

Utrecht University Case Study 2

Autumn 2015

This case study is carried out during November and December 2015 and covers a series of formative assessment activities on the topic of graphs based on the use of the Digital Assessment Environment (DAE) that was designed by the Dutch FaSMEd team. The sixth-grade teacher involved in this case study conducted a number of formative assessment activities in her classroom in four steps:

1. Assess the students' knowledge of graphs by using the DAE Graphs A Test.
2. Conduct a lesson (Lesson 1) about graphs based on the findings from the DAE Graphs A Test and using additional materials provided by the Utrecht FaSMEd team, as well as providing an alternative activity for high performers.
3. Conduct a lesson (Lesson 2) about graphs using materials found online for the high performers and using home-developed tasks for the rest of the class.
4. A follow-up lesson (Lesson 3) for high performers and assessing students' knowledge of graphs after the intervention using the provided test in the DAE (Graphs B).

Lesson 1 and Lesson 2 were observed and are reported in this case study. We also discuss the resources used in this case study, the background of the class in terms of mathematics performance, the teaching practices of the teacher outside the context of the FaSMEd study, and the visions of a small group of students with the q-sorting statements as a means to elicit verbalisation of their thoughts.

1. Tasks and resources used

1.1 Assessment and practice problems provided through the DAE

For Step 1 and Step 4 the teacher used the problems of the DAE Graphs A and B Tests (see Appendix A). For Step 2 the teacher used the additional materials provided by the Utrecht FaSMEd team (Appendix C) and for Step 3 she used a combination of problems found on the Internet and teacher-designed activities.

The DAE logged the answer of the students on test A and provided the teacher with information about the students' accuracy in answering each problem as well as their given answer. In addition, the teacher could further analyse the students' steps in solving the problems by viewing the answers to sub-questions in the DAE. The teacher could deduct in which step the student had made a particular interpretation or calculation mistake by analysing the answers to these sub-questions. This information was supported by digital scrap paper: Students had the option to make notes on a digital scrap paper, and their notes remained visible for the teacher.

The set of practice problems used in Step 2 was provided in the DAE, but the teacher decided not to let each student work individually on a computer, but to print the problems for the class and support her explanations of the problems by displaying the same problems in the DAE on the smartboard. The problems as presented to the students can be found in Appendix B.

1.2 Materials and support for the teacher

The teacher used the manual written for FaSMEd teachers as a resource (for an English version, see: *FaSMEd: Digital Assessment Environment, version 28 June 2015*). This manual contains information about the theoretical background of formative assessment, the instructions for using the DAE, and didactical information about each of the subject domains assessed using the DAE, including graphs. The manual was distributed and discussed during the professional development meetings (see Section 2: Work with teachers).

In addition, the teacher asked the researchers to provide input for the lesson. In response to this request, the exercises made available for the teacher in Case study 1 were made available to her. The researchers listed a number of options for her to consider using e-mail. The teacher decided to use the materials provided, but to use her experience with the students and individual differences between them to manage the approach of presenting students with these materials. In addition, for lesson 2, she used a series of exercises from the Freudenthal Website Rekenweb to entertain the highest performing students in her class (see: <http://www.fi.uu.nl/toepassingen/03310/treinmachinist1/inleiding.html>). She found these exercises on her own accord.

1.3 Information collected by using the DAE

A general overview of students' answers to each problem and associated accuracy can be found in Figure 1, for the Graphs A Test. The overview in Figure 1 shows that in the first lesson, students were capable of solving, on average, slightly over 60% of the problems correctly ($M = 4.25$). The Graphs B Test was postponed until after Christmas and is therefore not reported.

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E	Ja		B			D			11				200		C	
E			B			D			11				200		C	
B			B			D			11				200		C	
B	Ja		D	Ja		D	Ja		11				440		D	
B			D			C			1				420		B	
A			C			C			11				200		B	
B	Ja		D			D			11				400		C	
B			B			D			11				200		D	
B			B			D			11				200		C	
E			C			C			11				640		C	
E	Ja		B	Ja		D	Ja						80km		D	
E	Ja		B			D			11				400		C	
A			A			D			1				400		C	
A			B			D			11				400		C	
D			B			B			11				200		B	

Figure 1: Information from the Graphs A Test in the DAE

Note. Columns in green and red display answers given by individual students, displayed on separate rows. Cells marked blue indicate the student has opened the digital scrap paper auxiliary tool.

1.4 Results from the Cito Mathematics Test

To measure students' general attainment in mathematics, scores on the Cito Mathematics Tests were collected. This is a national test completed by primary school students twice during each academic year, consisting of primarily context problems that cover a variety of mathematics domains, such as numbers and operations, measurement, and rational numbers. Test scores are converted into ability scores that typically increase throughout primary school, making a comparison of results throughout the academic career possible (Janssen, Scheltens, & Kraemer, 2005).

Prior to the start of the study¹, the average ability score on the Cito Mathematics Test E7 was 108.8 ($SD = 10.3$). These test scores did not significantly differ from the national average of 105 (Flik, 2014), $t(17) = 1.55$, $p = .14$). Post-test performance will be measured in February 2016.

2. Work with teachers

The observation study was part of a study with multiple components involving the DAE designed by the FaSMEd researchers from Utrecht University. Schools for this study were recruited in June and July of 2015, and the study was conducted between September 2015 and February 2016².

To get acquainted with the materials offered within the DAE, the principles of formative assessment, and the ways in which teachers could interpret and use student data, three professional development meetings were organised with clusters of schools. Schools were clustered based on geographical location and meetings took place at a school in a central location. The school at which Case study 2 was conducted was located in the north of the Netherlands and clustered with two schools that were also in the north. Each session lasted about 90 minutes and was led by one or two of the participating researchers. Table 1 shows the content of each professional development meeting.

For each meeting, the researchers prepared a powerpoint presentation which was presented on the smartboard in the classroom. The information given to the teachers was supported by these slides (with printed handouts), as well as printed copies of the Teacher Manual. In meeting 1, group discussions about the purpose of assessment were initiated and facilitated by the researchers by asking questions about the teachers' perception of assessment. Discussion in meetings 2 and 3 centred around student work on the previously completed tests. To facilitate the discussions in meetings 2 and 3, the researchers selected some interesting examples of student work as input for the discussion. All present teachers participated in all of the discussions as a group.

After each meeting, teachers were asked for their opinions on the study, the assessment tools, and, in the case of the second and third meeting, their students' work. The teachers reported that they were enthusiastic about the materials offered to them and that they could see the merit of formative assessment in the current form. A few of the teachers reported that they had little time to analyse the results of the students, but that the requirement to send the researchers a small report helped them complete the analyses in time. Other

¹ Please note that the study did not only contain assessment of graphs and resulting lessons, but also assessment of all the other domains addressed in the DAE and consequent actions taken by the teacher.

² The 3rd meeting will take place in January 2016, but has been included in this report for completeness.

teachers did not complain about time restrictions, and even inserted a few extra lessons into their curricula to mend difficulties they encountered in their analyses. The professional development meetings were evaluated by the teachers as clear and well-structured.

Table 1

Professional Development Meetings for UU FaSMEd Case Study 1

Meeting	Topics	Resources
1	<ul style="list-style-type: none"> • Theoretical background of formative assessment • Didactical background of percentages • Didactical background of fractions • Using the DAE • Planning of the study 	<ul style="list-style-type: none"> • Teacher Manual: FaSMEd Digitale Toets Omgeving • Handouts of presentation for teacher
2	<ul style="list-style-type: none"> • Discussion of percentages output • Discussion of fractions output • Didactical background of the metric system • Didactical background of graphs • Further planning of the study 	<ul style="list-style-type: none"> • Teacher Manual: FaSMEd Digitale Toets Omgeving • Student work (of participating classes) on percentages • Student work (of participating classes) on fractions
3	<ul style="list-style-type: none"> • Discussion of metric system output • Discussion of graphs output • Evaluation of the study • Further reading and resources • Planning of observation lessons 	<ul style="list-style-type: none"> • Teacher Manual: FaSMEd Digitale Toets Omgeving • Student work (of participating classes) on the metric system • Student work (of participating classes) on graphs

3. Classroom teaching

The teacher in UU Case Study 2 has studied at the Pedagogical Academy in Leeuwarden (University of applied sciences). By the time of the study, she had been teaching for 30 years (since 1985), all at the same school. During her work as a teacher, she further developed her expertise by enrolling in post-academic education. She is now qualified as a remedial teacher, a specialised group teacher, and an internal counsellor.

Between 2008 and 2010, the teacher in UU Case Study 2 had followed a trajectory to become an internal counsellor for the school (a teacher to whom other staff members can turn for discussing difficulties in the class or making action plans for individual students, but who is also responsible for selecting professional development courses for teachers and draw up a plan for advances in pedagogical approach for the school). Within one of the courses, she was assigned to write a paper about a self-selected topic. She had chosen formative assessment as a topic, which had triggered her desire to gain more information about FA and lead to her signing up for this study. She had no previous experience of bringing FA into practice. During the study, the teacher expanded her knowledge about FA using the meetings organised by the researchers and the supportive materials handed out during the meetings. She also got her first experiences of bringing FA into practice.

The teacher had experience with using technology for teaching and assessment in mathematics – the textbook has a software package with practice problems, assessment tools, and applications to use with the digital blackboard (digiboard or smartboard). The teacher liked to involve digital materials in her lessons, but often ran into problems with the Internet connection, which made paper-and-pencil materials the safer but less desirable choice.

Prior to the start of the study as well as during and after the study, the teacher followed the manual provided with the textbook Alles Telt used in the classroom. Dutch teacher manuals for textbooks typically give extensive instruction on teaching materials, the pace of teaching, and the way to differentiate between student with a quick, intermediate, and slow learning pace. Student performance is elaborately indexed using test scores on each of the tests to be administered at the end of a series of lessons. In addition, this teacher used the answers of her students on practice problems and regular class assessments to determine whether each individual student would need extended instruction about a topic. Finally, the textbook Blits was used in the classroom to help the students develop study skills. These study skills include data management and reading graphs, relevant for this lesson series. However, the textbook mostly contains information on different types of graphs: bar graphs and pie charts. Time-distance graphs are not covered.

During her teaching, the teacher practiced Explicit Direct Instruction. This collection of instructional practices is aimed at, for example, involving all students in a lesson, making explicit the aims of a lesson, and checking understanding of students during any phase of learning on a regular basis. The book used as background material is translated as *Expliciete Directe Instructie* (Hollingsworth & Ybarra, 2009). Techniques discussed in this book include using ice lolly sticks with the students' names to select a student for answering a question, and using mini whiteboards to check understanding of all students simultaneously. The teacher adopted both techniques in her lessons.

Learning aims of the students primarily centred around the nationally determined reference levels 1F and 1S (Noteboom, Van Os, & Spek, 2011). At the end of primary school, students need to have acquired a certain amount of knowledge and skills. The desired level is level 1S (strive). Students who cannot keep up with the desired pace need to minimally perform at level 1F (fundamental) at the end of their primary education. An elaborate manual describes which aspects of subject material within various domains of mathematics should be covered to achieve each of these levels. Textbooks for mathematics are written so that all students at a high and intermediate level should be able to achieve level 1S at the end of primary school, and so that students at a low level should be able to achieve level 1F. Heterogeneity within a classroom is dealt with by constructing basic exercises for students of all levels, and more specific learning materials for students in each level group (high, intermediate, or low). In addition to this differentiation, the teacher often designed her own lessons with creative problems for higher performing students to solve, while working in a small group with the children who had difficulties understanding the taught materials.

4. Lessons

4.1 Procedure

The observation lessons were initiated by the researchers, who asked the teachers taking part in the data collection of Autumn 2015 whether they were willing to teach two

lessons on graphs for observation purposes. The teacher from the observed school gave her consent, and planned the lessons at a convenient time.

Prior to the observation lessons, the teacher assigned her students to complete the DAE Graphs A Test. This test was performed on one of the three available computers for the students. The computers were connected to the Internet so that the students could log into the DAE. The teacher downloaded student results and analysed her students' performance before his next lesson on graphs. The researchers offered input for the lesson, and the teacher agreed to look into the practice problems that were originally designed for Case study 1, but also applicable in the current situation.

The next lesson (Lesson 1) was an observation lesson. The lesson was observed by one of the researchers who was present in the classroom. The lesson was audio recorded and notes were made of the content. The lesson took approximately 60 minutes and all of the students in the class participated ($n = 17$).

