Case study Norway case 2

School: S (primary school)
Time distance graphs
Dates of lessons: 2015 October 15 and November 11
Age of students: 11 (grade 6)
Data sources:

Observation sheets: from two session
Audio transcripts: two sessions, teacher pre interview, teacher post interview, (student interviews, student q-sorting)
Video recordings: video files from both sessions
Audio recordings: from sessions, from teacher interviews pre- and post, post session reflection with teacher, interviews and q-sorting with students
Photos: from the sessions, from student work
Files: Pasco files and screen shots from computer work during activity
Lesson plans: both sessions

Context

School S is a primary school, grades 1-7. The school is in an area of a medium size city in Norway. The number of students is close to 600, and the number of teachers around 35. Most students and teachers in this school are born in Norway, with very few immigrants with foreign language background.
The teacher has general teacher education, with specialization in mathematics and history. He has been working as a teacher for 7 years, the last three years in this school. He has been teaching mainly mathematics, and also some science. He now teaches only mathematics. During the project he has been teaching the same class, starting in grade 5 and continuing with the same group of students in grade 6.
This teacher has been working with the Fasmed project since the beginning. He has taken part in our cluster meetings at the university, and also at the schools when we have observed different classes at his and two other schools.
In total there are 31 students in his class, with 15 girls and 16 boys. The students are aged 11 or 12.

The lessons

The theme of the sessions were graphs, in particular time-distance graphs. Prior to the observed lesson, the students had been through one introductory lesson about graphs and the connection to real life situations. The objective of the lessons was for the students to be able to connect a graph and a situation given by a story, and vice versa. Each session consisted of two parts.
In one part of the lesson, students experimented with technology for visualization of time-distance graphs. The students tried out how to make graphs by walking in front of an echo sounder connected to a computer. The computer would give a live display of graph in a time – position coordinate system. The other part of the lesson was spent on a task about connecting graphical representations and stories. For the “walking a graph” activity, we used data logger technology, a motion sensor based on ultrasonic pulses connected to a laptop, and an app with premade tasks was presented to the students.

The tasks were a mix of practical tasks: "Walk a graph", and open-ended questions about interpretation of the graphs from the walks. All the results were saved and can be used by the teacher for assessment and feedback to the students.
The case consists of two sessions with two different groups of students in each. In the first session, the students were regarded as relatively high achieving students. Working with mathematical graphs connecting situations and graphical representations is usually not done in Norwegian primary schools. Functions and graphs is usually not introduced until lower secondary school, and is not a specified learning goal for students until after grade 10. This would therefore be the first time this teacher had worked with students in primary school on graphs. Because of this, he wanted to test the lesson on a group of students that he considered high achieving and with an interest in mathematics.
To complete the sessions as a part of Fasmed, we also asked the teacher whether it would be possible to run the same type of lesson with not so high achieving students, which he agreed to do. As it turned out, the designated low achievers were able to perform well and display great enthusiasm during their session.

Each lesson started with a plenary introduction. Thereafter the students split in two groups. One group worked with a task about *connecting graphs and stories*, the other group worked with the *echo sound activity*. Half way through the lesson, the groups switched.
The activity about connecting graphs and stories used the template provided by the Fasmed project, originally developed by the Shell center[1] in Nottingham, UK. The text was translated into Norwegian by the HiST Fasmed team.

