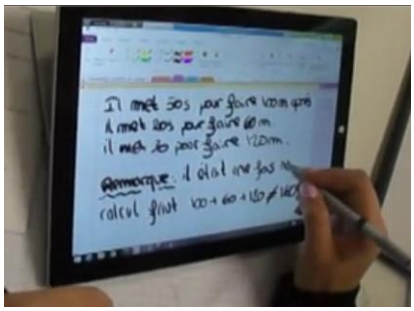
As we can see in the following excerpt, the teacher succeeds in making the discussion occurring in the group. It's interesting to notice that this organisation of the groups work allows students to enter in the FA strategy: "activating students as instructional resources for one another". If we refer to the three dimensional model, it is possible to say that this session is within the cuboid (Peers/groups, sending and sharing, activating students as instructional resources for one another).

The four students try to understand the graphics and to answer the question of writing Tom's story. The first part of the work is to interpret the distance Tom walks on each part of the graph. Two main difficulties occur:

- the first is related to the scale used on the y-axis. Indeed, 20m are represented by an interval on the y-axis when 10s is represented by the same length on the x-axis.
- the second is related to the interpretation of the line drawn on the graph and it is possible to see in the movements of fingers on the graph that the curve appears sometimes more like the drawing of the path than like the graphics of the distance to home regarding the time.

Once the first difficulty overcome, they write on the tablet:
Tom walks 30s and covers 100m
Then he walks 20s to cover 60m
he walks 30s to cover 120m
The second difficulty is more conceptual and remains present in all the discussions even if the discussions allow to mathematise the reading of the graph as the written answer testifies. The following excerpt shows a discussion between students about the interpretation of their first results.

Dialogue	Remarks
1- S1: But it's not logical at all! He walks 30s and he covers 100m but here he walks more time and covers only 60m.	
2- S2 (she is the owner of the common tablet): So, here he is on a horse and he goes to walk, to trot, to gallop. I promise, it works!	Laugh, Silence. They interpret the graph in term of Tom's speed. in the same time, S3 is following the constant part of the graphics with her pen (below)  However she doesn't give an interpretation of this part of the graphics except:
3- S3: he arrived here...	She is actually trying to understand this part of the graphic. By her gesture and her sentence we can interpret that the constant part of the graph is not seen as a distance related to time, but as a place in the space: "he arrived here". However, her remark is not taken into account by her mates. On the contrary they face another problem:
4- S1: but, it's not possible! 5- S2: what is the point, S1? 6- S1: there is something which is not logical because here Tom covers more… between the two… There is something wrong… 7- S3: beh yes! 100 and 60. 8- S2: but here, there is also 120, something is wrong. 9- S1: then you write it as a remark (S2 erases the last line) 10- S1,S2: no don't erase (she writes again the sentence that S4 dictates)[...] 11- S1: 100 and 60 and 120… 280, it gives 280… (speaking to the teacher) Sir, it's not possible! 12- Teacher: so write it! (S1 writes: Remark: Once upon a time a false calculation: $100+60+120 \neq 160$)	



In this session, students working together are able to overcome difficulties and it is clear that at the end of the group session, the four students have understood that the x-axis represents the time and that the y-axis represents *a* distance. But there are still some parts that are not fully understood, amongst them the interpretation of the kind of distance that is represented on the y-axis. The discussion about the "false calculation" (lines 4-11) shows clearly that the students don't interpret the fact that the curve is increasing or decreasing. They understood and indicate properly the number of meters that Tom covers in each part of the path as well as the time he is walking but they don't interpret the direction in which he is walking. The teacher by his interventions in the group encourages the work and initiates debate. The final remark given by the group will be used later in the classroom in order to point out the interpretation of the meaning of the y-axis. Instead of answering the questions that students ask, the teacher returns the question as for example with this intervention to the whole class, written on the board:
If the graphic seems to you problematical, write it and explain! (Write your remarks!) (fig. 7)
He still engages students in the group (line 12).

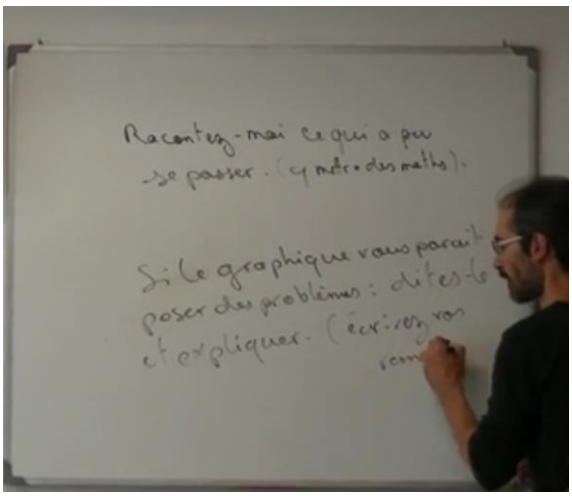


Fig. 12 : The teacher engages students in a reflexive thought.

The teacher finally asks to group 2 if they have a story to send.
S1: *Yes, but it is wrong…*
Teacher: *How many times we said it? We don't mind that it is wrong. Wrong doesn't mean anything. The only thing that wouldn't be fine would be whether you don't work.*

Through this words the teacher encourages the students to make their proposal, right or wrong it doesn't matter. This teacher's intervention is completely in the spirit of formative assessment, since it "activates the students as the owner of their own learning", inviting them to share their ideas and discuss them in the classroom.

Time of sharing

The teacher starts the time of sharing of the different stories by saying:

Teacher: *I invite you to note down on your notebook what you find interesting in the other stories. We are going to work again on this later, on a slightly different activity, and we will work again on it on Thursday and on Friday. The objective is that at the end your story has evolved, a little bit.* [...] *Take some notes about what you find interesting or maybe different from what you have done.*

The teacher "clarifies the learning intention and criteria for success" when he explicitly specifies the objective of the sequence of lessons: "*The objective is that at the end your story has evolved, a little bit.*". In relation to this goal, inviting students to take notes about the others' stories is the strategy the teacher uses for "activating students as instructional resources for one another" at the peers/group level. The technological device composed of the network of tablets, Net Support School and IWB facilitates the sharing of data coming from students (Fig. 8) and supports the teacher's strategy.

Students are invited to analyse the other stories by noting down interesting things, whereas the teacher reads them. He does not give feedback on their validity but he comments on the process that led to them (Fig. 9). For instance, the teacher comes back to the story of group 2:

Teacher: *I come back on this question of "It is wrong". We had the criteria of trying to use maths in the story* (pointing at the tasks on the blackboard) *and, on the contrary of Christian's story which was nice, they* (showing Elodie's story) *wanted to respect it. So for the moment, there is no good or bad productions, there is a production that we are trying to do in a collective way and we will see what does it look like at the end.* [...] *In every production there are interesting things.* [...] *I want you to take notes because I will ask you to argue on each production.*

In the spirit of formative assessment, while analysing students' proposals to understand where the students are in their learning, the teacher recalls that there are no good or bad productions. This is a feedback for the classroom that inspires for further inquiry instead of providing solutions. This phase of the lesson is a dynamics between the cuboids (peers, sending and sharing, activating students as instructional resources for one another) and (teacher, sending and sharing, clarifying learning intentions and criteria of success & providing feedback that move the learners forward). Furthermore, this tactic engages the students as active learners in the classroom and keeps them focused on the activity.

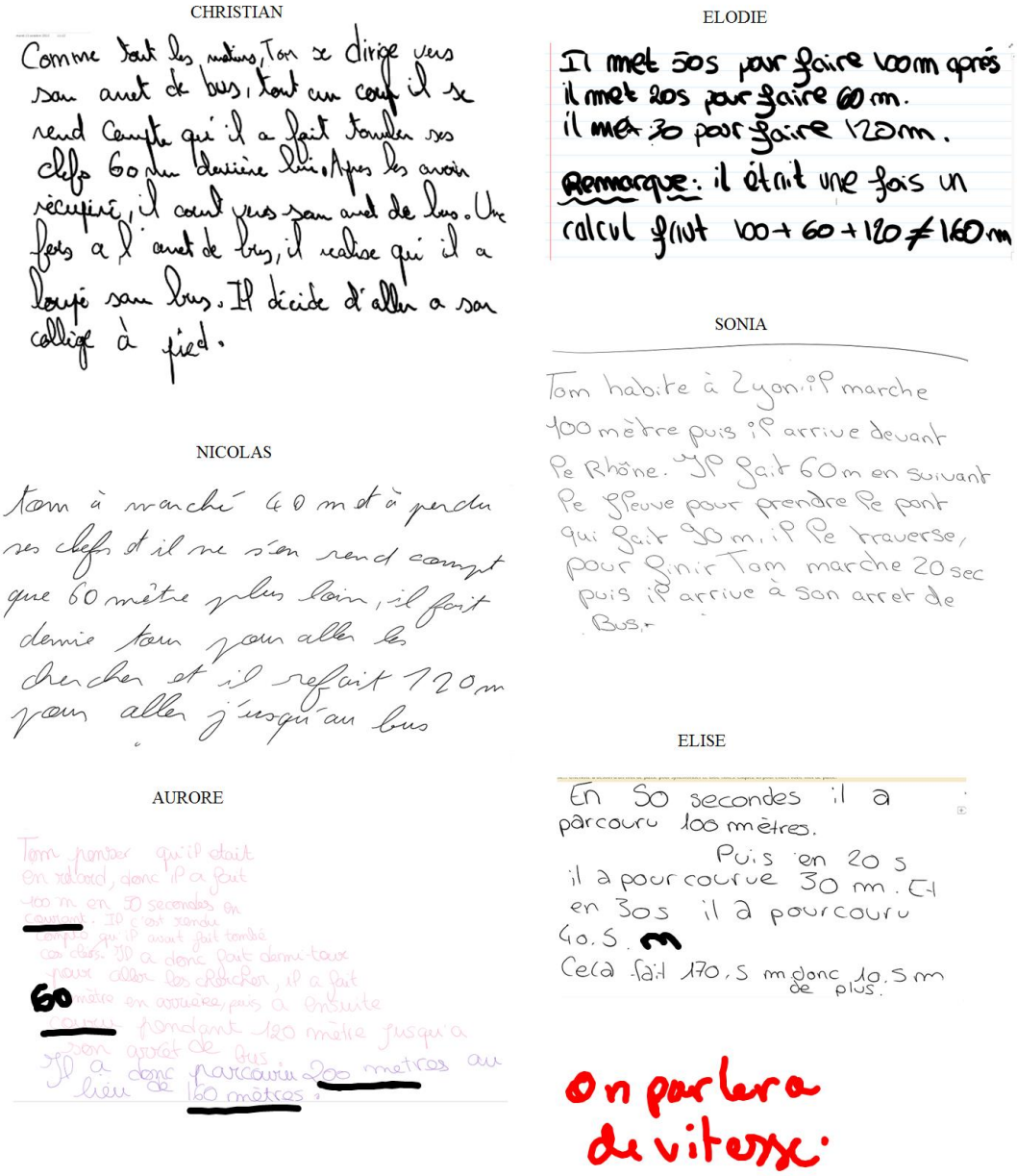


Fig. 13: Students' proposals displayed at the IWB through screenshots of students' tablets.

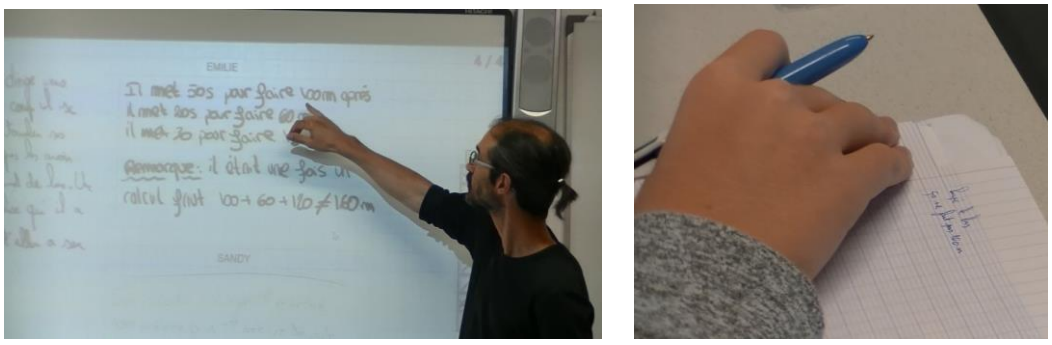


Fig. 14 and 15: The teacher reads, shares and comments the students' productions; students take notes of interesting elements.