The majority of students received printed resources from the DAE: the practice problems originally designed for Case study 1 were printed on A4 paper, with one problem per page. The students did not use electronic resources during this lesson, but the teacher logged into the DAE with the laptop that provided input for her smartboard and went through the problems with the aids of the digital tools provided in the DAE. In the meantime, the highest performing students who had grasped the theory on graphs were assigned to design a problem of their own.

The next lesson on graphs (Lesson 2) was also an observation lesson. During this lesson, the majority of students worked together to create two bar charts of car rides enacted in the classroom (and partly in the kitchen attached to the classroom) and then structured into two comparable charts. The high performing students divided into three small groups and worked on printed problems and problems presented on the computer.

4.2 Observation of Lesson 1

Date : 2 December 2015

Grade : 6 (11-12 years old)

Before Lesson 1, students had completed the Graphs A Test from the DAE. The teacher had analysed the response by the students, and decided to teach a lesson about problems that were similar in nature. She had noticed that a large part of the class did not yet perform at the desired level, and intended to explain graphs further to them. To do so, she created a lesson plan included in Appendix B.

The lesson started at 9.00h, after a spelling lesson. The teacher started her instruction by pointing out the objective of the lesson, written on a small blackboard with an overview of the day's schedule: 'We are going to learn how to read off or display time, speed, and distance in a distance-time graph'. She then checked whether the students knew what the word display meant (weergeven). She gave one student the opportunity to answer the question, complimented her, and provided an explanation in her own words.

The teacher told her students that she had various exercises available. Children who made only one mistake or less on the Graphs A Test (written down on her lesson plan and read off to the students) got an exercise to complete outside the classroom. The remainder of the children would stay inside the classroom and get some more explanation, and work

together on completing new problems. She also explained to the children that they would do another test (Graphs B) at some point to check whether they had understood today's lesson.

The teacher then asked her students to think back of the lesson of previous Friday, when two train drivers had visited the school and told the children about their job and the trains they drove. She first asked the students how fast a train *could* go, and then how fast a train *was allowed* to go. After some discussion involving several students, the students concluded that the train driver had told them that a train *could* go 120km/h, but was only *allowed* to drive 140km/h in the Netherlands.

The teacher then told the students that the average speed was usually lower than the top speed of a train. She asked the children which possible reasons they could think of for a train to drive slower than the maximum speed. The children then briefly discussed this with their neighbours. After a minute, the teacher again asked for the attention of the class and drew out a cup with ice lolly sticks, all bearing the name of one child. She would draw several sticks and let the children she drew give examples of why a train would drive slower than the maximum speed. In several turns, children gave a number of answers: the danger of the train derailing, braking for things such as a train station or things on the track, the need to build up speed after stopping, a power outage, weather conditions such as frost and leaves on the track, bends, or running out of coals. The teacher complimented the children and explained some answers in her own words, and added examples of her own: speed limits or doors refusing to close after a stop.

She then repeated the objective of the lesson written on the blackboard, and told the students that some children had already met the objectives. These children solved all the problems on the Graphs A Test correctly or only made a single mistake. These children would get a different assignment. The assignment was (quoted): 'Think of a number of situations that you can process into a distance-time graph. We just covered trains, those are now off-limits. But there are other situations that have to do with distance, speed, and time. Think of a number of those situations. Give me an example.' Student: 'A bicycle.' 'Yes, a cyclist. You are going to list a number of examples, and choose one. You are then going to make a mathematical problem about it for 6th grade, and think about the problems that you did yesterday. You are going to make up similar problems. Be aware: Make the problem so clear that the class does not have to guess what you mean, so very clear. First make the verification sheet, and then the sheet to fill in.' The teacher then divided the high performing students into pairs and gave each pair a printed copy of the assignment. The students worked on the assignment in the hallway.

After the small group of students left the classroom, the teacher handed out a booklet with problems, found in Appendix C. These problems were directly taken from the DAE, where a set of practice problems had been made available. She then drew the attention of the students back to the objective of the lesson, and had one student read it off the board. She asked the students whether they understood what it meant, to which the students answered affirmatively. The student with intellectual difficulties was addressed personally, she nodded, confirming that she had also understood. Next, the teacher asked the students to take out their mini-whiteboards and to write down what they needed to know ('something about this, something about that') if they wanted to make a distance-time graph. After about 20 seconds, the students held their whiteboards under their noses, and the teacher read what she saw:

primarily distance and time, and occasionally speed. She explained that distance and time were the things they were going to plot, and that speed was also important because it could tell something about the time and distance.

The teacher then proceeded to Problem 1 (Appendix C) and first pointed out which variable referred to time, and which to distance. She then asked the students to colour the section where the train had the highest average speed. After seeing that some students were giving her questioning looks, she went through the problem step by step. She first analysed the time intervals of the table, and one student was given a turn to say that each interval consisted of ten minutes. Then, she asked how many kilometres the train had driven after each time interval, giving different students turns to talk, repeating each answer for the class, and repeating the entire sequence when all answers had been given. She listed each distance again, adding the phrase ‘driven in ten minutes’ to each distance. Again, she asked the students to choose a section, and gave a few students a turn to give their answers. She then compared their answers and asked the students to apply their logic: ‘Do you need to drive faster to drive 21km in ten minutes, or to drive 22km in ten minutes?’ This question was asked to two individual students: first an average performing student, and then a weak performing students, who both gave the correct answer. The teacher concluded with pointing out where the speed had been highest.

Problem 2 was next. The teacher first pointed out that the table below the graph looked more or less the same as that in Problem 1, but with different time intervals. Then, she told the students that the graph referred to the same journey, and asked the students to think about where the time was displayed, and where the distance. They were to tell their neighbours about their thoughts. After a minute, she asked whether everyone had collected their thoughts, and gave the students the correct answer. She told the students that getting this information clear was an important first step in dealing with any graph. She then told the students that they could fill out the rest of the table based on the graph. Students who knew how to proceed could do so independently, but the students who found this difficult could keep listening to her instructions. She asked who would be listening to instructions, and most of the students raised their hands.

The teacher then guided the students through the problem by verbally describing the situation of a train driving fifteen minutes and ending up having driven a certain number of kilometres. She gave individual students turns to fill in each blank in the table. She paid a little extra attention to the section where the train was standing still, explaining that the time continued, but that the train was not driving anymore.

After Problem 2 had been completed, the teacher announced that the class would do Problem 3 together, but that after that, most of the students would have to work individually. She first described the journey of the black train (red on the smartboard), and the students verbally joined in, calling out where the train would be at each timepoint. Then, focusing on the blue train, she first asked when it would be leaving point A. When only two students raised their hands, she encouraged the rest of the class to also think of an answer. She repeated the problem written on the worksheet, and then rephrased her question, first asking when the red train left point A, pointing out that the blue train left an hour later, and asking what time it was then. She then selected a student to give an answer. She took the (correctly given) answer and explained how to transfer this information onto the graph. The asked the

students again where it would be an hour later, and after one more correct answer, assigned to students to complete the problem themselves. The teacher took this time to walk around the classroom and correct students when they were ‘on the wrong track’, all the while asking questions to guide their thinking.

Students who felt they understood the problems were then told to complete the problems on their own, and when finished, create a problem of their own, just like the higher performing students working in the hallway. The students who wished to join them for further explanation were invited to the large table at the front of the classroom. The teacher also remarked that reading was always the first step, and a step that students often skipped. Therefore, she told the students in the instruction group to start reading and checked on the other students in the hallway as they did so.

When the teacher returned, she proceeded the instruction with a small group of six students. She divided each problem into many smaller steps and challenged each student to think about the problems by asking many questions and sometimes asking to repeat some information. She checked on a regular basis whether the students felt they understood what she was telling them, and motivated them by telling them that they were one level ahead each time they had completed another part of a problem. She often repeated all the relevant information before asking for a final answer to a problem, and asked students which pieces of information given in the problem were important. When the students had to draw a graph in Problem 6, she gave each student individual support. Problem 7 was skipped because the time for the lesson was up.

Ten minutes before the end of the lesson, the students working in the hallway were called back into the classroom. While working outside the classroom, they had formed three groups (two pairs and one group of three) to create one problem on graphs for the class. They were then given turns to verbally present their problem to the classroom. The following problems were presented:

1. A bus drives for four hours. It starts with 80 km/h the first hour, and each hour, it goes 10 km/h faster. How far had the bus driven after four hours?
2. A bus starts driving at 15.00h, and stops only at 21.00h. It starts by driving 80 km/h for an hour, then 60 km/h for an hour, and so on. How far did it get?
3. We made a graph of the speed of a train and ask what the average speed of the train has been.

The teacher finished the lesson by asking students for a summary on the main points of the lesson. Her first question was: ‘What do you need to pay attention to when working with graphs?’ A student answered that one needed to pay attention to what was being asked. The teacher then asked where the students could find this information (answer: in the text). Another student added to this that you also needed to know where time was displayed, and where distance was displayed.

The teacher then pointed out a method for the students to use, written out on a poster on the classroom wall (see Figure 2): GOUD, consisting of looking at data (G), finding a solution method (O), do the calculations (U) and seeing whether your conclusions match the question (D). She pointed out that this last point was particularly important, because many students did not match their answers to the questions.



Figure 2: GOUD method as displayed

The teacher ended the lesson by telling the students that they would continue their work on graphs during next week's lesson, and by stating that she was curious to see whether they thought the problems had become any easier.

4.3 Observation of lesson 2

Date : 8 December 2015
Grade : 6 (11-12 years old)

Before the start of Lesson 2, the teacher made a lesson plan that can be found in Appendix D. She also collected some materials that she would need for the lesson: a few measurement tapes bought at the local hardware shop, a phone and two stopwatches taken from her own collection or borrowed from colleagues, and a set of toy cars that she asked one of her students to bring from home.

Just prior to the lesson, the teacher tried to load some information onto her screen on the smartboard, but the images failed to load due to a poor internet connection. The teacher then started the lesson by drawing the attention of the children back to the lesson of the previous week and told her students that they would again be working with distance-time graphs. She acknowledged that a number of students had found the topic very difficult and explained that they would be working in groups again. A group of children would be working on the classroom floor with toy cars to see how these graphs worked, and the students with very good understanding would be working on a sheet of problems about this topic.

To introduce this, the teacher asked the students to draw a system of coordinates on their mini whiteboards. She explained the term using a graph in the DAE displayed on the smartboard, and the students followed her instructions. She then noted that it was important to know what each axis displayed, so she asked the students to label their axes. After half a minute, the students held the mini whiteboards under their noses for the teacher to check. There were differences between teachers. The teacher showed that the DAE example had the time on the horizontal axis and the distance on the vertical axis. Then, to check understanding, the teacher asked the students to look at the example on the blackboard and told them to write

down how many kilometres the train had driven at 14.30h, and next after how many minutes the train had driven 110 kilometres. The students wrote both answers on their whiteboards, and the teacher checked answers on each questions, after which she was satisfied that most children had understood the basics of distance-time graphs. She complimented the students on their knowledge.

Next, the teacher assigned the students to draw in five minutes a long road with a car at the end, with elements by which one could see where the car had been able to drive fast and where the car had been forced to drive more slowly. She asked for examples of when a car would have to slow down, and the students called out various answers: bends in the road, traffic lights, crossings, zebra crossings etc. She then announced that she would draw an ice lolly stick, and that the student would have to repeat the assignment. One student repeated the assignment correctly.

The teacher then noted that she forgot to go over the objective of the lesson. She read it off the blackboard: ‘I can (with measurement tapes) make a distance-time graph, and tell how to see whether the speed is constant or variable’. She then asked the student whether they knew what constant meant, which one student was able to explain. The teacher then explained what the term variable meant, and that the drawing of the children would show how the speed of a car could become variable instead of constant.

Next, the teacher handed out sheets of paper for the students to draw on. The students who did not receive drawing paper would get a booklet of problems to complete in three small groups. There were two types of assignments in the booklet: two paper-and-pencil problems and a set of problems on the computer. The three groups would have to use the available computer one by one. They got a measurement tape, a few cars and a stopwatch or phone to bring. The teacher selected the group that would use the computer first. The worksheets for them to work on can be found in Appendix E, and the computer assignment can be viewed at <http://www.fi.uu.nl/toepassingen/03310/treinmachinist1/inleiding.html>. It should be noted that the problems the teacher selected were designed by the Freudenthal Institute, but that she picked these problems herself. This was not based on a suggestion by the researchers.

