FaSMEd

Raising Achievement through Formative Assessment in Science and Mathematics Education

Distance-time graphs

Subject:	Mathematics
Age of students:	14 - 15 years
Hardware:	iPads and IWB
Software:	Showbie
Functionalities:	Sending and Displaying
Time:	1 hour
FaSMEd partner:	University of Nottingham
Short Abstract:	The lesson focused on developing students' understanding of distance-time graphs, including construction of graphs, interpretation and calculations of speed.

1. Content

The lesson was designed for concept-development on the topic of distance-time graphs. Students were required to both interpret and construct distance-time graphs to match given descriptions of journeys and also recognise the link between gradient and speed. Numerical calculations of speed, distance and time, from data provided in graphical or textual form, were also expected.

2. Activity

2.1 Aims

The aims of the lesson were to:

- Build on students' prior knowledge in order to develop better understanding of distance-time graphs;
- Identify and deal with common misconceptions;
- Build fluency in the interpretation and construction of distance-time graphs;
- Recognise connections between gradient and speed;
- Use data provided graphically or in textual form to accurately perform calculations involving speed, distance and time.

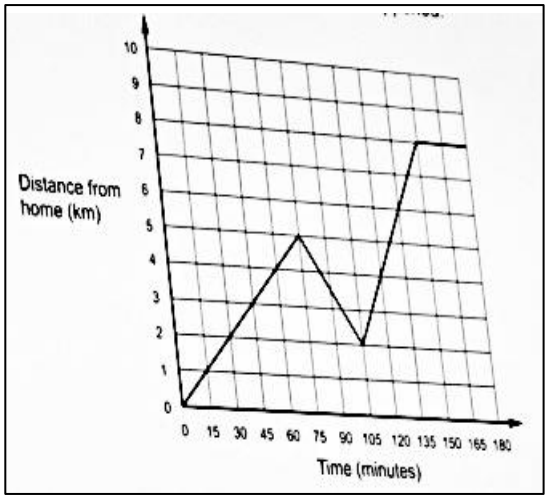
2.2 Structure / Methodology

The lesson was based around the distance-time graph lesson within the Mathematics Assessment Project (MAP) materials but was adapted for use with iPads through a collaborative design research process with the teachers. The intention was to explore the potential offered by the technology to enhance the formative assessment opportunities planned into the existing lesson.

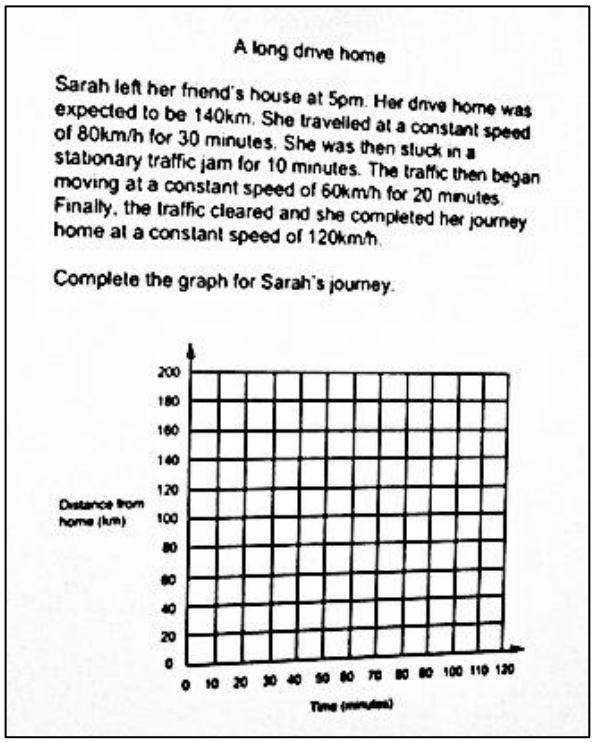
Firstly, instead of setting a preliminary question for homework, the two questions below were used at the beginning of the lesson, as an assessment of prior knowledge intended to expose common misconceptions. The first of these questions was a task entitled "A walk to the shop" in which students were asked to describe a 'story' to match a given distance-time graph. The second task, "A long drive home", required students to draw their own graph to represent a given 'story'. Students were expected to work on their individual iPads and return their answers to the teacher using *Showbie*[1]. Discussion between students was encouraged during the task and, once the teacher had received students' solutions, samples were selected and used to stimulate class discussion.

[1] Showbie is an application which creates an environment in which students can access questions, work out solutions and send their work to the teacher for assessment electronically. See: https://www.showbie.com.

Diagnostic questions:



A walk to the shop



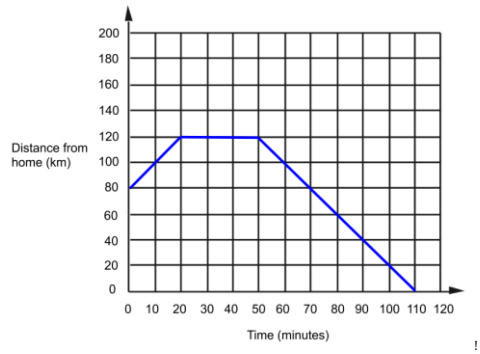
A long drive home

In the second part of the lesson, students worked on activities that are described as 'mirrored'. Students in one half of the classroom were asked to work on Set A questions and the students in the other half of the room were given the complementary questions, Set B, to work on. As the example below illustrates, the questions in Set A and Set B were actually about the same situations but students were provided with different translations to perform (either writing a possible story that would fit a given distance-time graph or drawing the distance-time graph from a given story of a situation).