The teacher finishes this time of sharing by saying:
Teacher: *A little remark that I note down for me: the next time we will have to talk of speed* (he writes "We will talk of speed" in red at the IWB). *I'm going to think about it this evening to prepare the lesson of Thursday.*
Through these words the teacher makes explicit that he is going to prepare his next lessons depending on the collected students' data, in a perspective of formative assessment. The teacher will analyse these data to establish what needs to be done to make the students reach the learning objectives.

Session 2
In this short session, the teacher sends to all students the Maple TA quiz where the graph is present as well as the three stories. At the beginning of the session, the teacher reminds that students have to answer A, B or C in the appropriate form. He specifies also that the work is an individual work. Students are working silently. The software gives an immediate feedback to students according to their answer as shown on the two pictures below (fig. 16):

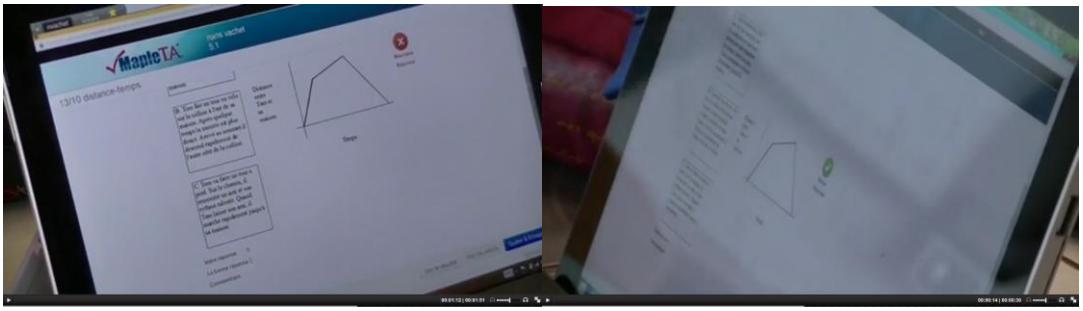


Fig. 16 Feedback of Maple TA

In that case, the teacher uses technology in the process of FA with at least two goals:
- to allow students to test their knowledge,
- to allow the teacher to understand where the students are.

Within the three dimensional model, this short session shows a dynamics from the cuboid (teacher, sending and sharing, engineering new tasks that elicit students understanding) to the cuboid (student, sending and sharing, activating the students as the owner of their own learning).
At the beginning of the next session, the teacher comes back on the class score relatively at this activity. The next session gives, in his mind, the possibility to confront and to debate about the different interpretations.

Session 3
The teacher shows the students' scores with Maple TA.
Teacher: *Your results on Maple TA, they are quite good. Considering that the problem is not actually easy, I think that your results are good. Because I worked on the problem last Sunday with my family, and with my wife, we spent some times to find the right answer. We didn't find immediately the right answer. The problem was not so easy, however, in the classroom there is 65% of good answers. More*

than half of you were right on this problem. And we are going to see if we'll still progress. And I have high hopes that you'll progress.

The teacher shows to the class the individual results and adds:

Teacher: *And we'll look at… we'll try to explain which mistakes have been made by those who chose A or B when the good answer was C.*

The teacher takes profit of the results to encourage students but he also wants that each student understands the interpretation of the graph. It is interesting to notice the motivation tactic that the teacher used implying himself and his family when he relates the difficulties they have had searching the same question. But also, he considered the students' wrong answers as mistakes coming from a reasoning and not only false answers: "*we'll try to explain which mistakes…*" ; finally, he implies himself in the work: "*And we are going to see if we'll still progress".* The progress of each of the students is a progress *for us.*

Relatively to the three dimensional model, we can consider that the Maple TA session at the beginning highlights the cuboid represented by (Student, Sending and sharing, activating students as the owners of their own learning) and moves to the cuboid (Teacher, Processing and analysing, Providing feedback that moves learners forward).

Time of sharing and discussion

The teacher invites one representative for each group to come at the IWB and explain the choices made in the story of his/her group. The teacher engages the students by saying: "*It's not to make fun of you at all! It is just for explaining you. We said that we only can make fun of the teacher in this classroom*". He displays the graph at the IWB. To focus the students' attention on the student who speaks at the IWB he says: "*Hey, I'm serious! When there is someone at the IWB you listen to what he says*".

The teacher's strategy of asking to students to explain the choices made in their own group facilitates the "activation of the students as the owners of their own learning" and creates a place for sharing their knowledge with their peers and the teacher. The classmates are invited to express ideas about the told story and ask questions for better understanding the classmate's point of view.

Within the three-dimensional model, this time of sharing depends on the dynamics between the cuboids (student, sending and sharing, activating students as the owners of their own learning) and (peers, sending and sharing, activating students as instructional resources for one other).

The student S1 tells the story of his group ("Christian" in Fig. 13), which contains the graphical misinterpretation of the constant part of the curve as "*Tom realises that he has missed the bus, so he walks towards his school*" (see Fig. 17). The teacher initiates the debate in the classroom and fosters the peers' evaluation (1).

1- T: *Do you have any question to ask him? Something in what he tells is a little bit incoherent. So ask him for explanation.*

2- S2: *He says that he lost his keys, where did it happen?*

3- S1: *I don't know… Here?* (he points to the point (70,40) as in Fig. 13)

4- T: *S3?*

5- S3: *Why he starts from the end and then he goes towards the beginning?*
6- S1: *I don't understand.*
7- S3: *Why do you start from the end, from the bus stop, and then you come back to the beginning?*
8- T: *Show him! Stand up and show him the part you are speaking of.* (S3 and S1 are together at the IWB)
[...]
9- T: *Where is the bus stop?*
10- S1: *Here* (retracing the constant part of the curve, as in Fig. 12)
11- T: *Where is it? Your finger is moving.*
12- S1: *Here* (pointing to the point (100,160)). *No, here* (pointing to the point (120, 160)). *No it is here* (pointing again to the point (100,160)).
13- Ss: [laughing].
14- T: *Is there anyone who can explain this? Is there anybody who can answer better to the question? He is not sure. Where is the bus stop? S4, go and show him where it is, trying to explain a little bit.* [...]
15- S4: *It is here* (he points to the point (120,160)).
16- T: *Why?*
17- S4: *Well, because it [the curve] finishes here.*
18- T: *Anybody else has another idea? Do you all agree with S4?*


Fig. 17 and 18: S1 using the graph as a support to his explanation.

The teacher asks questions to the whole classroom for engaging the students in the discussion (1, 14, 18) and to the student who is telling the story for clarifying some points (9, 11, 16). He also invites the students to cooperate at the IWB on the graph (8), facilitating the peers' evaluation. In this excerpt, thanks to the teacher's and the classmates' questions, we can see that the student S1 feels that his story is not so clear on at least two points: where Tom lost his keys and where the bus stop is.
The discussion about "*where is the bus stop?*" initiated by the teacher wants to be a provocation linked to the misinterpretation of the constant part of the curve, where according to the students Tom has to walked and cannot be still. This kind of feedback (11) is the teacher's strategy to move the learner forward in his reflections. Therefore, the dynamics between the two cuboids (student, sending and sharing, activating students as the owners of their own learning) and (peers, sending and sharing, activating students as instructional resources for one other) is animated by the cuboid (teacher, sending and sharing, providing feedback that move the learner forward & engineering effective classroom discussions that elicit evidence of student understanding).
Also S4 is invited to tell the story of his group ("Sonia" in Fig. 13). The teacher intervenes with some questions prompting the student, such as "*Why 90 metres?*", "*Show me where you are reading this?*",

"*Where do you see the 20 seconds?*", and fostering the classroom's reaction, such as "*What do you think about this?*". Finally, the teacher initiates a debate based on the comparison of the two told stories (19 and 21).

19- T: *Has he told the same story as S1? Has he said the same things?*
20- Ss: *No.*
21- T: *Who is right?*
22- S5: *Both of them.*
23- S1: *He is right because he speaks about unities.*
24- T: [...] *It's good. He has added some unities.*

S1 thinks that S4's story is better since he refers to numbers and measure unities (23). The teacher gives a positive feedback (24) but he moves the discussion forward. In this case, S4 seems more sure of his story. Prompted by the teacher, he adds the representation of the river to be crossed by Tom on the graph, as well as the cathedral of Lyon (Fig. 19).

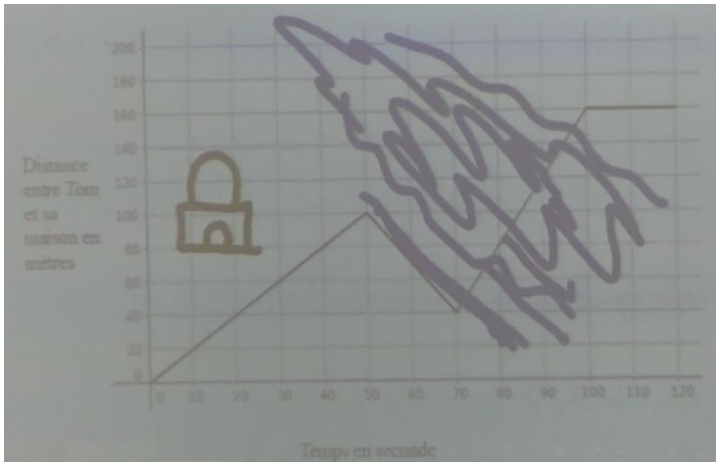


Fig. 19: S4's interpretation of the graph as a map.

This is a provocative request by the teacher linked to S4's misinterpretation of the graph as a map. This strategy is effective in making the students react:

25- S5 (talking about S4's drawing) *It is not a graph anymore.*
26- T: *Why it is not a graph anymore?*
27- S5: *Because he draws on it.*
28- S6: *Yes, because he has made directly the trail.*
29- T: *And what do you think? Is the graph directly the trail?*
30- Ss: *No.*
31- T: *Why not? What word we would use instead of graph? What has he done?*
32- S7: *Map.*
33- T: *And do you have seconds on a map?*

34- Ss: *No.*

The teacher invites the students to look at the stories A, B and C proposed on Maple TA (see Activity 2, Fig. 5). He displays them at the IWB and asks "*Which answer is wrong because it considers the graph as a drawing?*" (Fig. 20). The discussion and the reflection on the fact that a graph is not a map (25-34) have enriched the students' knowledge so that the teacher thinks they are now able to reject one of the wrong answers on Maple TA (story B).

Fig. 20: Re-discussing the Maple TA question.

Finally the teacher makes the students focus on the sloped parts of the curve, and then he asks "*So, what happens here?*", pointing to the constant part of the curve. Some students try to answer:

35- S8: *He stops running.*
36- Teacher: *Yes, of course. He stops running.*
37- S2: *He takes the bus?*
38- Teacher: *What would happen if he takes the bus with respect to his home?*
39- S9: *He would go faster.*
40- Teacher: *So the slope would be?*
41- S9: *Higher.*
42- Teacher: *So what does he do here?*
43- S4: *He stops.*

44- Teacher: *And what does he do?*
45- S10: *He stays there.*
46- T: *And what does he do?*
47- S11: *He waits for the bus.*
48- T: *He waits for the bus. How long?*
50- S4: *20 seconds.*
51- T: *20 seconds.* [...] *Well, we will see if you have progressed on these elements.*

The teacher succeeds in making the students share their interpretation of the constant part of the graph (S2, S8, S4, S10, S11). He validates some answers (35, 48) or asks for more details (38, 40, 42, 44, 46, 48), providing feedback to students. Having made explicit two of the great misinterpretations that he has found in the students' stories (the graph as a map/drawing and the constant part of the curve), the teacher proposes the Activity 3 on Maple TA as an exercise that can make the student progress (51).