After helping the groups of students get started, the teacher returned to the classroom and told the students to finish their drawings quickly. She then asked the students what they thought what the most interesting things were that they thought of that could slow down a car. Students came up with a zebra crossing, a traffic jam, traffic lights, speed limits, bridges that were about to collapse, a tree on the road, a plane crash, a rocket engine behind the car (at which the teacher noted that it would probably speed up), and a detour. The teacher told the students that they would use these ideas later for an experiment. The class would make a road on the classroom floor.

To start the experiment, the teacher first asked the students to move furniture to the side of the classroom so that there would be enough room for them to work in. The students were then told to take place on the floor, and one of them stretched a measurement tape across the width of the classroom and into the kitchen attached to the classroom. The teacher explained that the measurement tape would represent the road, and that the class would create a distance-time graph with the tape. One child would drive the car, one child would manage the time, and a number of children would mark the tape to remember where the car was after each interval of five seconds.

The class then explored the working of the beep counter – an app on the smartboard that beeped every second, and gave a lower tone each fifth second. The teacher first asked the students to listen, and then asked them to explain how it worked. One student gave a correct explanation. The teacher told the students that the car would start driving when the beep counter started, and that with every fifth second, a child close to the current position of the car would make a mark.

The first few rounds of driving were testing rounds. The children with a marker pretended to make marks on the measurement tape, with the top on the markers. It took a few turns to make sure the start of the beep counter was synchronised with the car starting to drive, and to determine how far the children with the markers would have to be apart. Some roles were switched in the process. After some rounds of testing, the students worked together well. The children then counted down to start the real experiment, all paying attention to make sure each mark ended up in the right place.

The students were then asked to recount their ideas of what would slow a car down. A looping was too difficult to create for the teacher, just as sharp bends, but a zebra crossing was acceptable. The teacher wrote cards to mark the zebra crossing, a traffic light, the start and end of a traffic jam, and an open bridge. These cards were laid out with a second measurement tape, so that all the students could see what was going to happen. Roles were switched between students so that other students would hold the markers, and the students did one round to test the car's journey.

The teacher explained to the students that the obstacles would make sure that the car would have a variable speed. Then, the students started the car ride and made marks on the measurement tape to record the car's progress. After the experiment had been completed, the teacher asked the students to stick the cards to the measurement tape with Sellotape so that the obstacles would not move across the road when children walked past them.

The teacher then divided the students into two groups, each of which would work with one of the marked measurement tapes. She told the students to number each section between two marks, and then cut the measurement tapes in sections and stick the sections on a piece of wallpaper taken from a roll in the back of the classroom. She made clear that both groups would have to be finished by the time she returned from checking on the small groups of students working outside the classroom. Because the students had not managed to complete the chart made from the sections of measurement tape, the teacher gave some directed instructions to finish the assignment quickly as soon as she returned. This still took longer than expected, but was eventually finished. The teacher remarked that the sections were longer than she had expected beforehand. A photograph of the resulting bar charts can be found in Figure 3.

The teacher then asked the students what they noticed about the charts. One student remarked that there were no obstacles at all for the ride charted on one of the papers, but that there were still some variations. These were smaller than the large variations in the other chart. The teacher asked what this meant to which the student responded that a traffic jam caused the car to slow down. The teacher gave some further prompting, and the student explained that with the other chart there were no obstacles and that the car did not have to wait long. Other students then filled in that the chart with the obstacles was more variable. Another student noted that the timing of the marks had been a bit off, causing a little

variation. Moreover, a student pointed out that his group had made the chart upside-down. The teacher remarked, however, that the variations in speed were still clearly visible, although you had to read from right to left. The students recalled how they had only realised the intention after they had already glued the first sections to the paper. One student then noted that the relation between time and distance was different in the variable chart because the car had to stop, making the average speed on some sections very low, even though it sped up after moving past the obstacle.

The teacher then asked the students what the difference was between the train graph and the chart. A student pointed out the difference between the line and the bars. The teacher then asked whether you could make a distance-time graph into a bar chart, to which the students responded affirmatively. The teacher asked for another difference. The students came up with the difference between centimetres and kilometres, and a student did not think the train had stopped. The teacher then discussed this statement with the students, and they came to the conclusion that the train had indeed stopped at a station.

Not getting to the answer she was looking for, the teacher pointed out that the distance-time graph was about the total distance driven, and the bar chart about distances between two sections, which is more closely related to the speed of the train. A higher bar indicated higher average speed. She then asked how the bar chart could be made into the time-distance graph, which was met with silence. A student opted to calculate the metres. The teacher then concluded that the question was too difficult to answer just like that, and that they would come back to that in a next lesson. To end the lesson, she again pointed out the difference between the constant and the variable speed, and then dismissed the class.

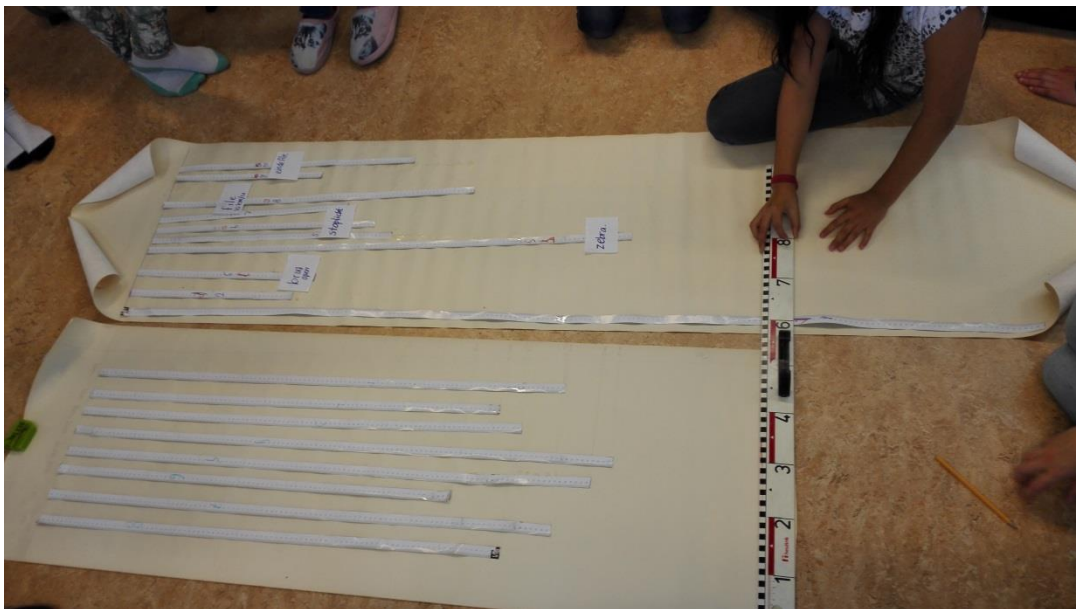


Figure 3. Resulting bar charts sections.

4.4 Reflections by teacher

The teacher reflected on her lessons on two occasions: before the first observation lesson, and after the second observation lesson.

Before the first observation lesson, the teacher looked at the output of the students on the Graphs A Test. This concerned the class overview found in Figure 1, but also the output from individual students. Examples of this output can be found in Figure 3. These examples show how three individual students solved the presented problem. The teacher noted that some of the students had already mastered the topic of graphs at an adequate level. These were the students who were typically high-performing in mathematics, although she noted that the entire class was high-performing in comparison to last year's cohort. However, she felt that other students were not paying attention to the correct pieces of information needed to solve the problem. With this in mind, she decided to design a lesson in which the students learned to pay attention to the information necessary to solve a problem. She would do this in several steps, so that she could differentiate between students who were generally doing well and students who were struggling. Prior to the lesson, she expressed doubts about whether this was what was expected of the lesson for the FaSMEd study, but she was quickly reassured when told that the observation was aimed at her teaching practices, and not a pre-defined model of teaching.

After Lesson 2, the teacher confessed that she had no idea whether her activities with measurement tape and toy cars would work before she started the lesson, but that she was satisfied with how it turned out. She did note, however, that she had intended to make the bar chart into a distance-time graph, but that she had to conclude near the end of the lesson that the step towards a distance-time graph was still too big at this point. She considered inserting another lesson before proceeding with the Graphs B Test in which she would challenge her high-performing students to make the bar chart into a distance-time graph. She would however, need to find some time to do this in the few lessons she had before the Christmas break and was unsure whether she would be able to pull this off.

Problem 6

Draw the graph of the following train ride:

The train leaves at 10:00

Then the train drives for half an hour at 160 km per hour

Then the train drives for half an hour at 80 km per hour

Then the train stands still for half an hour

Then the train drives for half an hour at 160 km per hour

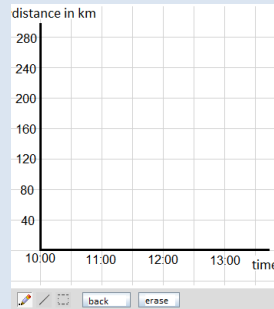
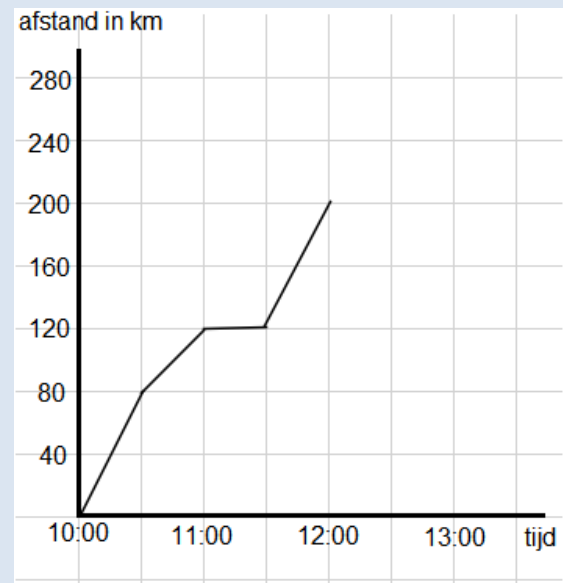
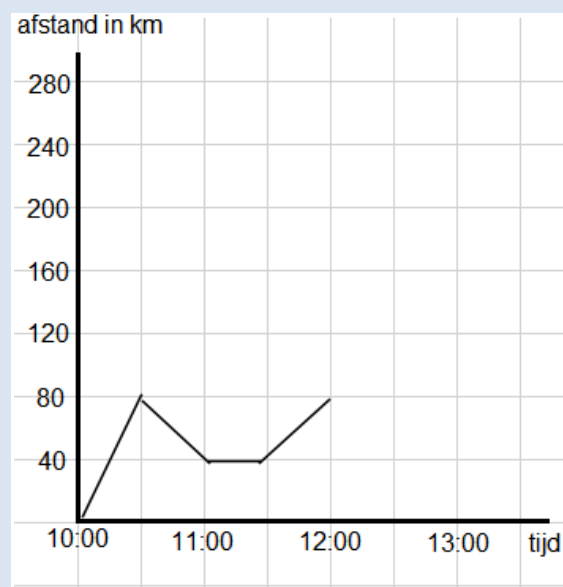
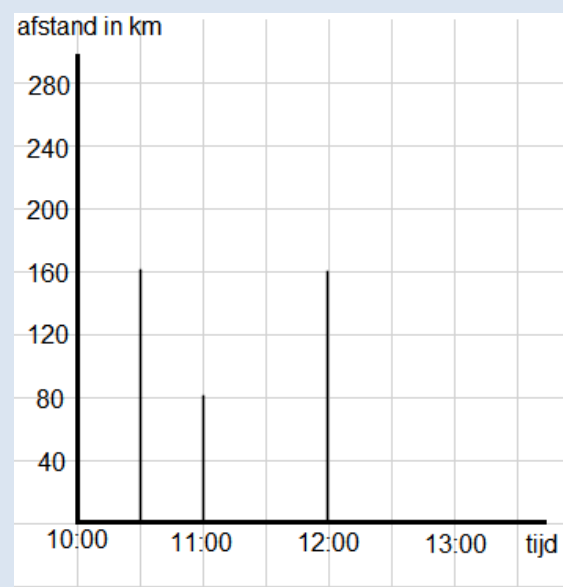
**Example Student 1****Example Student 2****Example Student 3**

Figure 3. Examples of output from individual students on the DAE Graphs A Test.

5. Pupil perceptions

5.1 Student background

Six students were selected for a group-discussion to map student perceptions by the teacher. The teacher selected students at random. All students were from the same 6th grade class. An overview of these students can be found in Table 2. The q-sorting session was audio-recorded.