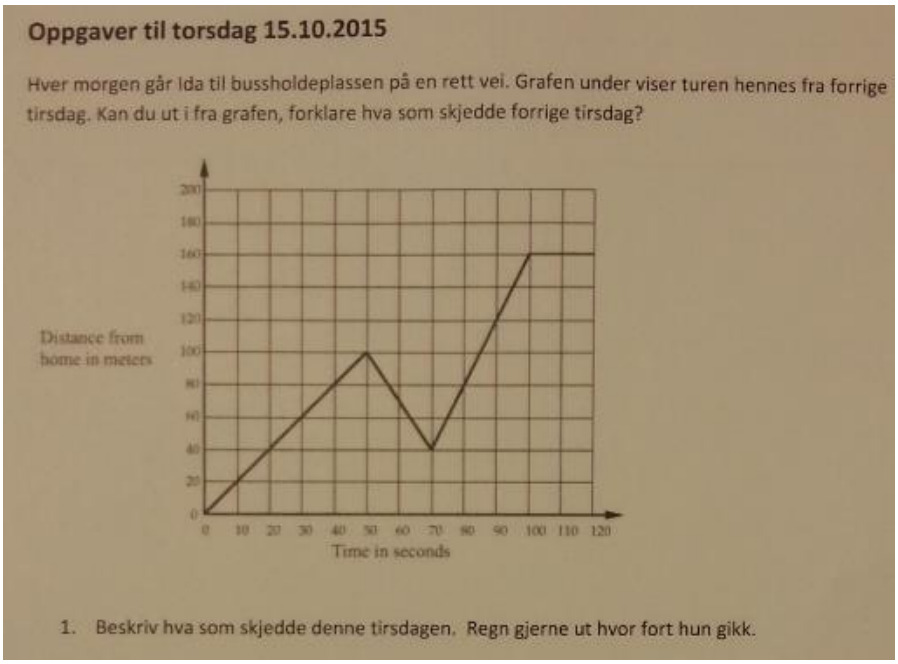


Figure 1. Homework task.

The echo sound activity used some tasks taken from the software bundled with the Pasco software. Instructions for using the software and tasks were translated into Norwegian by the Fasmed team. In addition some new tasks were added.

[1] Interpreting Distance-Time Graphs. © 2012 MARS, Shell Center, University of Nottingham

The technology used was two echo sounder devices developed by Pasco. It allowed students to walk back and forth in relation to a logging device, such that a graph was drawn on the computer screen indicating how near they were the device during a time lapse of ten seconds.

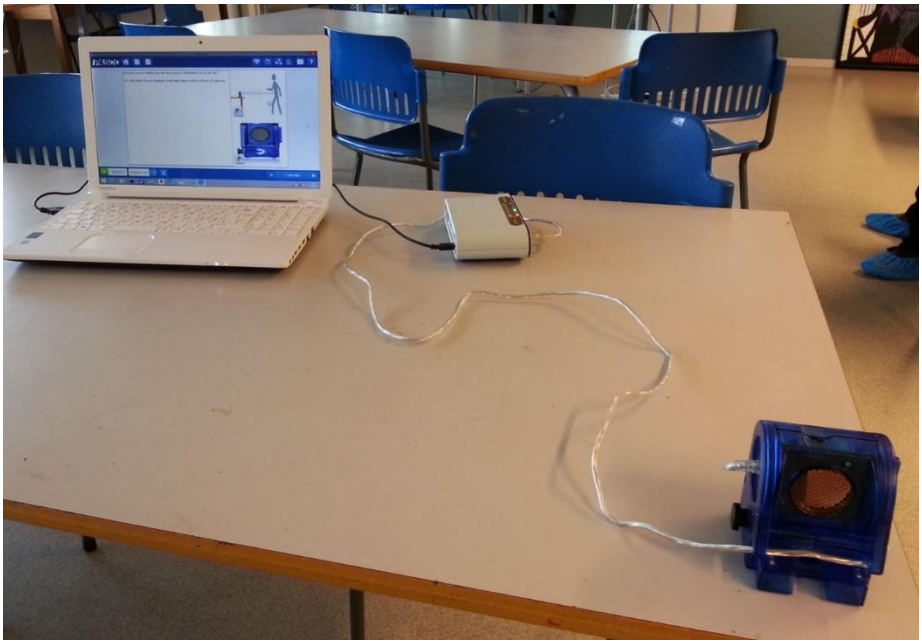


Figure 2. The echo sound logger setup.

Analysis

Relating class room activities to real life.