Activity 3

Introduction of the activity 3 by the teacher:

Teacher: *You have 18 minutes to do the job. Listen to me please. We are going to work five minutes individually, silently, and after five minutes you can speak together. You have opened Maple TA, but it's just to have it open. The wording is here* (the teacher shows the sheet of paper that has been already given to students). *So, you begin to think with paper and pencil, individually, each drawing corresponds to a story and it is asked to match stories and drawings. You can write your answers on the sheet of paper, on your notebook and at the end you'll write them on Maple TA. Are you OK? So you opened Maple TA, you first work on the paper and finally you'll answer on Maple TA. I'll tell you when you can speak together, but now, you work alone. Is there any question?*

The teacher organises the students' work with paper and pencil and technology. He uses the platform Maple TA for sending them the activity 3 under the form of a questionnaire and he engages them in the new task. In terms of FA strategies, in the first phase of individual work with paper and pencil, the teacher engineers learning tasks that elicit evidence of student understanding and students are activated as the owner of their own learning. In the second phase of collective discussion in the group, students are also activated as instructional resources for one other. In the last phase, where students individually insert answers on Maple TA, each student sends his/her answers to the teacher who we will process and analyse data with technology for deciding the future FA strategy.

Groups 1 and 2

As asked by the teacher, the students work individually, on the sheet of paper, reading the stories and pointing different graphs. When they begin to work together, one student considered as a low achiever (S) calls the teacher and:

1- S: *Sir, when we walk normally the point is a line or…*
2- Teacher: *So, ask them!* (speaking to the group) *she has a question. You have to reach an agreement.*
3- S: (returning the question to her mates) *When he walks, what is the* (inaudible)

4- S1: *it depends but* (Movement with the hand)
5- S2: *yes it's not too inclined*
6- Teacher: *it's fine, S. what she explains, you can make a starting point of that*. *Do you understand her answer?* (the teacher draws away but continues to listen to the discussion of the group)
7- S2: (explaining and showing the graphs) *Here he walks, there he runs, and here he is running very fast… do you understand?*
8- S: *Yes, I understand, but it piss me off, because I understand nothing.* (she frowns)
9- Teacher (coming back to the group): *What she said is fine. You can work starting from this base. You can't say that you understand nothing. The fact that you ask the good question is the proof that you understand. You ask precisely the question that needs to be addressed!*

This dialogue is an example of teacher's attitude towards the students' knowledge construction: instead of giving an answer, he sends the question back to the group (2) and also encourages students to take into account other students' proposals (6 and 9). Therefore, in this case, students, as the owners of their own learning, interact in the group becoming instructional resources for one other. This dynamics is fostered by teacher's FA strategy of engineering effective discussions. In this episode, FA strategies are employed by the teacher or by the students without the support of technology. As we can see in other moments of the work in the classroom, the functionalities of technology of "sending and sharing" and "processing and analysing" allow to amplify such strategies, namely sharing all the students' productions at once or following the progression of a single student. However, the fact that such FA strategies are employed by the teacher and by the students even without the use of technology shows that they are becoming naturally part of the teaching and learning processes in the classroom.

Group 3

The three students of group 3 work individually for a while. A low achiever (S) is reflecting upon the story 2 (see Fig. 6) and he starts discussing with his classmates.
S: *The 2 matches the E, I think.*
S1: *[inaudible] No, in fact, we have not to do the drawing of the hill* (retracing the graph E as in Fig. 16) *It is what he [the teacher] has just said. I have thought about D, you see, because he walks slowly* (Fig. 17a), *when he arrives on the top he walks a little bit faster* (Fig. 17b) *and then he goes down fast* (Fig. 17c). (To the whole group) *The 2 matches the D, I think* (S1 and S write "2-D" on their respective notebooks).

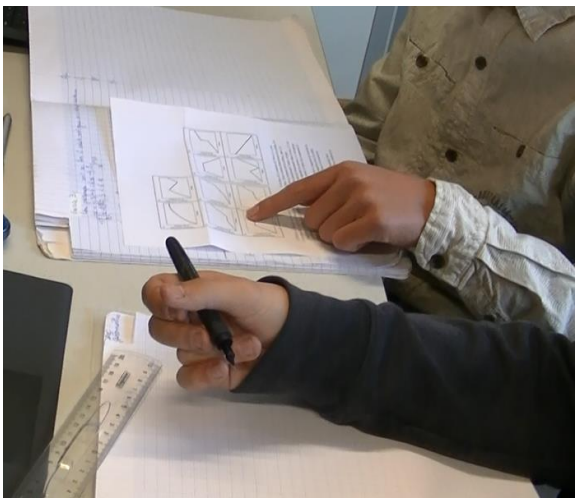


Fig. 21: S1 refers to the teacher's remark to comment S's proposal.

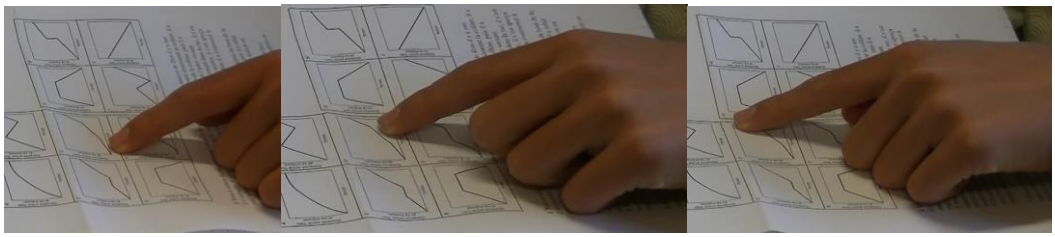


Fig. 22 a, b and c: S1 matches the story 2 with the graph D, following the graph with his finger.

In order to contrast S's proposal, S1 recalls the teacher's remark on the misinterpretation of the graph as a drawing, showing that he has internalised it in his own knowledge and properly uses it. He makes his own proposal following the graph D with his finger (Fig. 22 a, b and c), while he is telling the story 2. In this case, thanks to the peers' evaluation, S rejects his proposal and writes the match "2-D" on his notebook.

Individual work on Maple TA

The teacher gives 8 minutes to the students to fill in the form on Maple TA (Fig. 23) and to submit their answers. Students discover that the list of graphs appears in different orders on their tablets. Indeed, Maple TA gives the possibility of changing the order of the answers from student to student, and this is the choice the teacher has made. Thus, each student has to verify carefully once again which story corresponds to which graph. The most part of the students perceives this constraint as an added difficulty.

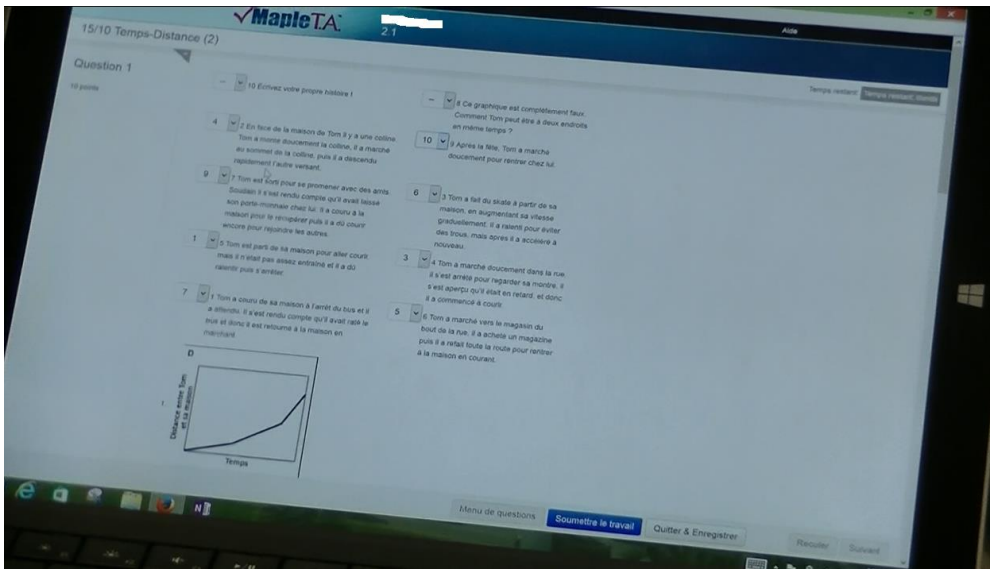


Fig. 23: The form on Maple TA on the screen of a student.

The lesson ends when all students send back the Maple TA form to the teacher.

Meeting for preparing Session 4
(appraisal of sessions 1-2-3 for preparing the session 4)

After the Session 3 (day 2), we met the teacher in order to evaluate the previous sessions and to prepare the Session 4 in relation to the principles of formative assessment.
Speaking in general about the activity, the teacher revealed that the he usually does not approach the concept of distance as a function of time, because it is too difficult and delicate to treat. Participating in this teaching experiment has been an occasion for him to try and take the challenge. After the third session, he wanted to reflect with us about what knowledge could be institutionalised from the work done with the students.
We pointed out two difficulties that have been discussed in the classroom, but not been completely overcome by all the students yet:
1) The confusion between the graph and the scheme/drawing/map and between distance from home and walked distance.
The teacher links this difficulty in reading the graph to one of the target competences on linear functions: reading images and inverse images on the axis.
Possible remediation:

- Discussing about the question “Where is the house?” for freeing the students from the idea of the scheme, since the house is not a specific point (namely the origin) but the entire axis of abscissas.

- Starting from the incongruity noticed by Group 2 in their story, asking to construct the graph of the walked distance as a function of time for providing evidence that the two distance are not represented by the same graph as time passes.

Learning objective of Session 4: pay attention to what each axis represents.
2) The justification of the slope.
Students have acquired at a technical level that the more the graph goes up, the more Tom goes fast. It is not clear if they have understood why.
Possible way to go further:
Asking to calculate the speed of each part of graph.

The teacher focuses on formative assessment. He feels the need of proposing some remediation and then verifying if students have progressed.

Teacher: *What do we do in terms of formative assessment for understanding if it is clear for them? It would be great if we had something to propose them at the end in order to get to measure their progression.*

The teacher and the researchers discuss about how to do it with technology. They reflect on which technology available in the classroom allows the teacher to collect, share and exploit students' productions in the simplest and the most efficient way.

Researcher: […] *It could be great if you make them write and then you collect what they write.*
Teacher: *On the asked questions? On the tablets, yes, on One Note.*
Researcher: *So that we can collect and detect where they are with respect to this. We would be, according to me, on a collection of formative assessment data.*
Teacher: *Technically, I cannot use the Net Support for sending something on One Note and then collecting it. So, I cannot collect all the students' production at once.* […] *On Maple TA they can type a text on their keyboard* […] *but the difficulty is that I cannot exploit it after, during the lesson, at the IWB.* […] *OK, they all work on One Note, then I collect and project at the IWB, as I usually do. This is easier for me.*

Then, the teacher and the researchers imagine the possible FA strategies facilitated by the chosen technological configuration, in particular 'engineering effective discussion'.

Researcher: *Then, a debate can be made. Many students will detect the house at the origin, I think.*
Teacher: […] *differently from other activities in which I know where I am going, I left them more free in producing what they want. And now it is difficult to me to rein the lesson in again. That's why I insisted on what I can institutionalize* […] *It gives me the impression that it is a very interesting work but difficult to frame for saying we studied this and that.*

It clearly emerges the importance of another FA strategy for the teacher that is 'clarifying the learning intentions and criteria for success' with students, for establishing where the learners are going.
Hence, the teacher and the researchers discuss about how to guide the students to the learning objective that is interpreting what a graph represents by focusing on the axis. The idea of passing through the interpretation of a specific point (in this case, (50,100)) arises.

We finally discuss about what kind of exploitation can be done of the students' answers on Maple TA of the Activity 3. The statistics provided by the platform are not significant of the students' progression, since some of them have correctly matched the graphs and the stories on the sheet of the Activity 3, but they have not entered the right answers on the platform. The teacher concludes that, although he cannot exploit them as a classroom's evaluation, it does not matter: the continuity of the individual work with Maple TA is important to give to students a space where they can find their work on the mathematical concepts at stake. They can follow their global progression, and sometimes when data are significant the teacher shows and comments data from the classroom.

Question à poser : où est la maison ?
Quelle est la distance totale parcourue par l'enfant ?
Ces deux premières questions sur one note (il refont le schéma sur one note ils indiquent où est la maison)
Débat : leur demander, au bout de 50s, où est la maison ?
Que veut-dire le point de coordonnées (50,100) ?
Synthèse : faire attention à ce qui est représenté sur chaque axe. Comprendre les axes, prendre du temps à les lire est indispensable)
(l'axe des ordonnées ce n'est pas : la distance parcourue mais la distance à la maison).