Table 2

Overview of Students Participating in Q-Sorting Activity

Student	Performance level	Gender	Learning difficulties
Student 1	Low grades	Female	No
Student 2	Average grades	Female	No
Student 3	No data	Female	No
Student 4	High grades	Male	No
Student 5	High grades	Male	No
Student 6	No data	Male	No

During the q-sorting session, the students were taken to a room designated for after-school care. The room contained two large tables with benches, several play corners, and a corner with two couches and several soft pillows. The students opted to take place on the couches. The first noticeable thing about their seat selection was that they separated into two distinct groups: the three girls sat together on one couch, and the three boys sat together on the other couch. The experimenter took a seat on the carpet. Early on during the sorting session, *Student 5* was moved to the carpet as well to prevent him from getting distracted from the session by playing with *Student 4*. The student agreed that this was for the best.

The printed q-sorting statements were spread face-down on the carpet and in front of both couches, which were placed at a 90° angle. The students were instructed to take the cards, read them, sort them, and talk about their thoughts on the statements written on the cards. Because the students had a tendency to become rowdy, turns were regulated strictly by the experimenter. They took cards one by one, and the student reading the card always took the first turn to reflect on a statement. All students got a turn to reflect on each statement, but they were not required to do so. The students then discussed the categorisation of the card. Because the time designated for the session was about to end before all the cards were sorted, the students divided up in pairs ten minutes before the end of the session and divided the remaining cards over the categories they had made. They then took a little time to decide whether there was anything about the categorisation they would like to change.

For the purpose of this case study, the q-sorting cards were translated to Dutch. The students only got access to the Dutch translation, not to the original English expressions. The translations of the q-sorting expressions can be found in Appendix F. The cards presented to the students only contained the translation, and no numbering.

5.2 Within-case analysis

The students were given the instruction to sort the cards according to what they felt belonged together. They were free to make as many categories as they wished, and freely made another category when they did not feel that the card they were holding belonged to an already

existing category. This resulted in the large number of 11 categories. A picture of their sorting can be found in Figure 4. To make clear which categories they made, the expressions sorted within each category can be found in Table 3, along with the numbers assigned to each expression (Appendix F). The category names were given post-hoc by the experimenter, and were not defined by the students.

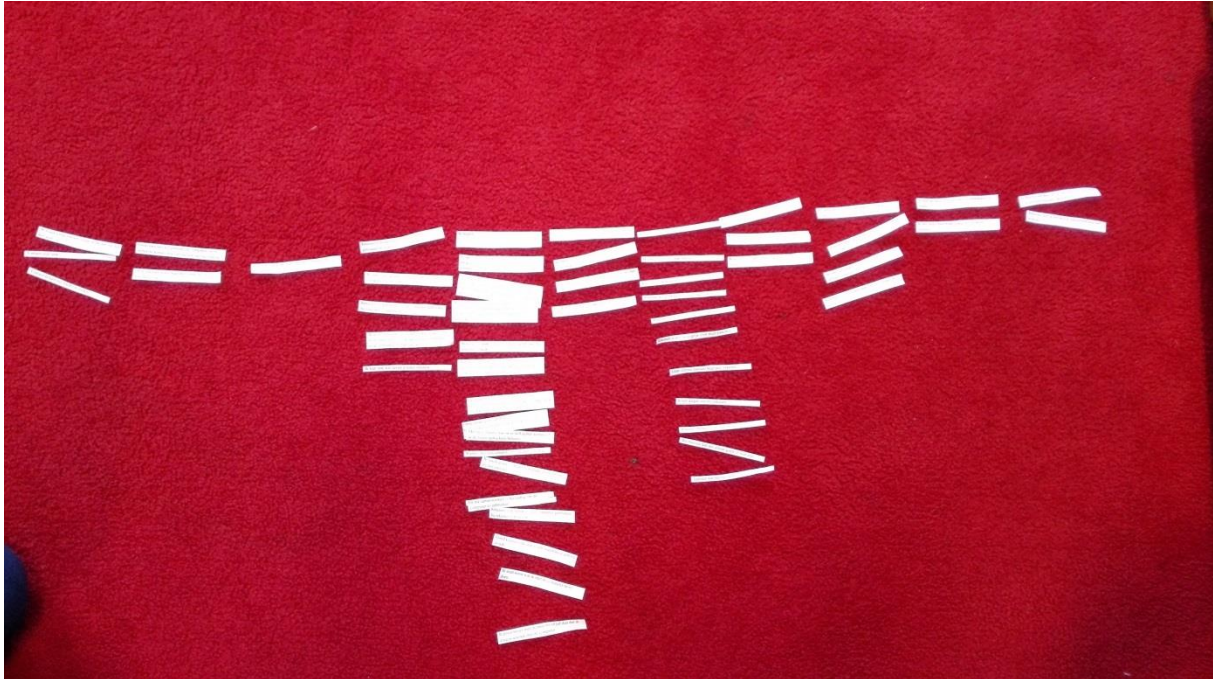


Figure 4. *Sorted q-sorting expressions on the carpet of the after-school care facility.*

5.2.1 Group process

The group of students was quickly distracted. They separated themselves into boys and girls, and found it difficult to focus on the group activity instead of starting smaller-scale discussions in their own smaller groups. The boys, in the beginning of the session seated on one couch, challenged one another physically (with the most interactions between *Student 4* and *Student 5*). The group of girls preferred to discuss things with one another quietly, bypassing the input from the group of boys.

Once the entire group became more focused and had understood that they were required to work as one team, *Student 4* became the most vocal one. He often took the initiative to elaborate on statements and backed up his ideas with experiences and related facts. He was often supported in this by *Student 5*, who also took a lot of initiative to voice his thoughts. *Student 1* was often the first to take initiative among the girls. *Student 2* and *Student 3* quickly followed up on her response on many occasions. *Student 6* was very quiet in comparison to the other students. He had to be encouraged to voice his thoughts and spoke quietly when he did so.

Near the end of the session the students were instructed to divide up in pairs to sort the remaining cards. Although they had listened to one another's thoughts increasingly well throughout the session, making pairs proved to be a challenge, because the boys and girls were reluctant to mix. They only made pairs after some encouragement, but then worked together. After the pairs had been constructed, each pair sorted a small stack of cards into the categories. *Student 4* and *Student 5* were working together well, discussing each card briefly

and explaining their decisions. Once, they asked for the attention of the entire group to discuss the categorisation of a card. *Student 1* and *Student 2* finished quickly and with a limited number of discussion points. *Student 3* left most of the sorting to *Student 4* at first, but helped him after a little verbal encouragement.

After all the cards had been sorted, the students were given the chance to change the sorting of cards if they felt it was needed. The students briefly studied their output, but then decided not to change anything.

5.2.2 Sorting output and reflections

Notable about the sorting output is that the students clearly recognised the role of technology in the expressions provided to them. Although they did not sort every card with a reference to technology into the technology category, they all sorted the technology cards with certainty. This became the largest category, with 16 cards. Moreover, the students found it difficult to reflect on the role of technology in the classroom. *Student 1* thought this had to do with the fact that they were so used to technology such as a smartboard that they could not compare their situation to a situation in which the same technology was absent. Their experience with computer-based individual mathematics problems was a lot more limited than the use of technology during group-based lessons due to the limited number of computers. However, they did like to use technology. *Student 5* explained that he associated technology with gaming, and that technology could be used to make school more fun. He did not, however, think that the use of technology alone could make scholastic tasks more fun, but more needed to be changed about the tasks to increase enjoyment. All students except *Student 1* agreed with this. Although students found it difficult to see the added role of technology, *Student 4* mentioned that he understood the objectives of assignments better with the use of a smartboard because he could read it clearly.

Another large category in the students' sorting output can be described as general views on mathematics learning and instruction. This category contains expressions about the role of mathematics in daily life and what it takes to learn mathematics. Of the three categories described by the research team (mathematics perceptions, learning perceptions, and the role of technology) this category covers the first two. Reflections by the children showed that they acknowledged the importance of mathematics for daily life. *Student 4* first noted that counting would not be possible without mathematics. *Student 1* added that 'you can no longer say one two three', and *Student 2* was concerned that she would not know how many letters there were in the alphabet. Then, *Student 4* deepened his thinking by saying that without mathematics, he did not think computers would exist, and that life would be very different without the presence of computers. *Student 5* added that phones and phone-numbers could no longer be used without mathematics, backing up the statements made by *Student 4*. In the end, the students together agreed that mathematics along with reading was the most important thing in the world, because it was involved in making everything they owned and used.

The students started a small discussion about whether mathematics could make them nervous. Although most students said that they did not become nervous during mathematics activities, *Student 2* reported that the lessons sometimes made her nervous because she was afraid to give the wrong answer to the teacher's question; her primary fear was that other students would make fun of her. *Student 4* and *Student 5* also mentioned that they might

become nervous if the school computers were too slow. It should be noted though that their facial expressions and gestures spoke more of frustration than of nervousness. *Student 4* used the terms stress and irritated. They also noted that they liked mathematics, unless they had to use the slow school computers.

All other categories are smaller categories and specifically targeted at key words and ideas, such as testing (in the original English expressions: exams) and cooperation. Two statements received a category of their own, making it impossible to classify and name based on common characteristics. In their reflections, students showed that they were capable of separating their thoughts based on context. Specifically, they noted that there was a lot more time to think about mathematics problems during plus-activities (activities designed for high performers) than during regular lessons. *Student 3* also noted that she understood her mathematics lesson better when the observed teacher was teaching than when her colleague took over.

The opportunity for students to resort the cards after they had sorted all the expressions once was intended to trigger deeper thought about the categories. This did not work out as intended. Possibly, the students were already tired after sorting so many cards, but it may be that they lacked the ability to reflect about these categories on a deeper level than by comparing two statements at a time because of their age.

Table 3: Q-sorting expressions sorted within each category

Testing	Teacher	Undef. Cat. 1	Views on experience	Technology	Maths lesson	General views	What is maths?	Maths and life	Undef. Cat. 2	Cooperati on
<p>37 Ik maak graag toetsen omdat ik dan kan zien hoe het gaat.</p> <p>36 Toetsen zijn saai.</p> <p>38 Toetsen helpen mij harder te werken.</p>	<p>51 Onze meester/juf gebruikt de computer om te weten te komen hoe ver we zijn met het rekenen.</p> <p>32 Of je rekenen kunt begrijpen hangt af van de meester of juf.</p>	<p>48 Voor mij helpt het niet om een computer te gebruiken.</p>	<p>10 Rekenen is frustrerend. + Een computer gebruiken bij rekenen is frustrerend.</p> <p>12 Ik reken niet graag. + Ik gebruik niet graag een computer bij het rekenen.</p> <p>4 Rekenen is spannend. + Een computer gebruiken bij rekenen is spannend.</p> <p>30 Ik word zenuwachtig tijdens rekenlessen. + Ik word zenuwachtig wanneer ik een computer moet gebruiken in rekenlessen.</p> <p>20 Ik kan ook wel leven zonder rekenen..</p>	<p>42 Ik begrijp het beter wanneer ik technologie (computer, digibord, enzovoort) gebruik in de rekenles.</p> <p>49 Volgens mij weet de meester of juf veel beter of we goed leren als hij/zij werkt met een computer.</p> <p>46 Als ik met technologie (computer, digibord, enzovoort) moet werken en het niet aan de meester of juf kan vragen, doe ik er twee keer zo lang over.</p> <p>44 Wanneer we technologie (computer, digibord, enzovoort) gebruiken in de rekenles snap ik eerder wat ik moet doen om het beter te begrijpen.</p> <p>2 Rekenen is leuk. + Een computer gebruiken bij rekenen is leuk.</p> <p>43 Wanneer we technologie (computer, digibord, enzovoort) gebruiken in de rekenles zie ik snel of ik foutjes maak en waarom.</p> <p>45 Door technologie (computer, digibord, enzovoort) te gebruiken in de rekenles begrijp ik het doel van de oefeningen beter.</p> <p>41 Onze leraar gebruikt altijd wel een vorm van technologie (computer, digibord, enzovoort) in de rekenles.</p>	<p>21 Ik leer het best rekenen als ik in mijn eentje mag werken.</p> <p>27 In rekenlessen is geen tijd om door te denken over dingen.</p> <p>33 In rekenlessen is het niet goed mogelijk om met eigen ideeën aan te komen.</p> <p>29 Als ik iets niet begrijp, dan werk ik net zo lang tot het lukt.</p> <p>22 Ik heb mijn rekenboek nodig om te leren rekenen.</p>	<p>18 Rekenen betekent zien dat iets bij elkaar hoort.</p> <p>31 Ik vind dat ik goed kan rekenen.</p> <p>3 Rekenen is belangrijk.</p> <p>25 Rekenen krijgt betekenis in het dagelijks leven.</p> <p>17 Rekenen helpt ons om logisch te denken.</p> <p>13 Rekenen is niet belangrijk voor mijn toekomst.</p> <p>28 Alleen slimme mensen begrijpen rekenen.</p> <p>16 Ik leer dingen snel bij rekenen.</p> <p>24 Rekenen betekent veel herhaling.</p> <p>11 Bij rekenen kan iets alleen goed of fout zijn.</p>	<p>15 Rekenen betekent dat je veel van dezelfde oefeningen moet doen.</p> <p>14 Rekenen betekent dat je iets moet uitzoeken en uitproberen.</p> <p>26 Rekenen is alleen voor in de klas, niet voor buiten school.</p>	<p>40 We gebruiken veel hulpmiddelen (blokjes, linialen, enzovoort) tijdens de rekenles.</p> <p>19 Rekenen helpt ons om de wereld om ons heen te begrijpen.</p> <p>6 Bij heel veel dingen in het dagelijks leven gebruik je rekenen.</p> <p>8 Rekenen is een hulpmiddel om iets anders te kunnen doen.</p>	<p>23 Je leert het beste rekenen door werkstukken te maken.</p>	<p>35 Ik begrijp het beter als ik met rekenen met mijn vriendinnen/vrienden samenwerk.</p> <p>34 Rekenen leer je het best in samenwerking met anderen.</p>