We identify the connection to real life situations in both the echo sound activity and the graph-situation activity. Looking at Figure 1 we see that this is directly connected to a real life situation, a situation that the students can recognize as such. The same goes with the flag hoisting task, see Figure 9 below. In fact, a student complained that it was the British and not the Norwegian flag being hoisted even if it was supposed to be the 17th of May.

Students were asked whether they had heard about echo sound. Echo sound and the use of echo sound technology is common on boats and ships, and we hypothesized that some students may have heard about this without having any deep knowledge. When asked about the concept of echo sound at the start of the activity, some students said they knew about this from the use on boats, e.g. for fishing. (p.7), which then related this technology to use outside of the classroom. In the tasks used in the connecting graphs and stories activity, all stories were descriptions of real life situations. We thus see that both parts of the lesson had strong links between mathematics in the classroom and life outside school.

The echo sound activity made this lesson stand out from ordinary mathematics lesson. A student said that “It was very different (…) In maths lessons we never move, we sit at our seat; except sometimes we go out to do measurements, but that is always during summer” (Student interview and q-sorting group 1 audio (q1) 02:30). The tasks were also considered different to normal mathematics exercises on two accounts. First, students were not used to doing mathematics tasks using computers. Second, in the class

room they usually have to compute things, whereas in these lessons “there were word problems and we had to do things” (q1 03:20).

In q-sorting, we see that students generally agree to statements connecting mathematics to real life. E.g. students agreed to the statements “Mathematics helps us to understand our surroundings” and “Mathematics is used in everyday life”, whereas they disagree with the statements “Mathematics is only for the classroom, not for real life outside school”, “I can do without mathematics” and “Mathematics is not relevant for my future life”. The q-sorting activities were done around two weeks after the time distance graph lesson. We may therefore claim that there is some evidence indicating that the lesson had made them aware of, or strengthened their awareness of, connections between mathematics in school and real life situations that can be described by mathematics or were mathematics is used. Students agreed that “Mathematics is important”, claiming that “We use it all the time. Everywhere. In the shop. (…) On trains. Airplanes. The bus.” (q1 12:42). Another student had experiences with mathematics in her hobby, horse riding: “We are computing steps when riding, and then we use mathematics” (q1 16:40). It seems that these groups of students held positive attitudes towards mathematics, and that they were able to see mathematics as relevant for themselves and for real life situations.

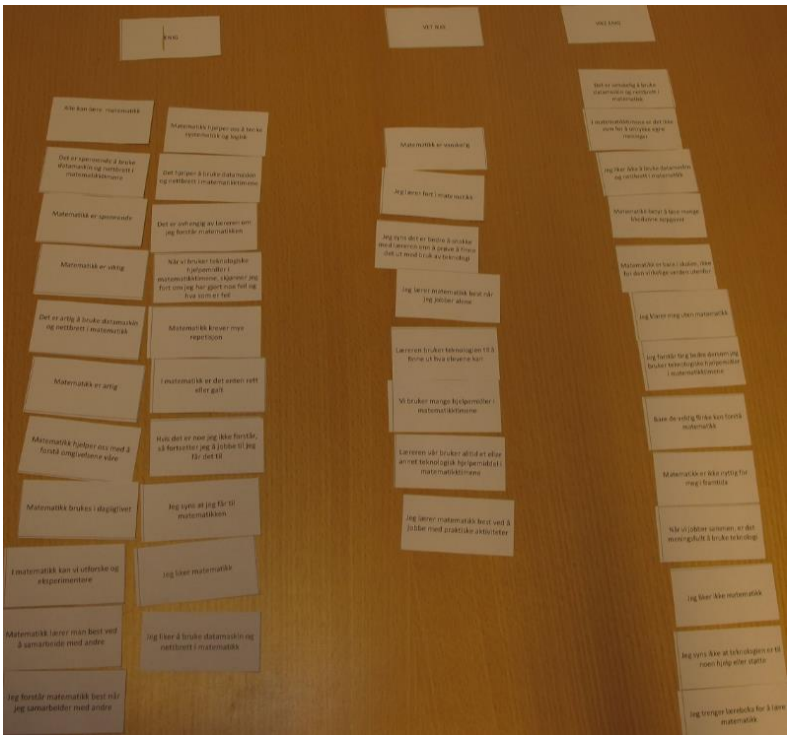


Figure 3. Q-sorting results.