On peut valider une histoire (copie dans cahier)
Leur faire tracer le graphique de la distance parcourue (à partir du travail du groupe d'Elodie)
On peut valider un graphique (copie dans cahier)
Donner la vitesse sur chaque portion du graphique.

Correction MapleTA activité 2
Raconter histoire sur le graphique 10.

Fig. 24: Thomas' notes of the meeting concerning the organisation of the Session 4.

Session 4

After having sent the graph of the first activity, the teacher asks students:
"On this graph, point out with your red pencil where is the house?"
He writes it on the board (Fig. 25).

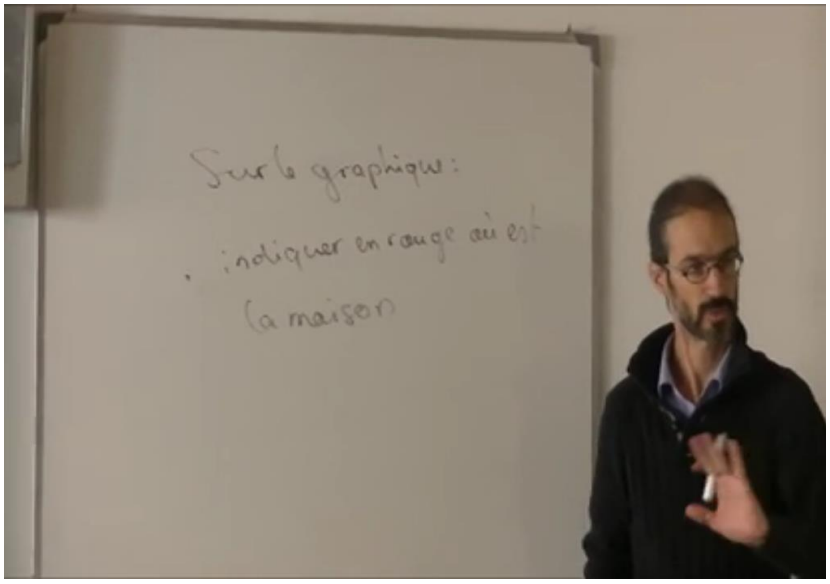


Fig. 25

This question comes from the analysis done with us of the students' conception of the graph seen as a map in the previous lessons (see section Meeting for preparing Session 4). Thomas asks students to work individually. He is sending and sharing information with students individually, "engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding" and simultaneously, he places students in a situation where they have to "activate themselves as the owners of their own learning".

In term of the Theory of Didactic Situation (TDS), the teacher attributes to students the responsibility of the task (this transfer of ownership is called *devolution* in the TSD) in an a-didactic situation where students are confronted to the environment that the teacher shares. The a-didactic situation which comes out participates to the FA strategy. In the same time, the results that follow from this individual work inform the teacher of the state of students' knowledge but also of students' conceptions and beliefs. In the next sections, we are going first to follow students' work and the pooling orchestrated by the teacher.

As expected by the *a priori* analysis, several groups place the house at the origin of the coordinate system (Fig. 26). The teacher points out this answer and writes on the board:

The origin seems to be favourite place for the house.

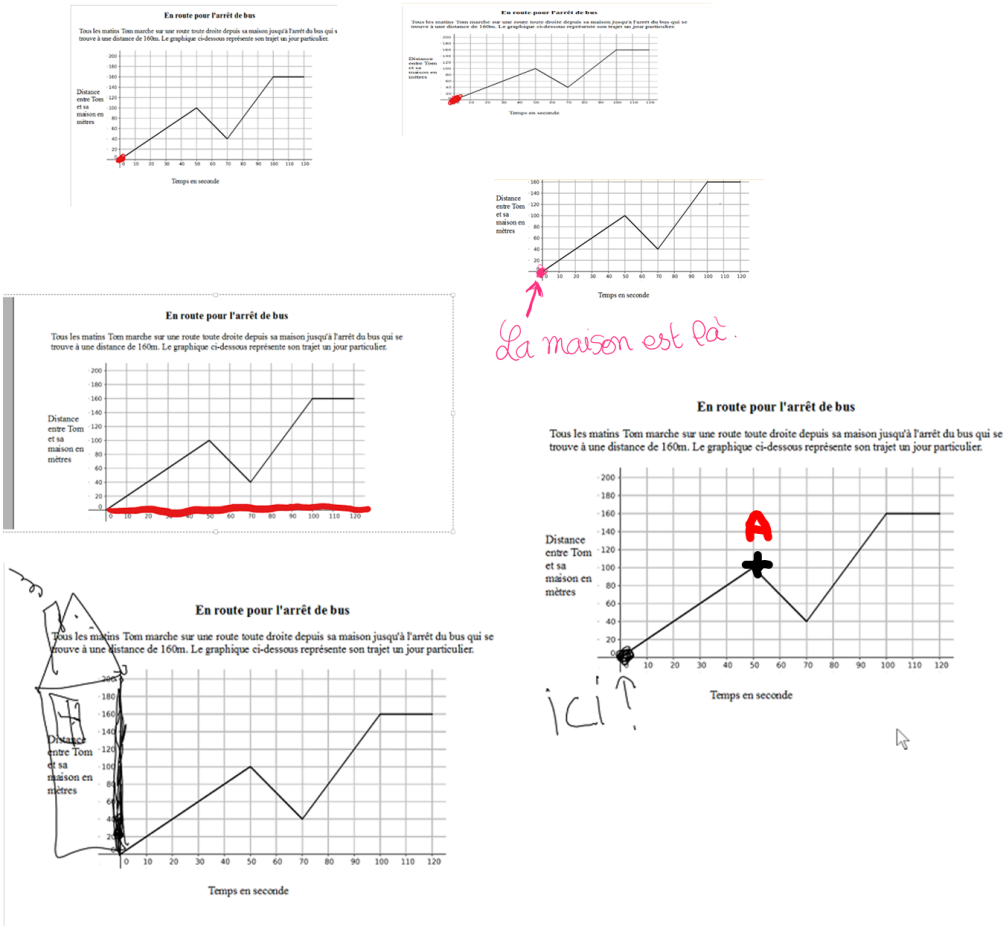


Fig. 26 The location of the house

In front of this misconception, the teacher begins a debate in the class, trying to make the students analyse the meaning of the axis:

1- Teacher: (showing the abscissa axis) *What is this axis? What is written on this axis? What is represented on this axis?*
2- S: *time in seconds*
3- Teacher: *the time! OK, then, what does it mean… you'll answer... this point* (marking the point (50,100) at the end of the first segment, Fig. 26) *you already have the graph, mark this point. We are going to call it A. I ask you two things: what are the coordinates of the point A? And, what does it represent?* (He writes on the board: Coordinates of A, What does it represent?)

You try to answer these two questions?... (students are working silently) *Give the coordinates and tell me what it represents… you can speak together…*(25s) *and as usual, there are no wrong answers, we are going to give a correction, but the important thing is that you write something…*(20s) *The question is perhaps badly asked… Perhaps, better, what does it indicate? which information does the point A gives us? The question are perhaps better formulated like that… And I think that the last one, is the easier question to answer, what information does it give us? Perhaps, you can switch the two first questions, the last one seems to me easier…*

Through these questions and the way he manages the class, the teacher shows the will of accompanying his students from "where the learners are right now" to "where the learners are going". Indeed, throughout all the session 4, we can interpret the teachers' actions as the implementation of "what needs to be done to make the students get to the learning intentions". But also, he wants to remind or to give definitions of mathematical objects at stake (definition of the origin, system of coordinates,...); as said the day before (see Meeting for preparing Session 4), the teacher wants to institutionalize some "concrete" knowledge. It is for example the case when he corrects the question of the coordinates of the point A: name of the axis, notation in use,... and later when he'll come back to Tom's speed.

Two examples of answer to these questions are in Fig. 27 on the notebook of some students. The first student has written:

- *Coordinates of the point A: 50 ; 100.*
- *What information does it give to us: the point A is at 50 seconds and 100 metres from the house.*

The second student has written:

What does it represent? It represents the moment when he stops to turn around.

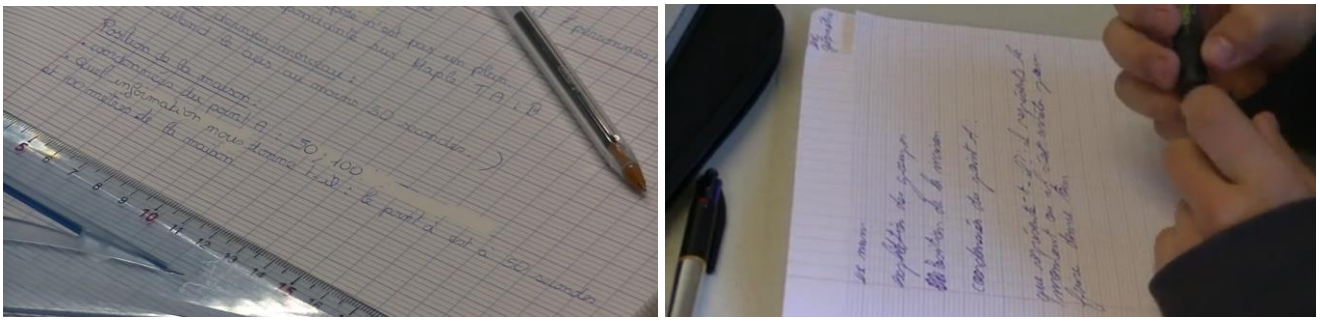


Fig. 27: Students' notebooks.

Time of sharing

The teacher encourages the students to share their ideas about what the point A represents, by inviting them to intervene from their seat or at the IWB.

The first remark is about Tom's speed: "*He walks 100 metres in 50 seconds*". The teacher notes it at the IWB in this form: *In the first part, he walked 100 m in 50 s.* It comes from a global reading of the graph: this information is referred to the interval [0,50].

1- Teacher: *Does he [your classmate] refer just to the point A when he answers this? What does he use for answering this?*
2- S1 (going to the IWB): *This* (first increasing segment) *and this* (decreasing segment).
3- Teacher: *Do you agree or not?* [...] *Which is the part that corresponds to 100 m in 50 s?*
4- S2 (goes and shows the first increasing segment at the IWB).
5- Teacher: *Yes, it is all this part.*
6- Teacher: *What does the single point indicate?* (pointing to A(50,100)) *It gives me one piece of information*.
7- S3: *It is the place where he turns around*.

The teacher wants the students to focus on what the single point A represents for fostering the reading of what each axis represents (see Meeting for preparing Session 4). So, he firstly makes the students analyse the classmate's proposal (1) and reflect upon the global sense of the given information (1-5). Then, he tries to shift their attention to the specific point A (6), but the students read a local information: Tom turns around (7). The teacher notes it as a second interesting remark: *The point A indicates that he turns around*.

8- Teacher: *What does it mean that he turns around?* [...] *The point A gives me two pieces of information. What does it tell us on this about-turn?*
9- S4: *At what distance he made it.*
10- Teacher: *Where was he?*
11- S4: *100 m.*
12- Teacher: *What else does it tell us? Where he turns around, and what else? I heard it.*
13- S5: *When.*
14- Teacher: *When he turns around. When?*
15- S6: *After 50 seconds*.

The students get to read the pointwise information given by A: Tom is at 100 m from his house (9-11), at the time 50 s (13-16). They conclude that this graph gives three pieces of information: the place, the time, and the speed even if the speed is present after an interpretation of the local information. But, as already said, the teacher is coming back to an easy institutionalizable notion that will not be taken up again.
Drawing on the fact that the point A contains two pieces of information (the place and the time), the teacher comes back on the question "Where is the house?": "*So, at the point A, when we are at the place and the time A, where is the house?*"

The proposal of a student is in Fig. 28a: the house is on the axis of abscissas. When the teacher asks him to detect it in correspondence to the point A, the student marks the point (50,0) as in Fig. 28b.