				<p>52 Met de computer kan ik er zelf achter komen of ik de rekenopdrachten beheers.</p> <p>39 Werken met een computer in rekenen is nuttig.</p> <p>9 Ik reken graag. + Ik gebruik graag een computer bij het rekenen.</p> <p>50 Als we samenwerken is het nuttig om de computer te gebruiken.</p> <p>1 Rekenen is moeilijk. + Een computer gebruiken bij rekenen is moeilijk.</p> <p>7 Goed kunnen rekenen is iets waarmee je geboren wordt.</p> <p>53 Ik weet nooit wat ik met de computer moet doen.</p> <p>47 Ik praat liever met de meester of juf dan dat ik dingen uitzoek met de computer.</p>		<p>5 Iedereen kan rekenen leren.</p>				
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5.3 Cross-case analysis

In comparison to the students from Utrecht University in Case Study 1, the students from Case Study 2 were more impulsive and playful, even though they were older than the other group. This resulted in a number of off-task activities and difficulties working together with the entire group to sort the cards. This observation was confirmed by the teacher, who noted that the students in this class were often uninhibited and eager to add their own thoughts to a class discussion rather than listening to other people's thoughts. The teacher attributed this observation to the fact that there were many high-performing students in the class who were all eager to prove that they had something to contribute.

Once the students were on-task, a number of them showed that they were capable of voicing, for their age group, deep reflections on the topic of study. Students 4 and 5 were most active in this. *Student 4* preferred to lean back on the couch and stare at the ceiling while reflecting on the statements, while *Student 5* looked at other students for confirmation. Still, the group only worked well together when guided by the researcher.

Although the students had more confidence that they could sort the cards well than the students in Case Study 1, the resulting categories were for a large part narrow. Sorting was primarily done by comparing the card to be sorted to the last card in a certain category and judging whether they fit well together. This may result from constraints in information processing capacities that are common in this age group. The opportunity to adjust the sorting after it had been completed did not resolve this issue. This may also be due to information processing capacities, but might also have to do with fatigue, because the sorting had taken over 30 minutes already,

6. Context

6.1 Contextual information of school

Table 3

Information About the School Context

School Context

School Roll (number of pupils)	234
Staff Roll (number of teaching staff)	14
Geographical location (urban/rural, etc.)	Urban/rural (town in a rural province with 13,000 inhabitants)
Relationship to other schools (e.g. cluster/Feeder/Part of a group of schools)	Part of a school foundation spanning the province containing 32 schools.
Age range	4-12
Single or mixed gender	Mixed gender
Ethnicity	n/a
Mixed ability or selected (could include Special Educational Needs)	Mixed ability
Socio-economic intake (with local contextual indicators, e.g. UK Free School Meals)	n/a
How the school is judged to be performing in local context	Inspection reports classify schools as satisfactory, poor, or very poor. This school classifies as satisfactory. Average Cito Mathematics (Final Test) score of the school was below the national average in the previous academic year, but above in all preceding years.
Past experience of using formative assessment	Internal counsellor (teacher of observed class) has written a paper on FA for her counsellors' course.
Past experience of using technologies/tools	Software that comes with textbooks Digital blackboards Student and staff computers available
Previous experience of working within other research projects	Yes – COOL study (Cohort Onderzoek OnderwijsLoopbanen; Cohort Study Educational Careers) and PRIMA study (Cohort onderzoek Primair Onderwijs; Cohort study Primary Education)

6.2 Teacher demographic information

Table 4

Information About the Demographic Background of the Teacher

Teacher demographic

Subject area (science or mathematics)	All (primary) – current study is about mathematics
Role (e.g. Head of Department/Teacher, etc.)	Teacher; internal counsellor
Gender	F
Age range (under 20; 21-30; 31-40; 41-50; 51-60; over 60)	Over 60
How long has he/she been teaching	30 years
How long has/she been working at this school	30 years
Past experience of using formative assessment within lessons	Theoretical knowledge learned during internal counselling course (paper)
Past experience of using technologies/tools within lessons	Software that comes with textbook Digital blackboard with Internet resources
Past experience of working in a research project	Yes – COOL study (Cohort Onderzoek OnderwijsLoopbanen; Cohort Study Educational Carreers) and PRIMA study (Cohort onderzoek Primair Onderwijs; Cohort study Primary Education)

6.3 Student demographic information

Table 5

Information About the Demographic Information of the Students

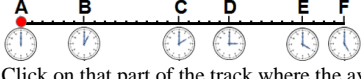
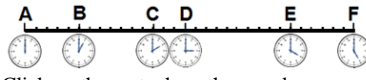
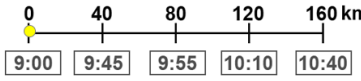
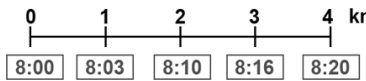
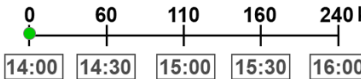

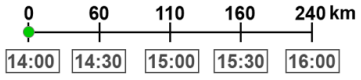
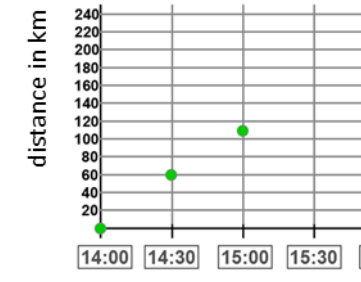
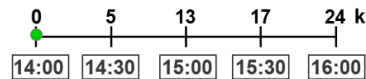
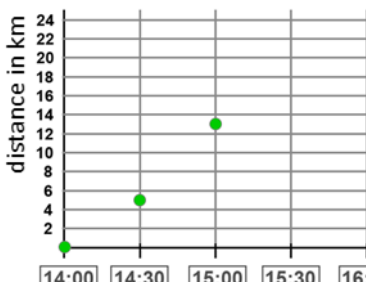
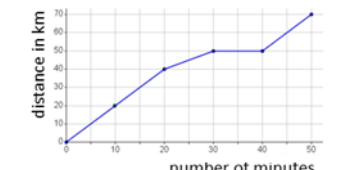
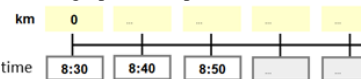
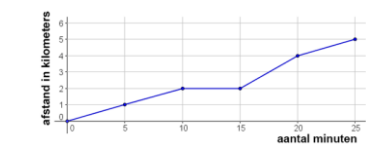

Class demographic

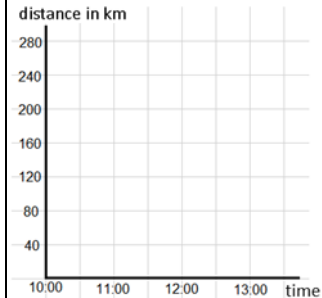
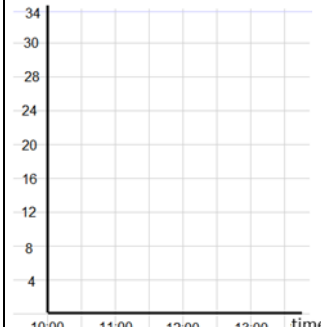
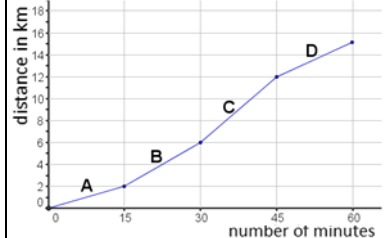
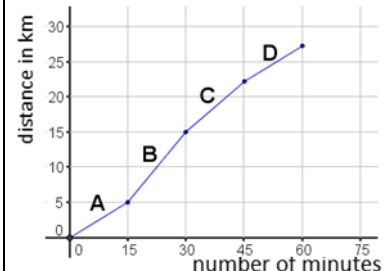
Age range	11-12 years (6th grade)
Number of students in the class	17 in study; 9 not in study (but present during teacher observation)
Gender split within class (male/female)	9 boys; 8 girls
Ethnicity	Various
Mixed ability or ability set	Mixed ability
Any relevant contextual information (do the class work well together or are there any particular difficulties/are they taught in this class for other subjects or only for this subject/do students have any additional needs (special educational need or are they being taught in an additional language/is there high mobility of students etc)	<p>The students are taught by the same teacher for all subjects. Two students have special educational needs (intellectual disability; ADHD), but they take part in the regular class curriculum. The language of instruction is Dutch, but many students speak a dialect of a local language in the home environment. The teacher characterises this dialect as a thin language with relatively few opportunities for cognitive engagement, which needs to be compensated for at school.</p> <p>The class contains a high number of high-performing students, and the teacher notes that the students are more rowdy than those in other classes. She ascribes this to the students' eagerness to answer questions and present their ideas.</p> <p>It should be noted that the class is shared between two teachers: the observed teachers on Mondays through Wednesdays, and a male colleague on Thursdays and Fridays.</p>

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Appendix A: Problems Presented to the Students in the Graphs A and Graphs B Tests

Graphs		
Core competency	Test A	Test B
Pictorially represented data: Drawing conclusions about speed for various distances that have been covered in the same amount of time	Problem 1 At twelve o'clock, the red train departs from A. One hour later it passes B. Here you see where the train is every hour.  Click on that part of the track where the average speed was the highest.	Problem 1 Jasmine makes a long ride by bicycle with her father. They leave A at 12 o'clock. An hour later, they pass B. Here you see where they are, each time an hour later.  Click on the part where the speed was, on average, the highest.
Schematically presented time-distance schedule: Drawing conclusions about speed for fixed equal distances that have been covered in varying amounts of time	Problem 2 The yellow train leaves at 09:00. After each 40 kilometers, the driver looks at his watch what time it is.  Click on that part of the track where the average speed was the highest.	Problem 2 Julius goes by bike to school. After each kilometer his bike computer gives a signal. Then he checks what time it is.  Click on which part his speed was, on average, the highest.
Schematically presented time-distance schedule: Drawing conclusions about the speed for varying distances that have been covered in fixed time slots	Problem 3 The green train leaves at 14:00. After each 30 minutes, the driver looks at the total distance so far.  Click on that part of the track where the average speed was the highest.	Problem 3 Karim goes by bike to his grandfather. Each quarter of an hour, he checks his bike computer, to see how far she is from home.  Click on which part his speed was, on average, the highest.
Completing a time-distance graph based on a schematically presented time-distance schedule in which the covered distances and needed time intervals are given	Problem 4 This is the schedule of the green train.  Use the green dots to complete the graph of this schedule. 	Problem 4 This is the schedule of Sandra and her Mum's bike ride.  Use the green dots to complete the graph of this bike ride. 
Reading data from a time-distance graph and making the corresponding schematic time-distance schedule	Problem 5  Use the graph to complete the schedule. 	Problem 5  Use the graph to complete the schedule of this bike ride. 