Understanding

During the echo sound activity, the students had to relate what they were doing, i.e. the way they were walking in front of the sensor to the graph the software would display on the PC screen. We can see evidence that students were able to connect the pace of their walking to the slope of the graph: “It raises earlier because you walk faster” (p.10). This relates the time (horizontal axis), distance from the sensor (vertical axis) to speed (how steep the curve is), a fundamental relationship in understanding time distance graphs, and a fundamental relationship in physics, and of course in everyday life. There were

several student utterances showing the same kind of understanding: “It will be more slanted the faster you walk. So you start slow, then you walk faster” and “It will go more straight up the faster you walk.” (p.12). Another student was asked how you can find from the graph were you walked faster. He said that “You can see, because, first it is quite slanted, and then it goes straight up” (p.13).

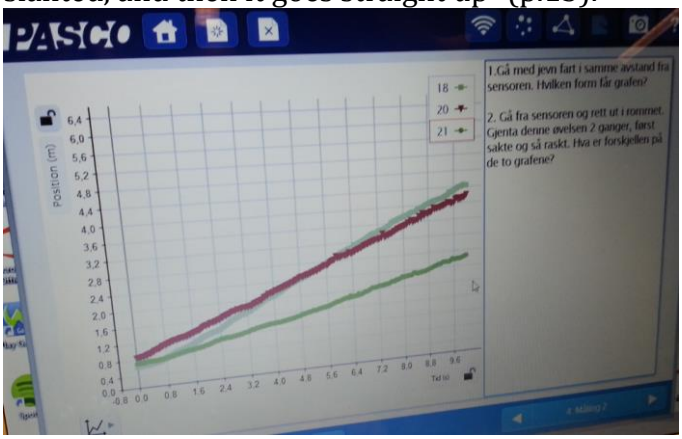


Figure 4. PC screenshot. Graphs where students were supposed to walk with constant speed.

Students also developed understanding of the fact that a graph does not have to start at the origin. When trying to walk in a way that would produce a W as graph: “You have to start far away [from the sensor] because then it goes downwards and then it goes upwards and then it goes downwards” (p.11). We see here that they understand that a graph can cross anywhere on the vertical axis, and the relationship between distance from the sensor and time passed. Their descriptions and discussions do not use a mathematical vocabulary or concepts, rather describing what they see in everyday terms.

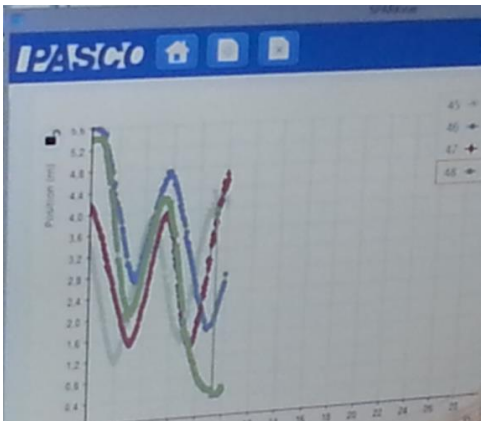
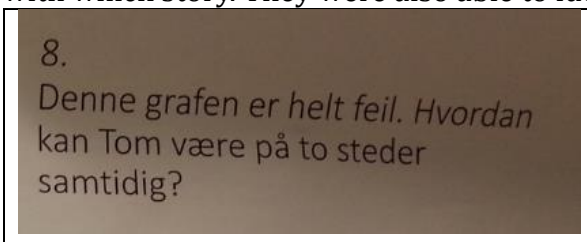


Figure 5. PC screenshot. Walking to make a W.