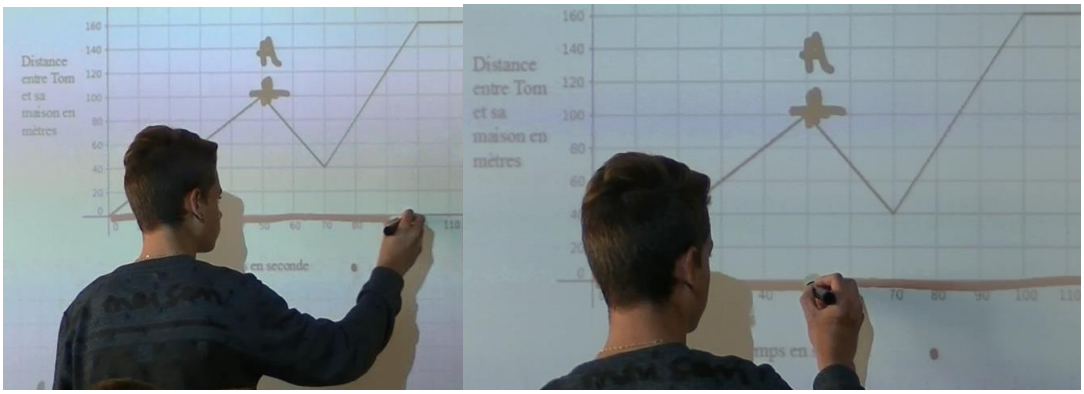


Fig. 28 a and b: Placing the house on the graph.

For this student, passing through a pointwise interpretation of the graph is not necessary, because he has already internalised a global interpretation of the graph. Nevertheless, the teacher asks him to detect the point representing the house at the time 50 s and draws on this for involving other students to come at the IWB and place the bus stop. Some students come and mark the points corresponding to the bus stop at the time 0 s (Fig. 29a), at the time 50 s (Fig. 29b) and at the time 100 s (Fig. 29c).

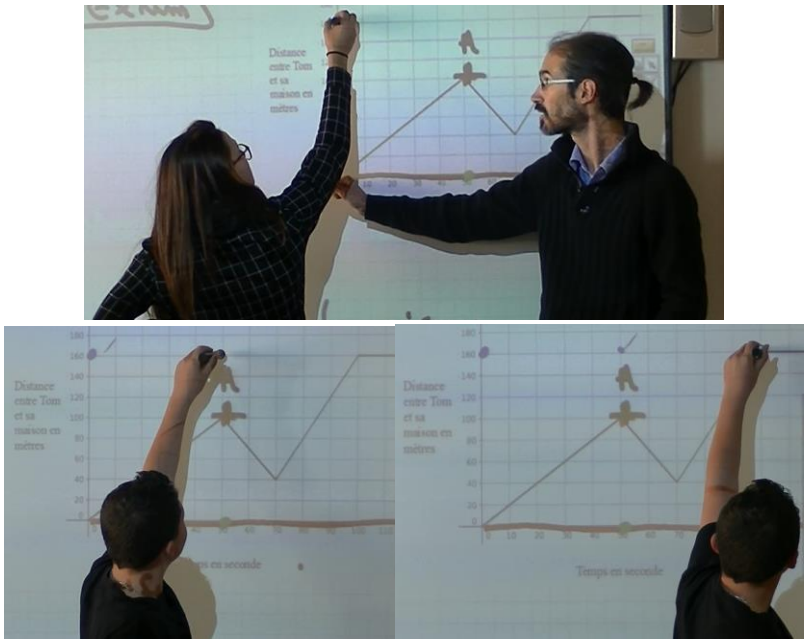


Fig. 29 a, b and c: Detecting the bus stop at the time 0 s, 50 s and 100 s.

We can see clearly that for these students a global reading of the graph was not yet internalised. The teacher's strategy of passing through the identification of some points representing the bus stop at different times successfully led these students to recognise that the bus stop lies on the straight line where the distance from home is always equal to 160 m as the time passes (see Fig. 30).

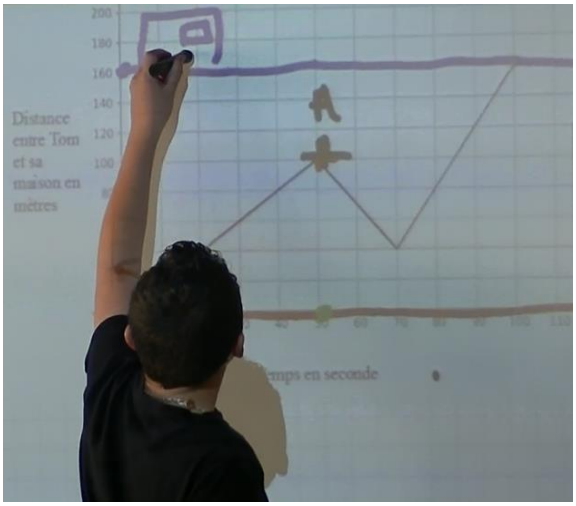


Fig. 30: Placing the bus stop on the graph.

The teacher concludes this time of sharing with some remarks:
The house is on the axis of abscissas (horizontal axis).
Method: In a graph (in a reference system), every point contains two pieces of information → Read what each axis represents.

A new task: graph of the walked distance as a function of time

As previously thought the day before, the teacher engages his students in a new task, that is to say representing the graph of the walked distance as a function of the time. He begins, starting from the results of the group 2 (first session) who has made the remark: 100+60+120 ≠ 160.

1- Teacher: (reading the group report) *Tom walks 50s and covers 100m, Then he walks 20s to cover 60m, and they are right!* (Thomas comes back to the graph and shows the x-axis and the line Fig. 25). *He walks 50s and covers 100m, and after he walks 20s and covers, from 100 to 40* (Showing the second segment of the graph and its vertices), *he covers 60m, and after they said, certainly something right* (he comes back to the group's report and read) *he walks 30s to cover 120m and finally they said: once upon a time a false calculation, with a spelling mistake* (laugh in the class, smile of the teacher) *100+60+120 is not equal to 160, and yes, it's not equal to 160. What did they calculate? Because they said a lot of right things, what did they calculate?*
2- S1: *the distance*
3- Teacher: *which distance?*
4- S1: *from the house*
5- Teacher: *ah no, here is the distance from the house* (showing the graph). *You were right, it's fine as it is, but the distance to the bus stop, we know, it's 160, then we don't have to calculate it, but what did they calculate?*
6- S2: *the distance he covered in all to reach the bus stop*

Teacher: *the distance he walked in all.* (Asking students who wanted to give an answer) *and you, boys what would you say?*
7- S3: *Uh, the detour he makes to go and search his keys*
8- Teacher: *the difference, it is the detour. I agree. Well we are going to say, what did you say* (asking S2)
9- S2: *the distance in all*
10- Teacher: *Well, you write it.* (he writes) *Distance…* (He erases) *Excuse me, because there are two information,* (he writes) *Time, distance that he did in all* [...] *So that means, you do that either on your notebook or on One Note. You draw your coordinates system and here we are going to still write the time in second and here we still write the origin, and here* (he shows the y-axis) *distance that he did in all* (he writes on the board). *You graduate with the same unit, and you draw the graph. And you still work on this graph* (showing the first graph) *and I'll let it on the board or you can also look at it on your tablet if you want, and it's the same story, it's the same guy, doing the same thing and goes to the bus stop.* (he repeats) *It's the same guy doing the same things, he lost his keys, he turns around, he goes to the bus stop with the same speeds, it is exactly the same situation, nothing changed. What I ask you. Here we had the distance from his house in meter and now you have to draw the graph giving the distance he did in all. So we are going to tell the same story with other information. Your turn!*

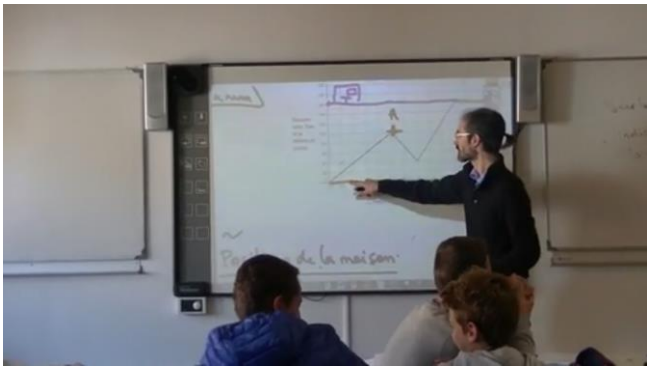


Fig. 31: The teacher comments a group's work

The first part of the excerpt shows the teacher's will to start from "where the students are" to brings them where he wants to go. It is also an invariant in his operating system to highlight his students' work and to orchestrate his lesson starting from the actual work done in the classroom. Technology brings here an help by its "sharing and sending" property. Sharing data is also a reason to remind students the way to read the graphic and to consolidate this knowledge. But, more deeply, technology plays here a particular role keeping the memory of the previous work and in his strategy of "providing feedback that moves the learner forward" the "displaying" property of technology allows teacher to come back to the classroom history. We can say that the dynamic in the three-dimensional model goes back and forth between the properties of "sending and sharing" and "processing and analysing".
We see in this excerpt the insistence of the teacher to explain the new task. The knowledge at stake is the goal where he wants to lead his students; it is the interpretation of the y-axis data and he wants to verify

that this knowledge will be effectively worked in the new task without any disturbing from the context: the word "same" is used nine times in the monologue 10!

Work in groups (focus on Group 4)

As asked by the teacher, the students work individually for constructing the graph of the walked distance as a function of time. Each student works on his/her tablet or notebook with the graph of the Activity 1 (Fig. 4) as a support (see Fig. 32).

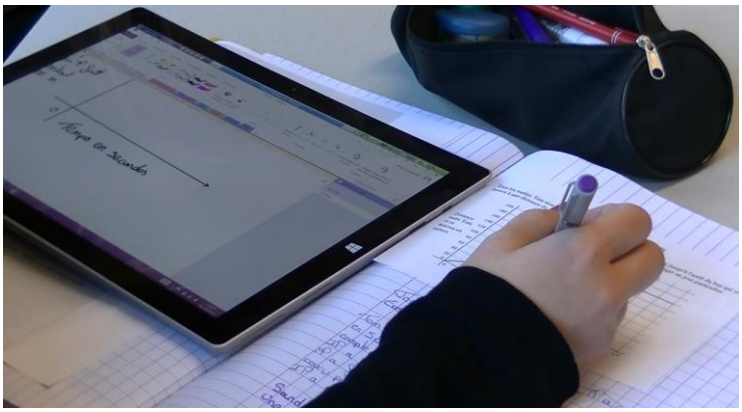


Fig. 32: A student working on her tablet and notebook.

The teacher walks through the classroom to check students' work, helps and gives feedback. His feedback is mostly directed to individual students, but when he realises that different students are asking the same question, or have the same doubt, he draws the attention of the whole classroom at the IWB in order to discuss it, as we can see in the following episode.

1- Teacher (talking with S1 from group 4): *So, the total distance will always...?*
2- S1: *It will always increase.*
3- Teacher (to S1): *The total distance will always increase.*
[...]
4- S2 (from group 1): *Do we have to do the same drawing?*
5- Teacher (to the class): *There are several students who are asking me the same question. Stop for a while, please. S2 asked a question that is very similar to the question asked by S3 just before and to that of S1 too. We are redoing the same drawing. Here, instead of distance from home I write "distance that he walked in all". So, what information would give this point* (pointing to (70,40))*? If you redo the same drawing. What is the information that this point contains?* [...]
6- S4: *40, 70.*
7- Teacher: *40, 70. These are the coordinates: (70,40). What would it give us as information?*
8- S5: *From the house, his distance is …*
9- Teacher: *No, no. It is this now* (pointing to "distance that he walked in all"). *So what does it indicate?*
10- S6: *It takes him 70 s to walk 40 m.*

The teacher provides individual feedback that confirms students' hypothesis (1-3), but also activates students as instructional resources for each other, when he shares and compares the doubts of two or more students who are working in different groups (5). The teacher tries to guide a classroom discussion that takes into account the different doubts. He decides to lead a reasoning by contradiction on the pointwise interpretation of the point (70,40) in the new reference system given by the distance that Tom walked in all with respect to time: "*What information would this point give? If you redo the same drawing*" (5, 7). The proposed reasoning turns out to be difficult for the students.

11- [...] Teacher: *If we want that this point is well-placed we have to mark it at 70, ...? 140. And so we get to your remark* (pointing to S1). *What does the graph do, if it is the distance that he walked in all? It must necessarily ...?*
12- S1: *Go up.*
13- Teacher: *Wherever we walk, the walked distance can just...?*
14- Some Students: *Increase*.
15- Teacher: *Increase*.