<p>Using the verbal description of travel times and covered distances for making the corresponding time-distance graph</p>	<p>Problem 6 Draw the graph of the following train ride:</p> <p>The train leaves at 10:00 Then the train drives for half an hour at 160 km per hour Then the train drives for half an hour at 80 km per hour Then the train stands still for half an hour Then the train drives for half an hour at 160 km per hour</p>  <p>How many kilometers was the total train ride?</p>	<p>Problem 6 Draw the graph of the following bike ride: Hans leaves with his race bike at 10.00h Then he rides 16 km per hour for half an hour Then he rides 24 km per hour for half an hour Then he walks 4 km per hour for half an hour Then the bike needs a repair (half an hour) Then he rides 16 km per hour for half an hour and arrives home.</p>  <p>How many kilometers was the entire bike ride?</p>
<p>Drawing conclusions about speed based on a time-distance graph</p>	<p>Problem 7 Click on the part where the average speed was the highest.</p> 	<p>Problem 7 Click on which part of the ride the speed was, on average, the highest.</p> 

Appendix B: Lesson plan for Lesson 1. Translation in orange for reporting purpose only.

Leuke les Nice lesson

Lesvoorbereiding tekenen di. 1 december.

Activering van voorkennis:
Terugblik op vrijdag. Er waren machinisten van de NS.
Hoe hard kan een trein?
Rijdt de trein steeds zo hard?
De gemiddelde snelheid ligt lager.

• Bespreek met je schoudermaatje: Bedenk oorzaken waardoor de gemiddelde snelheid van een trein lager ligt dan de topsnelheid.

Inventariseren oorzaken met ijscostokjes.

Lesdoel: Lesson aim:
Wij gaan deze les leren hoe je de tijd, snelheid en afstand in een afstand/tijdgrafiek kunt aflezen of weergeven. *We will learn this lesson how to read or display time, speed, and distance in a distance-time graph*
Woordenschat: gemiddelde snelheid, afstand/tijdgrafiek, aflezen, weergeven.
Vocabulary: average speed, distance-time graph, read (off), display.

• Cvb-vragen: Wat gaan we vandaag leren?
Checking understanding questions: What are we going to learn today?
Concept: Concept:
Welke gegevens heb je nodig (tabel met afstand en met tijd)
• Cvb-vraag: Vertel aan je schoudermaatje wat je hier ziet. (opg. 1)?
Which data do you need (table with distance and time). Checking understanding question: Explain to your neighbour what you see here (problem 1).
Grafiek: x-as / y-as (opg. 2 combi van tabel en grafiek)
• Cvb-vragen: Waar staat de afstand? Waar staat de tijd?
Hoeveel km heeft de trein na 15 min. gereden? En na 30 minuten? (controle met wisbordjes).
vul de grafiek verder in. *Graph: x-axis/y-axis (problem 2 combi graph table).*
Checking understanding questions: where is the distance? Where is the time? How many km did the train drive after 15 min.? And after 30 min.? (Check with mini whiteboards). Complete the graph.

Vaardigheid:
Skill:
Aflezen tijd, snelheid en afstand in een afstand/tijdgrafiek.
Belangrijk is om goed te lezen wat de opdracht is. Er wordt steeds op een andere manier gevraagd.
Gebruik GOUD! *Reading off time, distance and speed in a distance-time graph. It is important to read the text carefully. The question is phrased differently. Use GOUD!*
Begeleid inoefenen met som 3
Ik doe één stap voor en laat de kinderen dit afmaken. Rondlopen om te controleren.
Supervision practice with problem 3. I demonstrate one step and let the children finish. Walk around to check.
Modellen som 4: stap voor stap de gegevens verwerken! (eerste 2 stippen)
Models problem 4: step by step process data! (first 2 dots)
De rest doen de kinderen zelf.
The children do the rest by themselves.

Zelfstandige verwerking:
Self-guided processing:
Maak in tweetallen som 5, 6 en 7.
Do problems 5, 6 and 7 in pairs.
Regels tijdens zelfstandig werken
Rules during self-guided processing
Werktijd 10 minuten → *Gynzy*
Stemvolume : fluisterstem
Je mag juf niet storen
Je werkt met je schoudermaatje.

Preparation maths lesson Tuesday 1 December
Activation pre-existing knowledge:
Looking back on Friday. There were train drivers from the NS. How fast can a train go? Does it go that fast all the time? The average speed is lower.
Discuss with neighbour: Think of causes for a train to drive more slowly on average than its maximum speed.
Bring up causes with ice lolly sticks

Werktijd 10 minuten → *Gynzy*

Stemvolume : fluisterstem

Je mag juf niet storen

Je werkt met je schoudermaatje.

Worktime 10 minutes → Gynzy

Voice volume: whispering voice

Do not disturb the teacher

You work with your neighbour

Belang van het kunnen aflezen afstand/tijdgrafieken of zelf kunnen weergeven:

Importance of being able to read off or display distance-time graph:

In een plaatje kun je informatie in één oogopslag laten zien. Het is universeel en veel korter en overzichtelijker dan in tekst.

In a picture you can show information at a glance. It is universal and much shorter and more accessible than in text.

Lesafsluiting:

Lesson ending:

De Plusgroep vertelt kort welke context zij hebben gebruikt voor hun opgaven.

We lossen één van de opgaven op met de wisbordjes. *The Plus group tells shortly which context they have used for their problems. We solve one of the problems with mini whiteboards. Shortly discuss problems of self-guided work.*

Kort nabespreken opgaven van zelfst. werken.

Waar liep je tegenaan? *Which problem was tough? What did you do then? Which things are important for the next time you work with distance-time graphs?*

Welke som was lastig? Wat hebben jullie toen gedaan? *Which problems did you face?*

Welke zaken zijn belangrijk voor de volgende keer als je weer met afstand-tijdgrafieken gaat werken?

- Waar staat de afstand? Waar staat de tijd? *Which problem was tough? What did you do then? Which things are important for the next time you work with distance-time graphs?*
- Lees de vraag goed.
- Stel de dus-vraag als je denkt dat je het antwoord hebt.

-Where is the distance? Where is the time?

- Read the problem carefully

- Ask the thus-question when you think you have the correct answer.

Groepen

100% goed.

Jisse
Ilse
Coen
* Timo

100% correct

86% goed

Talea
Vito
Victor

71% goed

Twan

57%

Sanne Esme

43%

Jenny
Amarino
Owyn
Sem

29%

Jordi
Jente

14%

Melanie

Mia eigen werk (Maatwerk).

Mia own work (custom fit)

Pluskdh (100% + 86% goed) zelf opg. maken.

Plus-children (100% or 86% correct) construct their own problems

Appendix C: Worksheets for Lesson 1 – Translation in orange for reporting purposes only

Oefeningen grafieken

Exercise graphs

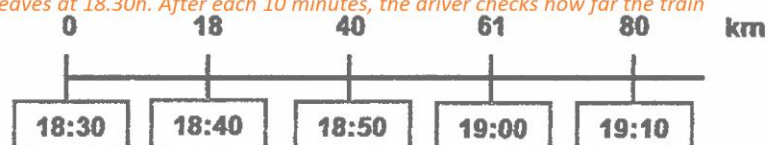
Opgave1

Problem 1

De trein vertrekt om 18:30 uur.

Steeds na 10 minuten kijkt de machinist hoeveel de trein totaal gereden heeft.

The train leaves at 18.30h. After each 10 minutes, the driver checks how far the train drove.

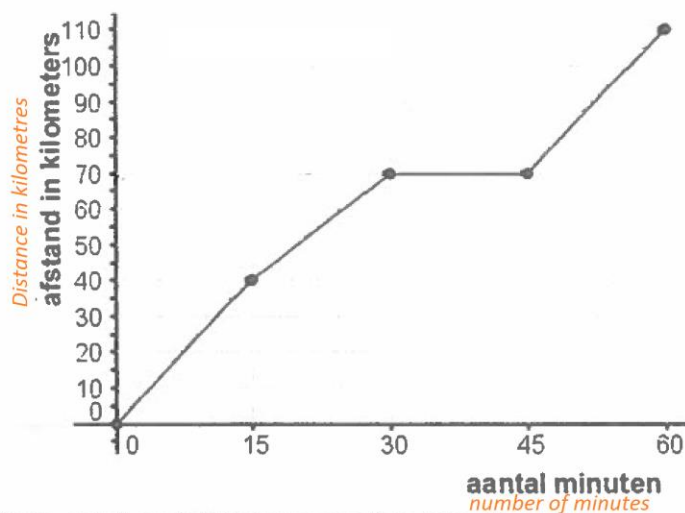


Kleur het stuk waar de gemiddelde snelheid het hoogst is geweest.

Colour the section where the average speed has been highest.

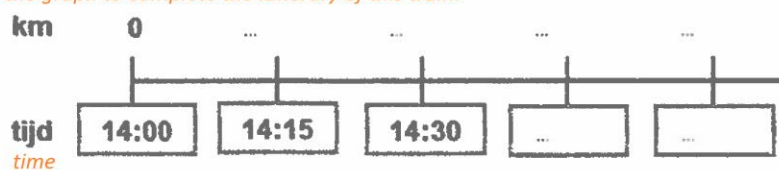
Opgave 2

Problem 2



Gebruik de grafiek om het rijschema van deze trein af te maken.

Use the graph to complete the itinerary of this train.



Opgave 3

Problem 3

F -

E -

D -

C -

B -

A -

Hier zie je waar de zwarte trein elk uur is (zwarte stippen).

De blauwe trein maakt dezelfde rit, maar vertrekt een uur later uit A.

Teken de blauwe stippen voor de blauwe trein voor elke plaats.

Here you see where the black train is each hour (black dots). The blue train makes the same journey, but leaves A an hour later.

Draw the blue dots for the blue train for each place.



Opgave 4

Problem 4

F -

E -

D -

C -

B -

A -

Een groene trein vertrekt om 1 uur uit C, passeert D om 2 uur, is in E om half 4, staat daar een half uur stil.

Daarna doet deze trein er 1 ½ uur over om in F te komen.

Teken de groene stippen voor deze trein op de juiste plaats.

A green train leaves C at 1 o'clock, passes D at 2 o'clock, is in E at half past 3, stands still there for half an hour.

Then, the train takes 1 ½ hours to get to F.

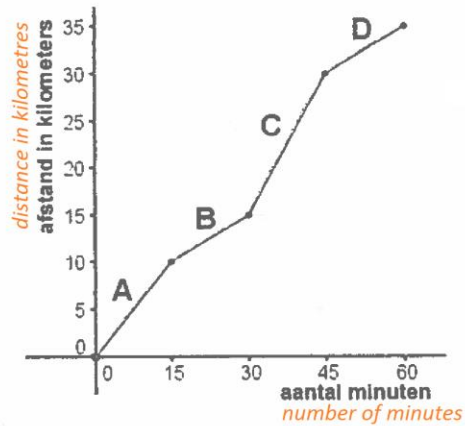
Draw the green dots for this train in the right places.



Opgave 5*Problem 5*

Kleur de letter bij het deel van de rit waar de gemiddelde snelheid het hoogst is geweest.

Colour the letter at the part of the journey where the average speed has been highest.

**Opgave 6**

De trein gaat rijden om 9.00 uur.

Dan rijdt de trein een half uur 120 km per uur.

Dan staat de trein een half uur stil.

Dan rijdt de trein een half uur 80 km per uur.

The train starts driving at 9.00h.

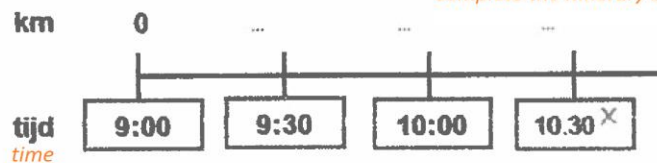
The the train drives 120 km per hour for half an hour.

Then the train stands still for half an hour.

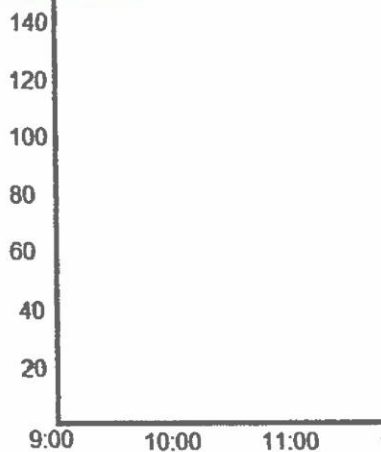
The the train drives 80 km per hour for half an hour.