Student understanding of interpretation of graphs developed during the session by the discussions taking place. A student describing a horizontal part of a graph (Figure 1) suggested that this could be “someone sitting on a bus”. Another student quickly replied that this would rather mean “she is waiting for the bus since the distance does not change” (p.3). Discussing the same graph (Figure 1), the teacher asked why the graph did not turn left when she walked towards home again, and a student replied “she does not go back in time!” (p.4).
When working with pairing stories and graphs, students discussions were common, and they had to argue and explain, trying to come to a common agreement about which

graph fitted which story. Sometimes the teacher asked them to argue their view, particularly in cases where they had done the wrong pairing. These situations generally lead to students correcting their answers. At q-sorting, one of the groups agreed to statements like “Mathematics is best learnt in collaboration with others” and “I understand better if I work with friends in mathematics”, and we can see clear indications of this taking place during these lessons, e.g. during the discussions about graphs and stories.
In the end the groups generally ended up with correct answers to which graph fitted best with which story. They were also able to identify “wrong” graphs, like the one below.



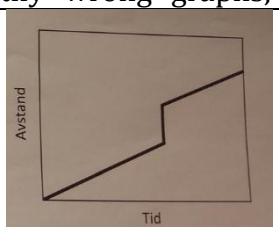
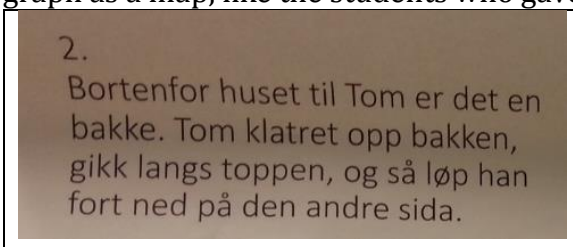


Figure 6. Student answer. Identifying a graph that must be wrong

Some misconceptions could be found, e.g. the well-known misconception of reading the graph as a map, like the students who gave the following pairing:



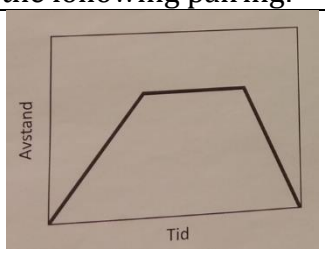
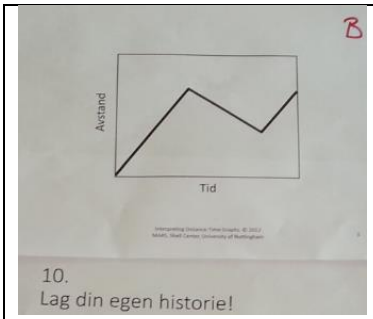
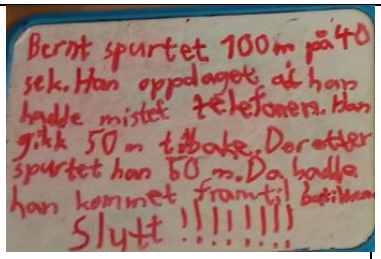
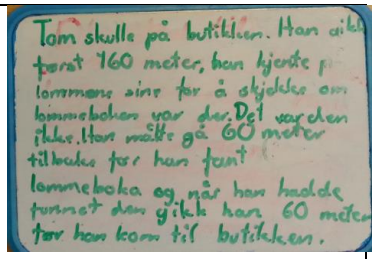


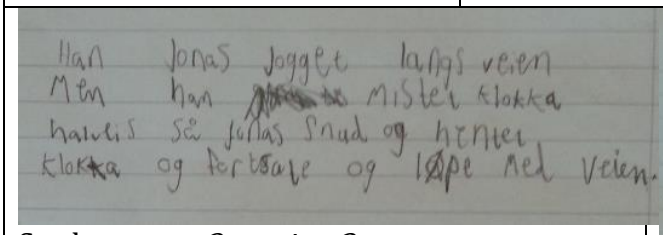
Figure 7. Student answer. Common misconception

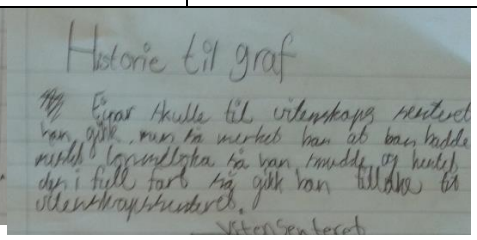
As far as we could see, this misconceptions did not occur with the first group of high achieving students, only with the second group of lower achievers.
Student understanding is transparent in their own “storymaking” to a given graph.