Notice that it is the teacher that concludes on the good position of the point in the new graph (11). With the reasoning by contradiction, he does not manage to involve many students in the discussion. In this phase, the discussion is strongly guided by the teacher, and the students' participation is limited to completing some sentences in the reasoning, without actually appropriating of it. Indeed, as we can observe in Group 4, two girls (S7 and S8) grasp and interpret just the teacher's last comment about the global increasing property of the new graph, as we can see in Fig. 33 a and b.

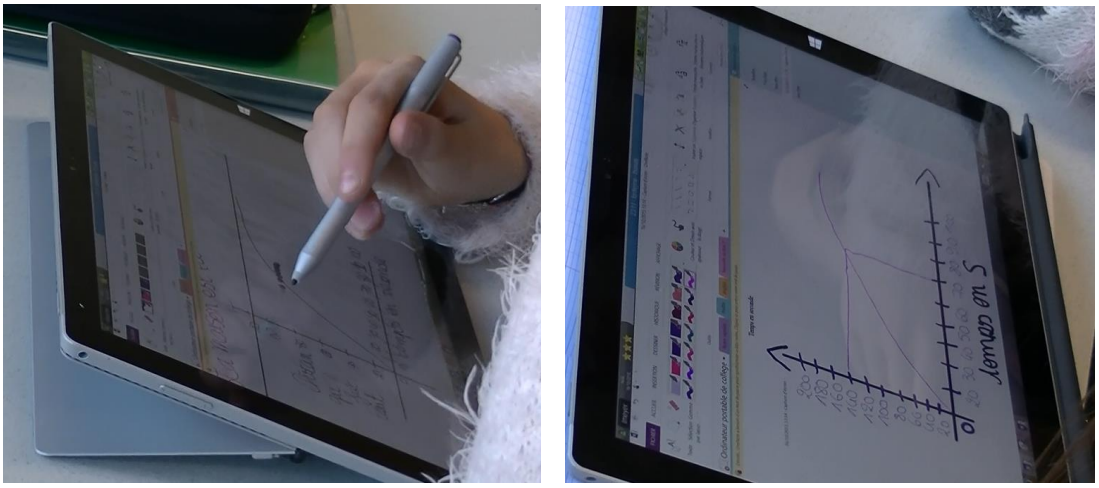


Fig. 33 a and b: S7's and S8's graphs.

Only S1, in the observed group, seems to grasp the teacher's suggestion of reasoning point by point (see Fig. 34), while the forth student (S9) felts lost in the resolution of the task.

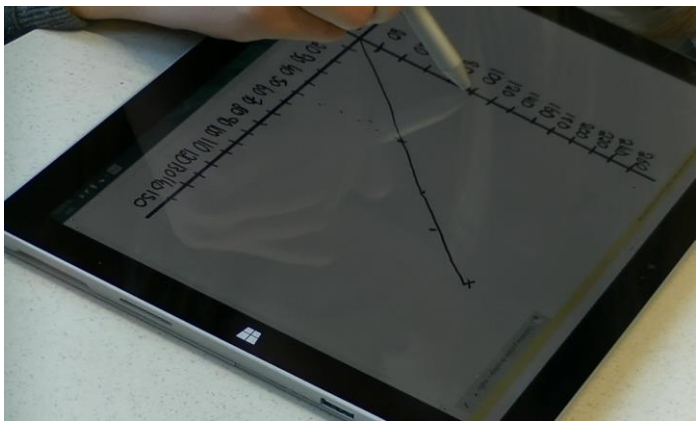


Fig. 34: S1's graph.

The teacher intervenes in the group for validating S1's graph, although he notices that it is too regular, due to inaccuracies of the freehand drawing and to the fact that the last point is detected at (100, 240) instead of (100, 280). He gives her a suggestion to improve her work: to retrace the graph on the grid provided in the Activity 1 (Fig. 4). Then, in order to unblock S9's work, he suggests her to look at what S1 is doing and to try to do the same.

Notice that all students who choose to work on their tablets (as the four girls of Group 4) are exploring the functionality "providing an interactive environment" offered by the technology at their disposal. In particular, observing Group 4, we can notice that the interactive environment of One Note supports students in tracing segments, but only if the student decides to use this specific command. This is what all the girls of Group 4 have done for tracing the axis. Nonetheless, they do not use the same command for tracing the segments between the detected points so that their freehand drawing does not appear accurate (Fig. 34). Notice that the student's choice of this command, that can facilitate their interpretation of the constructed graph, depends on the student's mastery of the knowledge at stake. Indeed, a correct global interpretation of the graph may lead the student to the expectation that the new graph is again composed by segments, and this may lead him/her to use the right command. This does not occur, for example, in the case of S7's and S8's graph (see Fig. 33 a and b).
Working in groups, a dynamics occurs between (student, providing an interactive environment, activating students as the owner of their own learning) and (peers/group, sending and sharing & process and analysing, activating students as instructional resources for one other). This dynamics can be activated by the students themselves, when they share their work and discuss in the group, and can be encouraged by the teacher, when he asks to a student to explain to another student.

The phase of working in groups ends with the teacher's correction at the IWB (Fig. 28) and the final remark: "*If we change what we have on the axis, for the same story we have a different graph. So the story does not depend on the graph. It is linked to the graph, but taking into account what is written on the axis*".

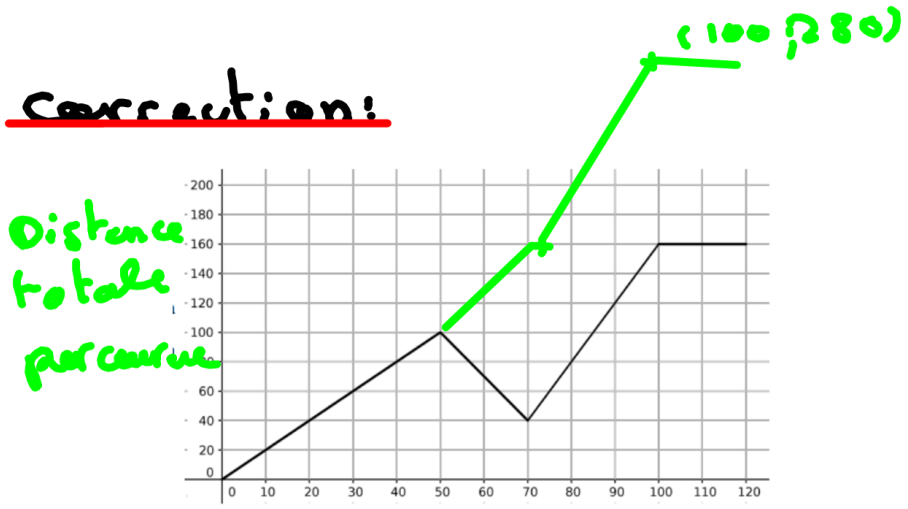


Fig. 35: Teacher's correction at the IWB.

The lesson finishes on the task: write one last story for the graph B of the activity 3 (Fig. 6). Giving this last task, the teacher comes back on the first activity proposed (see the graph in Fig. 1). Collecting and analysing new data from students allow him to detect any progression and where they are in their learning *now* with respect to the initial state of knowledge, with a particular focus on the difficulties and the misinterpretations pointed out during our meeting. Each student works individually on his/her tablet or notebook.

DYNAMICS WITHIN THE THREE-DIMENSIONAL MODEL

Legend

Red=Teacher / Blue=Peers or Group / Green=Individual student

A: Clarifying/sharing/understanding the learning intentions and criteria for success

B: Engineering effective discussions and new learning tasks

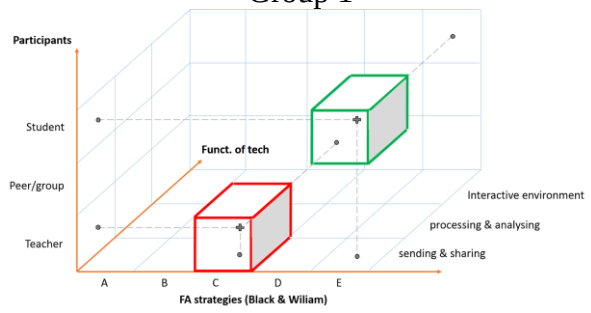
C: Providing feedback that moves the learner forward

D: Activating students as instructional resources for one other

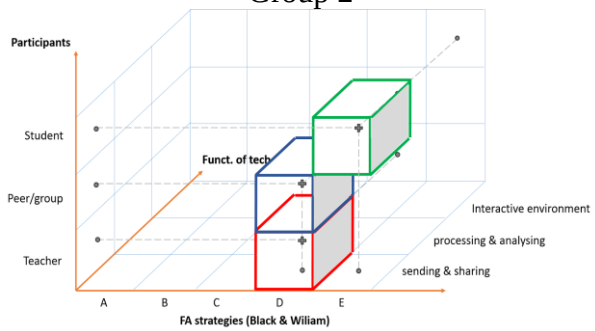
E: Activating students as the owners of their own learning

Session 1: Activity 1

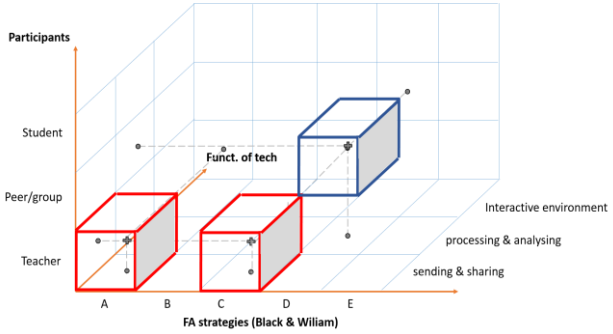
Group 1

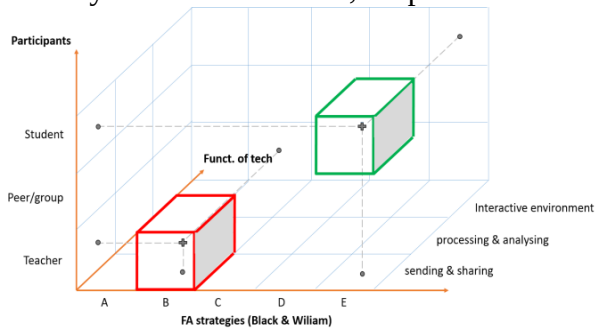
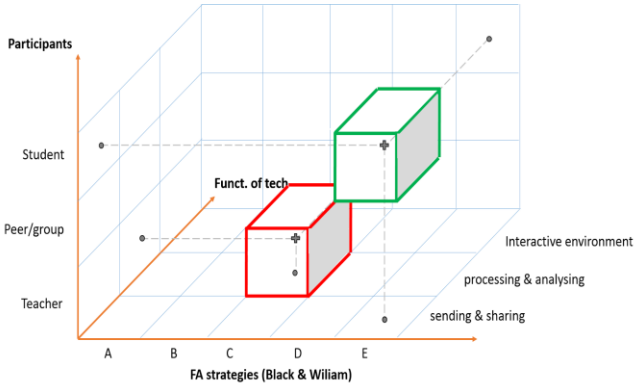