6a Vul hieronder het reisschema in.

Complete the itinerary below.



afstand in km
distance in km



6b. Teken de grafiek van de treinrit.

Draw the graph of the train's journey.

6c. Hoeveel km was de hele treinrit. _____ km.

How many km was the train's entire journey

Opgave 7**Problem 7**

Teken de grafiek van de volgende treinrit:

Draw the graph of the following train journey:

De trein gaat rijden om 8:00

Dan rijdt de trein een half uur 160 km per uur

Dan rijdt de trein een half uur 80 km per uur

Dan staat de trein een half uur stil

Dan rijdt de trein een half uur 160 km per uur

Hoeveel kilometer was de hele treinrit?

... kilometer

The train starts driving at 8:00.

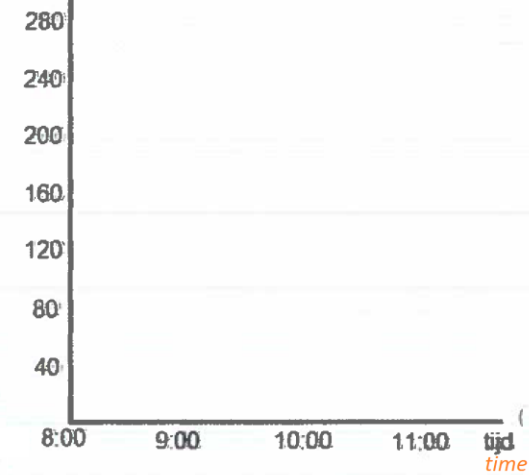
Then the train drives 160 km per hour for half an hour.

Then the train drives 80 km per hour for half an hour.

The train stands still for half an hour.

Then the train drives 160 km per hour for half an hour.

afstand in km
distance in km



How many kilometres was the train's entire journey?

... kilometres

Appendix D: Lesson plan for Lesson 2– Translation in orange for reporting purposes only

Les 2 afstand-tijdgrafieken

Lesson 2 distance-time graphs

Materialen: *Materials:*

Veel autootjes, meetstroken (Karwei), telefoon/stopwatch/horloges.

Graag computers die het doen. *Many little cars, measuring tape (Karwei), phone/stopwatch/watches. Computers that work.*

Activeren voorkennis *Activating pre-existing knowledge*

Keuze: oud leerdoel opfrissen *Choice: refresh old learning aim* *Look back on previous week. Made*

Terugblik naar vorige week. Opdrachten gemaakt over afstand-tijdgrafieken. *problems on distance-time graphs.*

Op digibord een lege x-as en y-as. *On digital blackboard an empty x-axis and y-axis.*

Cvb-vraag 1: Wat moet erbij staan als je een afstand-tijdgrafiek maakt? (Teken op het bordje).

Dit heet een assenstelsel. (Belangrijk voor de excellente groep) *Checking understanding question 1: what do you*
This is a system of coordinates (important to excellent group) need to include when making a distance-time

Cvb-vraag 2: Welke afstand heeft de trein afgelegd om 14.30 uur? *graph? (draw on mini-whiteboard)*

CU question 2: which distance did the train cover at 14.30h?

Cvb-vraag 3: Na hoeveel minuten heeft de trein 110 km gereden?

CU question 3: after how many minutes did the train drive 110 km?

Lesdoel: *Lesson aim:*

Ik kan met meetstroken een afstand-tijdgrafiek maken en vertellen waaraan je kunt zien of de
snelheid constant is of variabel. *I can make a time-distance graph with measurement tape and report how to tell*
whether the speed is constant or variable.

Laten herhalen. Ingaan op de begrippen 'constant' en 'variabel'.

Let repeat. Go into terms 'constant' and 'variable'.

Opdracht voor de kinderen die de toets of oefentoets meer dan 80% goed hebben gemaakt:

Assignment for children who got more than 80% correct on practice test:

Uitleg: over het opdrachtenblad. *Explanation: about worksheet.*

De groep in tweeën of drieën splitsen. (Eén groep in het bso-lokaal, één groep in het speellokaal, één

groep bij de computer: opdracht www.fi.uu.nl grafiekenmaker. Opdrachten met de treintjes.

Werkblad kopiëren! *Split group in two or three. (One group in out-of-school care facility, one group in play*
room, one group at the computer: problems www.fi.uu.nl graph maker. Problems with
trains. Copy worksheet.

Ondertussen opdracht voor de instructiegroep: *In the mean time for instruction group:*

Maak een 5-minutentekening: *Make a 5-minute drawing:*

Teken een lange weg met een autootje. Teken zo, dat je kunt zien waar de auto snel heeft kunnen

rijden en waar de auto langzamer moest. Bijvoorbeeld door een stoplicht, 30-km-weg, koeien op de

weg, enz. *Draw a long road with a car. Draw it so that you can see where the car had been able to drive fast,*
and where the car had to go slow. For example, because of traffic lights, a 30-km road, cows on the
road etc.

Instructie *Instruction*

Als de excellente groep aan het werk is: *When the excellent group is working:*

Cvb-vraag: Bespreken tekeningen (kort). Kernvraag: door welke omstandigheden heeft de auto niet

steeds een constante snelheid kunnen rijden? *CU question: Discuss drawings (shortly). Core question: why was*
the car not able to drive at a high speed all the time?

Meetstroken neerleggen in de klas. Piepteller uitleggen. Opdracht: *Lay out measurement tape in classroom. Explain*

1 leerling rijdt met het autootje heel langzaam langs de strook. Elke 5 seconden zet iemand een *beep counter.*

streep op de strook op de plaats waar het autootje dan is. (De 5 sec. zijn te horen op de piepteller).

Kk. Opdracht geven: Jij zet streepje bij 5 sec., jij bij 10 sec. enz.

Er zijn ook een aantal verslaggevers. Zij schrijven op wat er onderweg gebeurt.

Assignment: 1 student rides the toy car very slowly along the measurement tape. Every 5 seconds
someone draws a mark on the tape at the place the car is then. (The 5 seconds are audible on the beep
counter).

Kk. *Give assignment: You put a mark at five sec., you at 10 sec. etc.*

There are also a few reporters. They write down what happens along the way.

Tweede keer: opdracht hierboven nogmaals herhalen. We plaatsen stoplichten, snelheidsborden, zebrapad, enz. Auto mag sneller rijden, maar komt obstakels/beperkingen tegen. Weer streepjes zetten. *Second time: repeat assignment above. We place traffic lights, speed signs, zebras etc. Car may drive faster, but runs into obstacles/limitations. Again make marks.*

Gesprek over de beide opdrachten. Staan de streepjes op dezelfde plaats? Nee, hoe komt dat? *Discuss both assignments. Are the marks at the same place? No? Why not?*

Uitknippen stroken en opplakken op grafiek (A1). Alle kinderen plakken hun eigen strook op.

Groepjes maken hun grafiek compleet. *Cut out bars and glue on graph (A1). All children glue their own bar.*

De grafieken worden opgehangen. *Groups complete graph.*

The graphs are hung upon the wall.

Opdracht in tweetallen: bedenk bij elke grafiek een aantal vragen voor de groep.

Assignment in pairs: Think of a number of questions for the group with each graph.

Afsluiting: *Closing:*

De excellente leerlingen vertellen kort over wat zij hebben gedaan.

De instructiegroep stelt een vraag bij de grafieken en de groep schrijft het antwoord op het wisbordje.

terugblik doel - constant variabel } hoe zie je dat?

The excellent students report on what they did.

The instruction group asks a question with the graphs and the group writes down the answer on a mini-whiteboard.

Look back aim: -constant

-variable

how do you see that?

Appendix E: Worksheets for high-performing students for lesson 2– Translation in orange for reporting purposes only

Werkblad afstand-tijdgrafieken (Plus)

Worksheet distance-time graphs (Plus)

In an ice-skating contest, 3 skaters compete for the best time. The time of each round is displayed in the table.

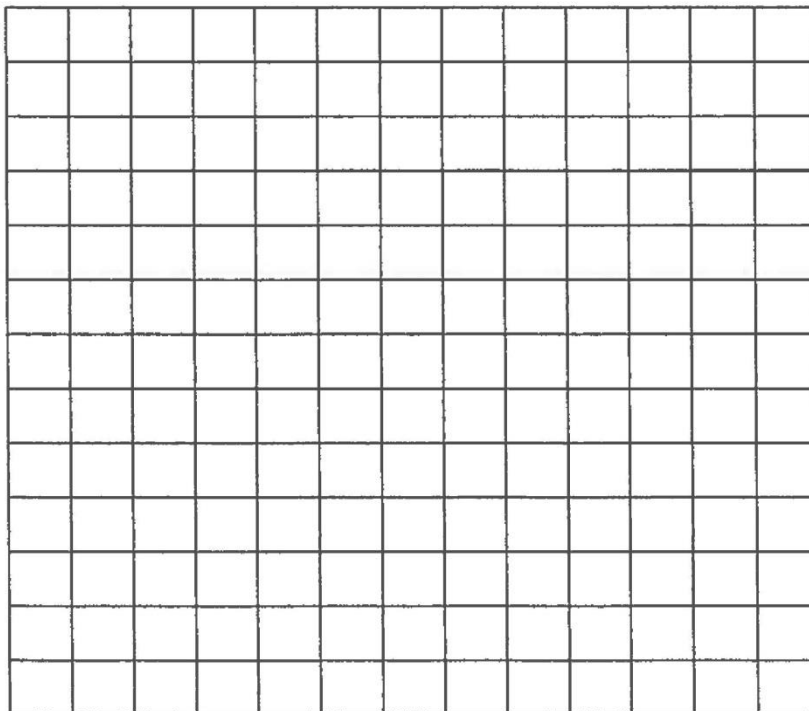
Opdracht 1: Problem 1:

In een schaatswedstrijd strijden 3 schaatsers om de beste tijd.

De rondetijden worden in de tabel gegeven.

Naam <i>Name</i>	300 m	700 m	1100 m	1500 m
Jan	32	36.5	106	145
Frits	31	64	101	139
Grietzen	32	69	104	138

- Maak een assenstelsel
- Maak eerst een grafiek bij de tijden van Jan.
- Maak in dezelfde grafiek van Jan ook een grafiek van Frits en Grietzen.



- Make a system of coordinates
- First make a graph of the times of Jan.
- In the same graphs, also make graphs for Fritz and Grietzen.

Opdracht 2: Problem 2:

In deze proef meet je weer afstanden en tijden *In this test you again measure distances and times*

Deze meetgegevens zet je uit in een afstand-tijdgrafiek.

You eventually put these measurement data in a distance-time graph.

Benodigde materialen:

- | | |
|----------------------------------|-----------------------------|
| - Horloge, stopwatch of telefoon | - Watch, stopwatch or phone |
| - speelgoedauto | - Toy car |
| - meetlint | - Measurement tape |

Needed materials:**Wat moet je doen:**

- | | |
|---|--|
| • Maak groepjes van 4 | <i>Make groups of 4</i> |
| • Eén laat de auto rijden | <i>One lets the car drive</i> |
| • De tweede schrijft de metingen op. Dit is de starter. | <i>The second writes down the measurements. This is the starter.</i> |
| • De andere twee meten de tijd dat de speelgoedauto een 2-meterpunt bereikt en geven die door aan de starter. | |
| • Meet een recht parcours af van 8 meter | |
| • Elke 2 meter moet de tijd opgeschreven worden. | |
| • Op het moment dat de starter de auto laat rijden begint de rest te meten. | |
| • Schrijf de metingen in de tabel. | |
- Herhaal de metingen met verschillende auto's**

What you have to do:**Resultaten:**

Beschrijf wat er gebeurt.

Wat gaat er goed en wat gaat fout.

.....

.....

.....

.....

.....

Measure a straight course of 8 meters.

Every 2 meters the time must be written down.

The moment the car starts driving, the rest is starting the measurement.

Write the measurements down in the table.

Repeat the measurements with various cars.