Student story 1 session1


Student story 2 session1


Student story 3 session 2


Student story 4 session 2

Figure 8. Students’ stories to a given graph.

In the interviews, students said the tasks in this lesson were more challenging than the mathematics tasks they normally work with. E.g., that they had to explain how they did things (q1 06:20). Being challenging is not really a bad thing, and students said they found the sessions to have been great fun and exciting. They claimed that they had learned a lot about graphs (e.g. q1 08:20-). During q-sorting, students agreeing to the statement "I can better understand when I use the technology tools in our mathematics lessons" said they agreed to that statement referring to learning about graphs "I learned a lot about graphs and how they change with the computers" (q1 13:40), and another said "I learn by watching videos on YouTube" (q1 14:00).

Technological issues

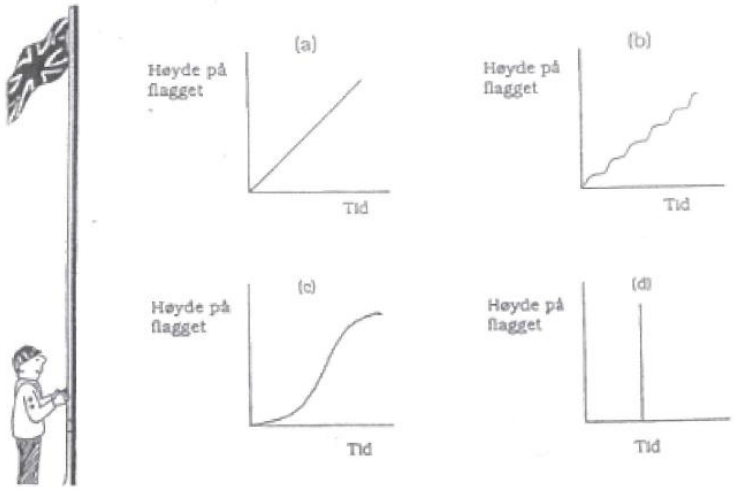
The technical setup with echo sounders was unfamiliar to most of the didacticians, the teacher and the students. In addition, the software had several minor bugs, some causing unpredicted results and stops in the activity. A student said that "Nothing is happening here" (p.10), upon which the didactician investigated the matter and figured out that a minor alteration in the setup had caused the measurements to not be recorded.

Students did find that it was more difficult to work with the echo sound activity than the tasks were they had to pair stories/situations to graphs, and they related this to the technical issues they experienced (q2 03:00), and that it was difficult to see the direct connection with their moving and the graph that appeared on screen, e.g. how to make sure that the graph started exactly where they wanted it to start (q2 03:20).
It seems that technological issues are unavoidable part of using technological tools in the classroom. In particular this will be the case with tools that are new or originally meant for classroom use.

Formative assessment

The start of each session was a plenary where the whole group of students comprised 10 (1st lesson) and 11 (2nd lesson) students. As homework after an introductory lesson, the students had worked with two tasks. The first task was about a girl walking along a road from home to the bus stop. A graph was given, and the students were supposed to give details about her walking path (Figure 1). The second task was about hoisting a flag (Figure 9). A story was given: "It is the 17th of May and you will take part in hoisting the national flag at school before setting for the town center to join the parade." Four different graphs were given, and three questions for the students: "a) Explain in your own words the meaning of each of the graphs; b) Which of the graphs describes the situation most realistically. Please explain why you think so; c) Which of the graphs describe the situation least realistically. Please explain why you think so." (Figure 9).
During the plenary at the start of the lesson, the teacher asked each student to describe his/her thinking about the first task. In this way the teacher learned about his students knowledge, and gained insight into the students vocabulary concerning graphs. He could see which conceptions they had concerning the axes in the coordinate system and the connection between the axes, a story, and the graphical picture/representation. Since the graph showed "time vs distance from home", to find the total distance walked, the students had to understand that a distance was walked even when the graph had negative slope, while no distance was walked when the graph was horizontal. The dialog where one student suggested that the horizontal part meant that "she is on the bus", showed the teacher that some students would have this common misconception. He was therefore able to take action by prompting further suggestions from other students,