Group 2



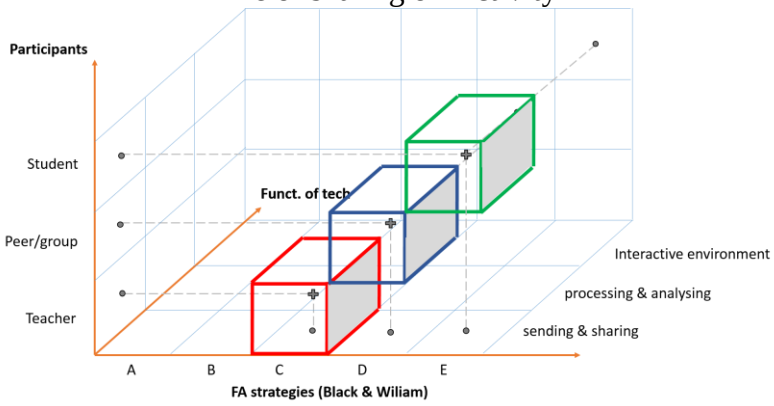
Time of sharing

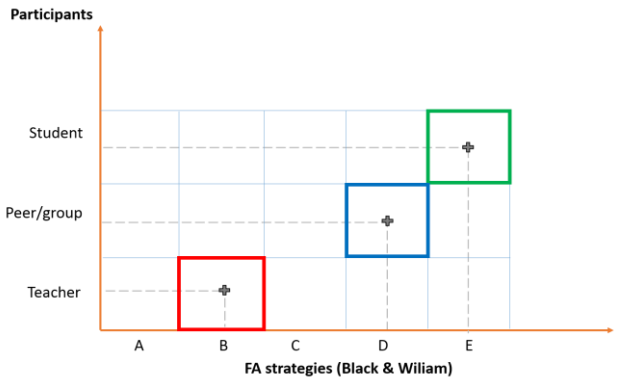
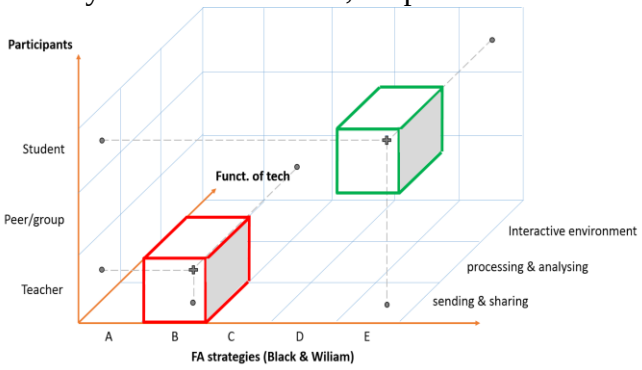


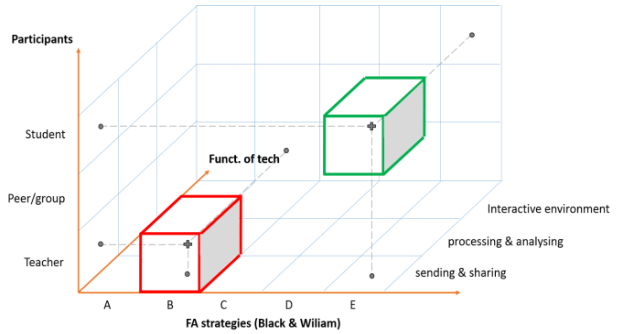
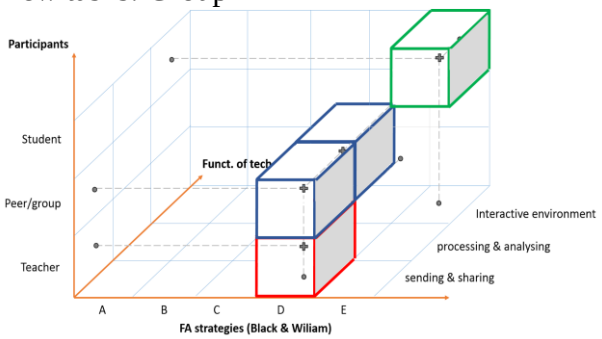
Session 2	**Session 3** - beginning
Activity 2: individual work, Maple TA 	Activity 2: Maple TA scores 

Session 3

Time of sharing on Activity 1



Activity 3: work in groups	Activity 3: individual work, Maple TA
	

Session 4	
New tasks 	New tasks: Group 4 

6. Pupil perceptions

Methodology

The Q-sorting activity was organised in two times:

- first before the lessons, we organised the Q-sorting with a group of 7 students divided into two groups. We separated the affirmations in “positive” and “negative” (see list) and asked the first group to sort the positive affirmations while the other group sorted the negative ones; after having sorted the affirmations we asked the groups to change there place to comment the choice of their peers; they had the opportunity to swap statements if necessary.
- second at the end of the week, we showed to the class the choices made by the participants of the first phase and asked them if they always agreed with these choices.

In the first session, we recorded the discussions, transcribed the dialogues and coded the sentences relatively to the different themes tackled by the Q-sorting affirmations:

- positive/negative feelings about the use of technology in the class
- positive/negative feelings about mathematics as a school topic
- positive/negative feelings about the work in groups
- positive/negative feelings about assessment and awareness of FA

It is interesting to compare, in a perspective of cross case analysis, with the Q-sorting activity made with students of the same school at the end of the previous year. They had been in the same context during the whole year. Each paragraph will be ended by this cross case analysis.