Results:

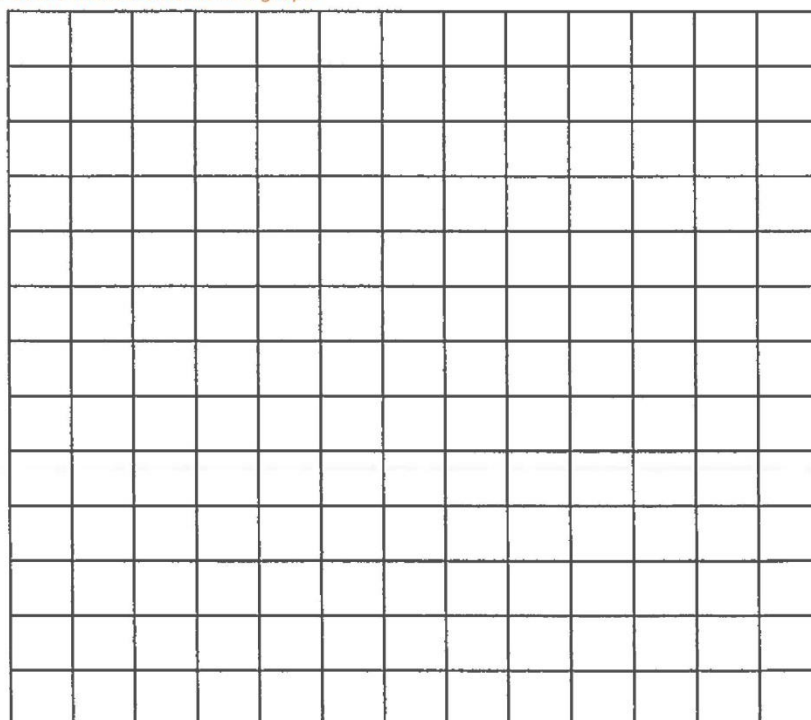
Describe what happens.

What goes well and what goes wrong.

beschrijving kleur auto	Meting na 2 meter	Meting na 4 meter	Meting na 6 meter	Meting na 8 meter
<i>Description colour car</i>	<i>Measurement after 2 meters</i>			

- Zet de metingen in een grafiek.

Put the measurements in a graph



Treinmachinist 1, werkbladen *Train driver 1, worksheets*

Opdrachten rond stukjes-afstand-grafieken *Assignments concerning sections-distance graphs*

Namen:

Names:

Spel: Hoe lang doe jij over een rondje?





Game: how long does it take for you to make a round?

You can use the buttons on the screen, but also the arrows on the keyboard.

De trein heeft ATB, dat betekent: Automatische Trein Beveiliging.

Als je te hard gaat, zet de ATB de trein stil.

Als je een station voorbijrijdt, laat de ATB de trein terugrijden.

	mouse	keyboard
optrekken:		 pull up
snel optrekken:		 pull up quickly
remmen:		 brake
hard remmen:		 brake hard

The train has ATS, that is: Automatic Train Security. When you go too fast, the ATS stops the train.

When you pass a train station, the ATS makes the train drive back.

1. Speel twee keer het spel van treinbaan A.
Onze beste tijd bij treinbaan A was:

Play the game of train track A twice. Our best time for train track A was:

‘Optrekken’ betekent: harder gaan rijden. Bij een auto doe je dat door met je voet op het gaspedaal te duwen. De treinmachinist heeft een knop die hij met zijn handen bedient (want een treinmachinist hoeft niet te sturen).

Bij treinbaan B zijn er twee knoppen voor optrekken. Met de ene knop gaat het rustig, met de andere trek je snel op. Er zijn ook twee knoppen voor remmen: rustig remmen en snel remmen.

2. Opdracht: Speel twee keer het spel van treinbaan B.
Onze beste tijd bij treinbaan B was:

Pull up means: drive faster. With a car you do that by pushing your foot onto the gas pedal. The train driver has a button to operate with his hands (because a train driver does not have to steer).

With train track B there are two buttons for pulling up. With one button it goes slowly, and with the other button you pull up quickly. There are also two buttons for braking: braking slowly and braking hard.

*Assignment 2: Play the game of train track B twice.
Our best time for train track B was:*

Werkbladen bij webquest Treinmachinist 1, p. 1

Work sheets for webquest train driver 1, p.1

9. Bij welke grafiek - c of d - heeft de trein het langste stilgestaan? Leg uit waar je dat aan ziet.

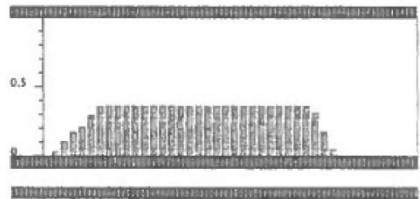
At which graph - c or d - did the train stand still for the longest period of time? Explain how you can tell.



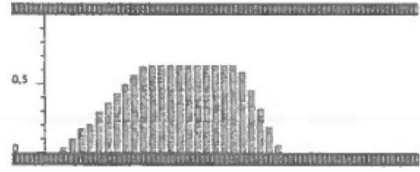
grafiek e *graph e*

10. Maak grafiek e na op de computer. Schrijf op wat de trein doet bij deze grafiek.

Copy graph e on the computer. Write down what the train does in this graph.



grafiek f *graph f*



grafiek g *graph g*

11. Maak grafiek f na op de computer.
12. Maak grafiek g na op de computer.
13. Bij welke grafiek - f of g - heeft de trein het *langst* gereden? leg uit.

Copy graph f on the computer

Copy graph g on the computer

At which graph - f or g - did the train drive longest? Explain.

14. Bij welke grafiek - f of g - heeft de trein het *verst* gereden? Kun je dat ook zien in de grafiek? Leg uit.

At which graph - f or g - did the train drive the farthest? Can you see that in the graph? Explain.

Appendix F: Selection and translation of Q-sorting cards

English	Dutch
1. Mathematics/science is difficult. + Using technology in maths/science is difficult.	Rekenen is moeilijk. + Een computer gebruiken bij rekenen is moeilijk.
2. Mathematics/science is fun. + Using technology in maths/science is fun.	Rekenen is leuk. + Een computer gebruiken bij rekenen is leuk.
3. Mathematics/science is important.	Rekenen is belangrijk.
4. Mathematics/science is exciting. + Using technology in maths/science is exciting.	Rekenen is spannend. + Een computer gebruiken bij rekenen is spannend.
5. Mathematics/science is something everybody can learn.	Iedereen kan rekenen leren.
6. Mathematics/science is used in everyday live.	Bij heel veel dingen in het dagelijks leven gebruik je rekenen.
7. One is born with mathematical/scientific understanding.	Goed kunnen rekenen is iets waarmee je geboren wordt.
8. Mathematics/science is a tool for doing something else.	Rekenen is een hulpmiddel om iets anders te kunnen doen.
9. I like mathematics/science. + I like using technology in maths/science.	Ik reken graag. + Ik gebruik graag een computer bij het rekenen.
10. Mathematics/science is frustrating. + Using technology in maths/science is frustrating.	Rekenen is frustrerend. + Een computer gebruiken bij rekenen is frustrerend.
11. Mathematics/science is either right or wrong.	Bij rekenen kan iets alleen goed of fout zijn.
12. I do not like mathematics/science. + I do not like using technology in maths/science.	Ik reken niet graag. + Ik gebruik niet graag een computer bij het rekenen.
13. Mathematics/science is not relevant for my future (life).	Rekenen is niet belangrijk voor mijn toekomst.
14. Mathematics/science means exploring and experimenting.	Rekenen betekent dat je iets moet uitzoeken en uitproberen.
15. To do mathematics/science means to solve many of the same tasks/exercises.	Rekenen betekent dat je veel van dezelfde oefeningen moet doen.
16. I learn things quickly in mathematics/science.	Ik leer dingen snel bij rekenen.
17. Mathematics/science helps us to think systematically and logically.	Rekenen helpt ons om logisch te denken.
18. Mathematics/science means seeing connections.	Rekenen betekent zien dat iets bij elkaar hoort.
19. Mathematics/science helps us to see/understand our surroundings.	Rekenen helpt ons om de wereld om ons heen te begrijpen.
20. I can do without mathematics/science.	Ik kan ook wel leven zonder rekenen..
21. I learn/understand mathematics/science best when I work on my own.	Ik leer het best rekenen als ik in mijn eentje mag werken.
22. I need the textbook to learn mathematics/science (or mathematics/science is best learnt with the help of a textbook).	Ik heb mijn rekenboek nodig om te leren rekenen.
23. Mathematics/science is best learnt by doing practical activities.	Je leert het beste rekenen door werkstukken te maken.
24. Mathematics/science requires a lot of repetition.	Rekenen betekent veel herhaling.
25. Mathematics/science makes sense in the real world.	Rekenen krijgt betekenis in het dagelijks leven.

26. Mathematics/science is only for the mathematics/science classroom, not for real life outside.	Rekenen is alleen voor in de klas, niet voor buiten school.
27. In mathematics/science (lessons) there is no time for reflection.	In rekenlessen is geen tijd om door te denken over dingen.
28. Only gifted people understand mathematics/science.	Alleen slimme mensen begrijpen rekenen.
29. If I do not understand something, I work with it until I get it right.	Als ik iets niet begrijp, dan werk ik net zo lang tot het lukt.
30. I am nervous in mathematics/science lessons. + I am nervous when using technology in maths/science lessons.	Ik word zenuwachtig tijdens rekenlessen. + Ik word zenuwachtig wanneer ik een computer moet gebruiken in rekenlessen.
31. I feel that I can do/understand mathematics/science.	Ik vind dat ik goed kan rekenen.
32. To learn/understand mathematics/science depends on the teacher.	Of je rekenen kunt begrijpen hangt af van de meester of juf.
33. In mathematics/science (lessons) there is no room for expressing one's own ideas.	In rekenlessen is het niet goed mogelijk om met eigen ideeën aan te komen.
34. Mathematics/science is best learnt (in collaboration) with others.	Rekenen leer je het best in samenwerking met anderen.
35. I understand better if I work with friends in mathematics/science.	Ik begrijp het beter als ik met rekenen met mijn vriendinnen/vrienden samenwerk.
36. Exams are boring.	Toetsen zijn saai.
37. I like exams because I can see how I am doing.	Ik maak graag toetsen omdat ik dan kan zien hoe het gaat.
38. Exams help me to work more.	Toetsen helpen mij harder te werken.
39. Working with technologies in mathematics/science is useful.	Werken met een computer in rekenen is nuttig.
40. We use a lot of tools in our mathematics/science lessons.	We gebruiken veel hulpmiddelen (blokjes, linialen, enzovoort) tijdens de rekenles.
41. Our teacher in mathematics/science always uses some kind of technology for the lessons.	Onze leraar gebruikt altijd wel een vorm van technologie (computer, digibord, enzovoort) in de rekenles.
42. I can better understand when I use the technology tools in our mathematics/science lessons.	Ik begrijp het beter wanneer ik technologie (computer, digibord, enzovoort) gebruik in de rekenles.
43. When we use technology during the mathematics/science lesson, I quickly understand if and why I am wrong.	Wanneer we technologie (computer, digibord, enzovoort) gebruiken in de rekenles zie ik snel of ik foutjes maak en waarom.
44. When we use technology during the mathematics/science lesson, I better understand what I have to do to improve my understanding.	Wanneer we technologie (computer, digibord, enzovoort) gebruiken in de rekenles snap ik eerder wat ik moet doen om het beter te begrijpen.
45. The use of technologies during the mathematics/science lesson enable me to better understand the objectives of the activities.	Door technologie (computer, digibord, enzovoort) te gebruiken in de rekenles begrijp ik het doel van de oefeningen beter.
46. It takes me twice as long, if I have to work with the technology tool, and cannot ask the teacher directly.	Als ik met technologie (computer, digibord, enzovoort) moet werken en het niet aan de meester of juf kan vragen, doe ik er twee keer zo lang over.
47. I prefer to talk to the teacher, rather than find out myself with the technology.	Ik praat liever met de meester of juf dan dat ik dingen uitzoek met de computer.
48. For me, the technology does not work, or help.	Voor mij helpt het niet om een computer te gebruiken.

49. I feel that the teacher knows much better where we are, when s/he uses the technology tools.	Volgens mij weet de meester of juf veel beter of we goed leren als hij/zij werkt met een computer..
50. When we work together, it makes sense to use the technology.	Als we samenwerken is het nuttig om de computer te gebruiken.
51. Our teacher uses the technology to find out where we are in our learning/with our exercises/ ...	Onze meester/juf gebruikt de computer om te weten te komen hoe ver we zijn met het rekenen.
52. With the tools/technology I can find out myself whether I can do the tasks in mathematics/science.	Met de computer kan ik er zelf achter komen of ik de rekenopdrachten beheers.
53. I never know what to do with the computer/technology.	Ik weet nooit wat ik met de computer moet doen.