which lead to another student quickly saying that “she is waiting for the bus since the distance does not change” (p.3). The total distance walked was important to find for those students who wanted to compute the average speed, which some had done. Talking about the first part of the graph, the teacher prompted a student to explain how he had found the average speed, which was not something they had learned in any lessons yet. The student answered “I divided 100 with 50” (p.4). When asked about the average speed for the whole walk in the story, a student explained that “I took 280 meters, because that’s what she walked in total, and divided by how many seconds she had walked. 100 seconds. And that is 2,8. 2,8 meters per second.”(p.5). We see here that the students had really grasped the information in the graph and were able to reason about it.
Next they talked about the flag hoisting task.



Historien som følger disse grafene er:
"Det er 17.mai, og du har fått i oppdrag å være med på å heise flagget om morgenen før dere drar til byen for å gå i tog."

a) Forklar med ord hva hver enkelt av grafene betyr.
b) Hvilken av grafene viser situasjonen mest realistisk? Forklar hvorfor.
c) Hvilken av grafene er minst realistisk? Forklar hvorfor.

Figure 9. Flag hoisting task.

Students immediately identified which of the graphs they considered most unrealistic and which were more realistic, giving reasons for their opinions. One student said about graph (d) that it was unrealistic because it starts at rest and then goes straight up. “It had used zero point zero point zero point zero seconds to go straight up.” (p.6). Thus the teacher had information about the students’ knowledge and conceptions of graphs, and we can identify this as an important part of formative assessment.
After the sessions the teacher said he had learned a lot about his students, and in particular how good these tasks had been to reveal misconceptions: “It is very smart for revealing misconceptions” (teacher reflection (tr), p.3). After the 2nd session he said that those groups who had done the echo sound activity first, solved the part with pairing story and graph faster. (tr2 00:49). The teacher found that this, with high probability, was because they had done the practical activity first and had better understanding of the concepts (tr2 05:50). Similarly, it was not possible to distinguish any big differences between the first session with higher achievers and the second session with lower achievers. The teacher did however find that the lower achieving group needed more feedback and direct instruction during the lesson (tr2 03:55).

It was also obvious that even if these type of activities with graphs is usually not done in primary school in Norway, that it had not been too difficult and that this is a topic that could easily have been done with the whole class. The teacher said that "I think, interpreting graphs, it could have been done quite easily. (…) I think this might be more fun in primary than in lower secondary school. They still find it exciting with graphs .. they are more curious and less biased" (tr p.3).
In the interviews all students said that they had enjoyed taking part in the project and performing the lessons with graphs: "In my opinion everything was good" (q2 02:25). "We learned a lot about graphs" (q2 02:33).

Final remarks

The core theme of this case was working with time distance graphs using two different approaches. One approach involved pairing stories and graphs which were already given on sheets of paper. The other approach involved the use of graph plotting technology connected to students themselves having to move in front of a sensor to create a graph. Our claim is that these two approaches worked well in tandem, and that each of them contributed to student understanding of functions and graphs. As a stand-alone activity, the echo sound graph plotting was very useful in giving the students hands on experience in using technology and use their own movements to create something. In the interviews, students claimed this was an important part of what they had learned and which distinguished these lessons from ordinary mathematics lessons. Since there were some technical issues, and since only a few students can work at the same time with the echo sound sensors simultaneously, we see it as important that one part of the lesson had another non-technical activity. That activity also prompted good discussions among the students and enhanced their understanding. We therefore see it as important to have varied activities during lessons, and claim that these lessons give some evidence that this is true.