Results

Q-sort

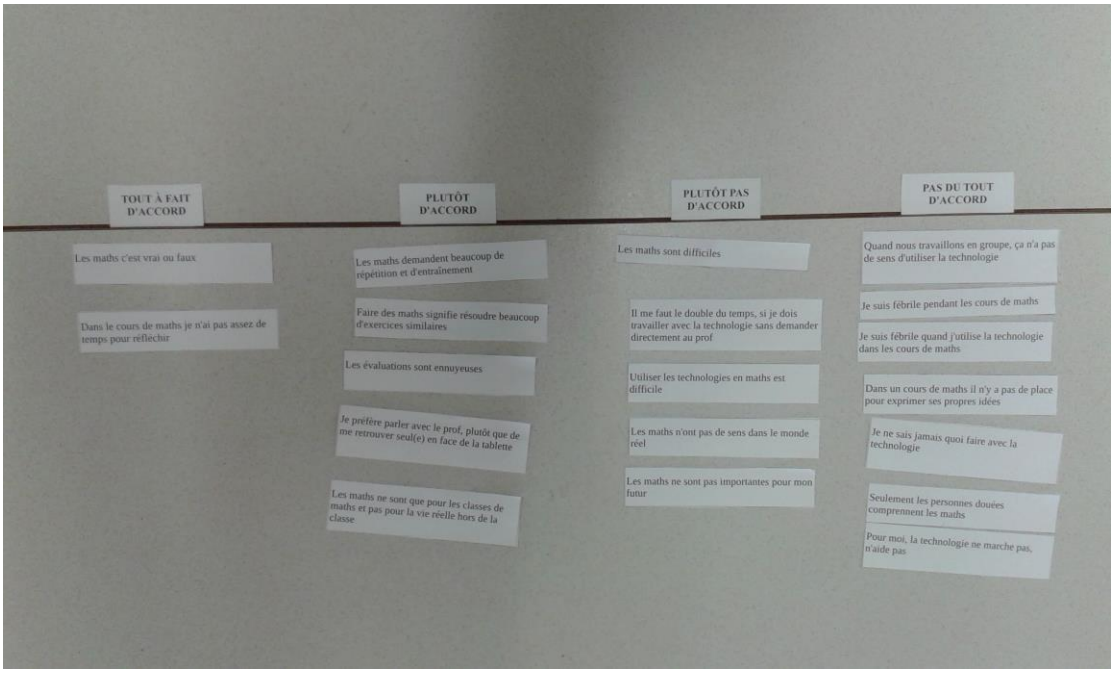


Fig. 36: Group 1 with negative sentences

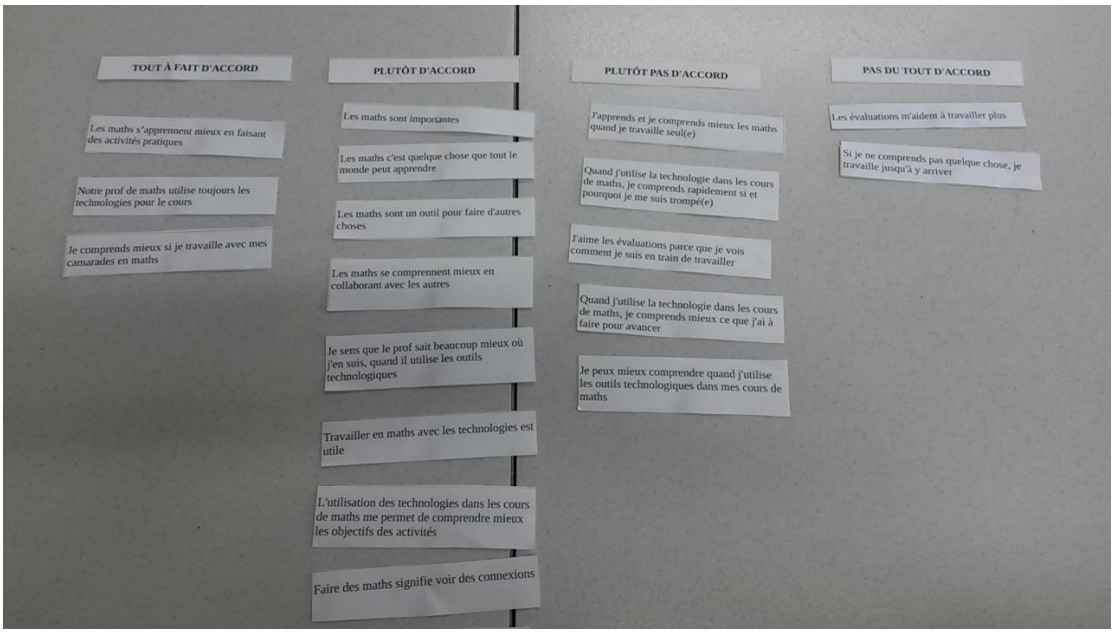


Fig. 37: The same group after having rearranged positive sentences

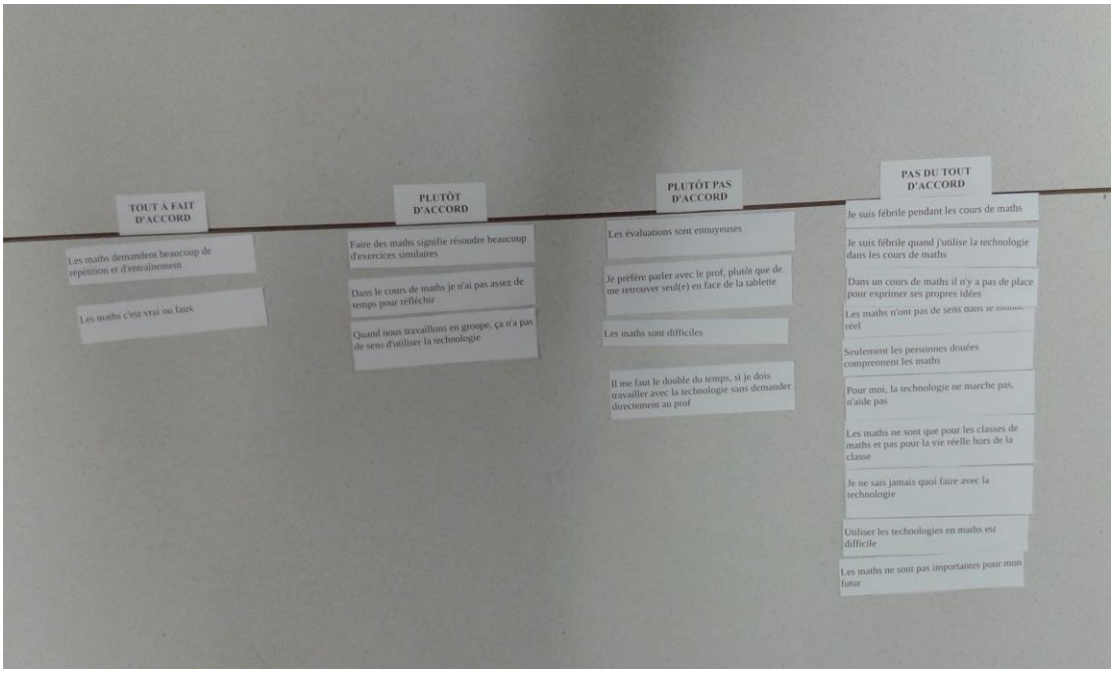


Fig. 38: The second group after having rearranged negative sentences

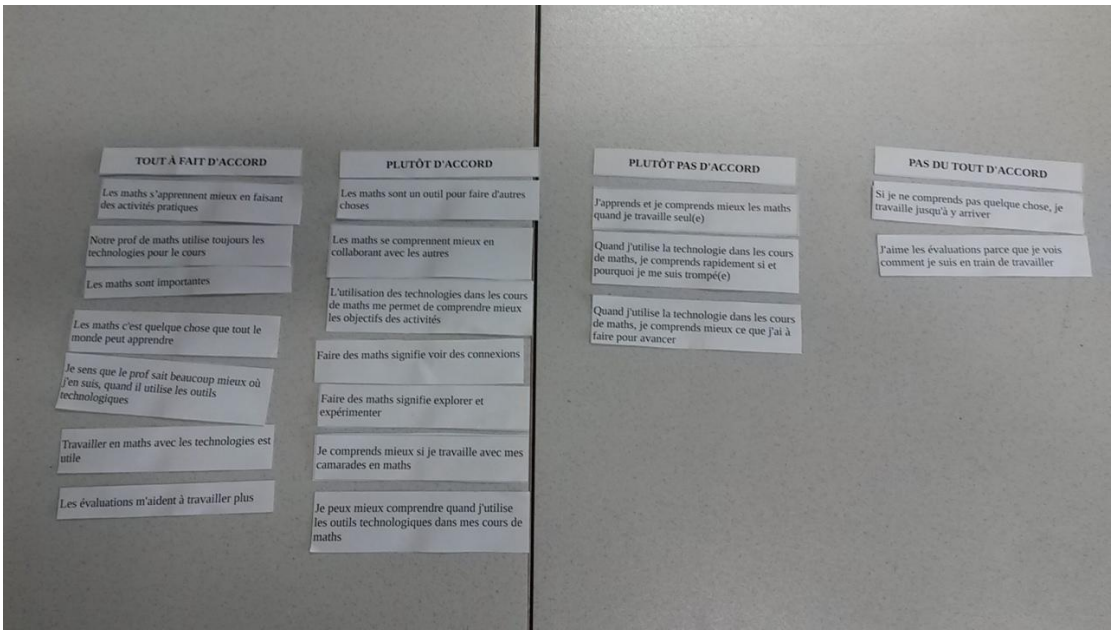


Fig. 39 The second group with positive sentences

Technology

It appears that the presence of technology is very controversial in the class. Both arguments for and against technology are present and very often one after the other, as for example:

in group 1:

- *Using technology in the maths class is difficult…*

- *Not at all, say, I disagree*
- *but, sometimes, using Geogebra it's hellish*

Later, commenting the choice of their peers

- *When I use technology in the mathematics lessons, I understand better if and why I made a mistake*
- *No, for me, on a notebook or tablet, it's the same*
- *For me also*
- *And sometimes with Geogebra it's harder*
- *Where do we put it?*
- *Be, completely disagree*
- *No, no, only disagree… After, he is going to take our tablets out!*

In a first time the whole group doesn't see the plus brought by technology (a notebook or a tablet, it's the same). Even, sometimes using technology brought difficulties that are added to the mathematics learning difficulties. The conclusion seems in that case a complete disagreement with the sentence, but, the last sentence shows also that for this student, using tablet is interesting and he wouldn't come back to a "normal" class without tablets. This ambiguity is also present in the other group:

- *there is no sense to use technology when we work in groups*
- *It's false, yes, it's logic*
- *No, but…*
- *If we put it here, he won't let us work with our tablets (Laugh)*

Commenting their peers' choices, about the sentence: "When I use technology in the mathematics lessons, I understand better if and why I made a mistake", the students disagreed:

- *Obviously we understand better maths when…*
- *No, for me I disagree*
- *Yes, for my own I don't change* (I disagree)

We can also look at this dialogue against the previous advices:

- *To work with technology in maths is useful*
- *Mmmh*
- *Not really! Look, last year we got by fine with Mr…*
- *And we worked with notebooks, it's the same*
- *It's the same*
- *putting aside desktop background!*
- *We say, we agree?*
- *Yeah, we agree*

The final session reinforced this feelings and we can consider as an evidence that students are torn between the pleasure to work with tablets and the feelings that they help them and the difficulties that they encountered or the necessary change in their learning habits.

Regarding technology, the students of the previous year let emerge from interviews that they used technology in a very natural way without however perceiving the overall contribution to their learning.

It was a tool, that they think, might be more convenient if he could more appropriate it and bring it home. It is possible that having had to leave the tablet to college could have been a barrier to an appropriation of the tool and thus the transformation of the school artifact into an instrument for their own learning perhaps remained unfinished. In that sense the two opinions converge.

Mathematics

Regarding feelings about mathematics, students expressed a very positive attitude about both maths learning and the place of maths in their life. Mathematics are difficult, it is necessary to work but everybody can understand and learn maths. Mathematics are considered as useful both in the school context and the real life:

Commenting the sentence "in a maths lesson, there is no place for expressing our own ideas", they said:

- *No, it's false*
- *I completely disagree*

and, considering the sentence "maths have no sense in the real world", they said:

- *Yes!*
- *It's false, too*
- *With x square, you can bombard your neighbour!* (Laugh)

In these discussions the students are rather referring to the school subject. The statements have not made clear their concepts of mathematics as a science. The sentence on the exploration or experimentation of mathematics brought some debate that confronted their visions related to their school experience of mathematics: mathematics appears more as a technique that need to be exercised than as an explanatory science. The cross case analysis shows clearly that this point of view is similar in the two contexts.

Work in group

As well as for mathematics, most of the students like to work in group and consider that it helps them to better understand mathematics as testified in the following dialogue about the sentence "I understand better maths when I work with others":

- *I would say I agree*
- *Yes*
- *For me, I completely agree*

Another group, looking at "It's easier to learn maths when collaborating with others"

- *Not really*
- *Yes, but rather yet*
- *I find rather good*
- *Yes, I too*
- *I understand better if…*
- *It depends, if you are bad at maths and if you work with the class, sure it'll be easier*
- *That's it!*

The only negative advice comes from students willing to have an individual help as expressed by this student: "*I prefer when there is an individual support because I understand better. when he* (the teacher) *works with the whole class, it's for him, it's not for others".* In that case this student considers that when the teacher works with the whole class, he cannot be attentive to each of the students. When reminding that with technology, the teacher follows her work, she replies that *it's not the same thing.* This advice even though in minority in the class is important to notice in order to keep a familiar and human communication even if technology is massively used in classroom. We can for example think to new experiment of virtual classroom where students and teacher work at distance.
Comparing with the previous Q-sorting analysis, it appears that there are not deep differences with the first group.

Assessment

For a majority of students, at this period of the year (the case study comes from an observation done in October), assessment is synonym of mark. What is done in the class in term of FA is not considered as assessment but rather as teaching methods of the teachers. However, discussions appear on the role of assessment and for example, the sentence "Evaluation is boring" (1) was put in the column "I agree" (Fig. 29) by the first group but was put in the column "I disagree" (Fig. 31) by the other group.
Considering the other set of sentences, "I like evaluations because they give me information about my work"(2) and "Evaluations help me to work more"(3), the second has been put in the "I completely agree" by the first group and "I completely disagree" by the second.
The first sentence has been put in the column "I disagree" by the first group:

- *No, I don't like evaluations*
- *Nor me*
- *Put "I disagree"*
- *Yes, I disagree*

The discussions show clearly that evaluation is related to summative assessment:
A first student reading:

- *I like evaluation…*
- *Ah no!*
- *The three first words, I don't like them*
- *Ah no, no, no, I put it straight here*
- *No, that's out*

It is interesting to compare, in a perspective of cross case analysis, with the Q-sorting activity made with students of the same school at the end of the previous year. They had been in the same context during the whole year. Regarding (1) they had the same advice (one group, I agree and the other group, I disagree) with rather the same arguments: "*Sometimes you don't understand, it's boring*", "*Can we put it between the two columns?*". "*You don't get bored because you always have something to do*", "*Yes but when you don't understand, you get bored!*"

(2) was considered in the same way, with arguments showing that evaluation was taken as summative assessment.
(3) They all completely agree with this sentence.
The cross case analysis shows both similarities when students speak of summative assessment and differences when the last year group considered assessment directly linked to their learning.

In both cases students became aware of the opportunity for teachers to follow their work in class but do not necessarily make the link with the possibility of personalized assistance throughout the year.

7. Conclusive remarks

Coming back to the questions addressed by the project, this case study shows that the FA strategies present in the teacher intentions are reinforced and augmented by the use of technology. In this part, we show how this teacher processes formative assessment data from students using the functionalities of networked tablets. But also, we notice that this teacher's FA process includes modifications of his teaching according to both an immediate and after reflection analysis. The second aspect that is addressed in this case study is the transfer of responsibility of knowledge construction to the students. This transfer is facilitated by the possibilities given by technology both to experiment with mathematical objects through interactive environment and to share researches, ideas, conceptions and misconceptions between peers and with the teacher. In this section, we begin by giving the teacher's FA intentions then we examine the evolution and the role of technology in the teacher's schemes of work.

Teacher's FA strategies

One general aspect that is related to this particular teacher, but that has been also observed with all teachers participating to the project, is that before the collaborative work with researchers FA seemed present in the teachers' intentions, but actually was not entirely implemented in the classroom. Typically, the teachers implemented some parts of the FA process but not FA as a whole. As this teacher wrote in a questionnaire we asked to fill in:

The use of formative assessment was implicit. I had very low awareness of it. No specific tool was constructed or used for this purpose. The collection of information was done through conventional tests, activities at the beginning of the session, oral exchanges, observations of students in their activities. The quality and regularity of the treatment of such information was highly variable.

However, this observation, but also the previous work done with this teacher as well as the observations made since the beginning of the project, allows to describe the teacher's teaching conceptions. Through his speech, and his attitudes in the classroom the teacher shows his teaching based on student-centered methods as illustrated by this dialogue with students (quoted at page 20):

[...] *there is no good or bad productions, there is a production that we are trying to do in a collective way and we will see what does it look like at the end.*

This conception which engages the students as active learners in the classroom is also present in different excerpts analysed above as, for example, when he highlights the students' work starting from their actual proposals to engage them in a new research. Another teacher's strategy is making the students discuss through provocations.
The teacher's FA strategies evolve during the project as it is possible to read in session 3 (Classroom teaching), but the observations show an invariant activity based on a student-centred pedagogy. In such a pedagogical system, the responsibility for learning naturally shifts to the student and the evaluation paradigm leads to FA processes. In this case study, the teacher's particular disposition is important to understand his actions all along the described sequence of lessons. The representations in the thee-dimensional model highlight this aspect of the teacher's practices: if we look at the plane actors-strategies, in each episode analysed above, the teacher and the students (as individual or peers) are concerned always simultaneously and in a dynamical way. The question is then to examine the third dimension of the model and to evidence the role of technology within the teacher's practices.

Technology and FA

The particular context of the class where tablets appear as a "natural" tool for students that they are using all the day long in the different lessons, gives to this case study a special taste where technology is omnipresent for both students and teacher. During the four lessons all functionalities of the technology has been used by the teacher to achieve his didactic goals. For this specific case study, it is important to notice that the teacher is particularly involved in the use of technology for pedagogical purposes as he declared in the interview:

I have been using systematically a computer associated with a video projector and an IWB for five years. I have a good command of these tools, technically as well as pedagogically.
Looking at the position of the teacher within the three-dimensional model, it appears that he uses the technological property of "sending and sharing" in three different FA strategies: engineering effective discussions and new learning tasks, providing feedback that moves the learner forward, and activating students as instructional resources for one other.
In the same time, "processing and analysing" data leads him to clarify and share his teaching intentions and the criteria for success as well as to activate students as instructional resources for one other. The technology is playing for the teacher a role of amplification of his teaching intentions and is facilitating his understanding of the students' knowledge construction. And particularly, Maple TA plays an important role when it allows to receive and to process data, despite the technical difficulties in managing such a tool.
Considering students (as an individual or in groups) the functionality of "sending and sharing" is associated to the FA strategies that lead them to cooperate with peers and to become owner of their own

learning. Therefore, the technology appears as a medium facilitating the shift of responsibility for learning.

The dynamic within the classroom leads to consider conjointly the teacher's position and the student's one. It has been observed that, within the same FA strategy, the different properties of technology are involved at different moments by different actors, and the engine force is coming from the didactic situation and particularly by the feedback of the *milieu*:

- for the teacher, the *milieu* is composed of the class confronted to an a-didactic situation in which he has engaged the students,
- for the students, the *milieu* is composed by the mathematical situation that has become their own situation by mean of the *devolution*. As seen above, the devolution of the situation is facilitated by the technology as an amplifier of the teaching intentions.