'Mirrored' questions

Set A	Set B

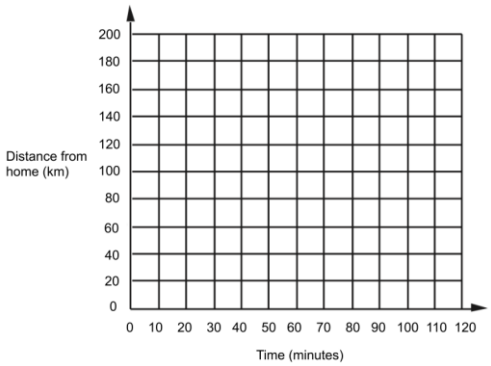
Speed Distance Time Graph 1



Complete the story below from the graph.

James is at his friend's house, which is _____ from his house. He travels away from his house to see his Grandma at a _____ speed of _____ km/h for _____ minutes. He stays at his Grandma's house for _____ minutes. He then travels home at a _____ speed of _____ km/h.

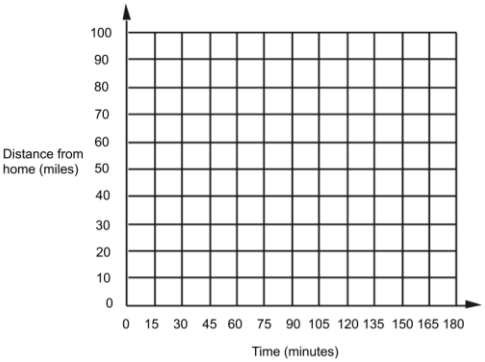
Speed Distance Time Graph 1



Complete the graph based on the story below.

James is at his friend's house, which is 80km from his house. He travels to away from his house to see his Grandma at a constant speed of 120 km/h for 20 minutes. He stays at his Grandma's house for 30 minutes. He then travels home at a constant speed of 120 km/h.

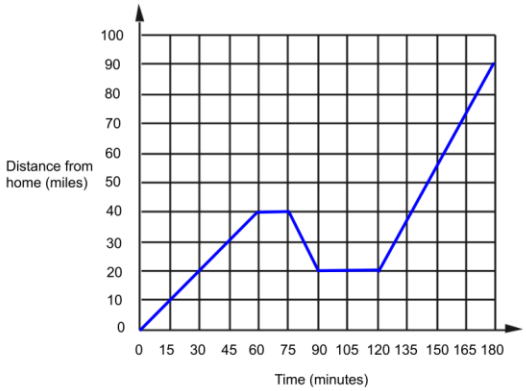
Speed Distance Time Graph 2



Complete the graph based on the story below.

Adil leaves his house in Bristol at 3pm, travelling at a constant speed of 40 mph for 60 minutes. He stops off at the toy shop for 15 minutes. Adil then drives to the supermarket at a constant speed of 80 mph for 15 minutes. He takes 30 minutes to do his shopping in the supermarket. Finally, Adil completes his journey to Portsmouth at a constant speed of 70 mph.

Speed Distance Time Graph 2



Complete the story below from the graph.

Adil leaves his house in Bristol at 3pm, travelling at a _____ speed of _____ mph for _____ minutes. He stops off at the toy shop for _____ minutes. Adil then drives to the supermarket at a _____ speed of _____ mph for _____ minutes. He takes _____ minutes to do his shopping in the supermarket. Finally, Adil completes his journey to Portsmouth at a _____ speed of _____ mph.

The students were initially unaware that they were working on 'mirrored' questions. After some time working individually, students were asked to move into pairs with someone who had worked on the opposite set of questions and assess each other's work. This approach using 'mirrored tasks' was planned with the intention to stimulate rich discussion between students in which they may be required to justify their solutions, face challenges to their own thinking and challenge the thinking of others. The presence of an anomaly in one of the 'mirrored' pairs of questions served to prompt discussion even if students agreed about their other solutions.

2.3 Technology

Within this lesson the main use of technology in formative assessment was the 'send and share' function, carried out using individual iPads and the *Showbie* software. This allowed the teachers to send the tasks to the students electronically, receive their responses and display selected student work for the whole class to review. In this way the teacher gained an overview of students' responses quickly and could view all the responses simultaneously. Speed and accessibility were identified as advantages of using technology in this process.

Using the information gained from this process, teachers found they were able to identify common misconceptions and select appropriate samples of student work for display as a basis for class discussion. Being able to select student work from their own iPad and display this quickly for all the class to view was useful, although alternative approaches with different technology, such as using a 'visualiser', would perform a similar 'display' function. In this lesson teachers utilised varied approaches to selecting and displaying student work with different levels of dependency on the technology. Although *Showbie* was used to collect and view students' completed responses to questions, during paired or individual work teachers often viewed student work in progress by walking around the classroom and information gained in this way was also used to inform their choice of work to display for discussion.

2.4 Aspects of Formative Assessment

The initial two questions in this lesson were designed and used to establish where the students were in their understanding of distance-time graphs. Through these questions teachers were able to make an assessment of students' prior knowledge and identify common misconceptions within the group.

The teachers then used class discussion to further clarify students' understanding and to move their thinking forward. Sample student responses to these two diagnostic questions were used as a basis for class discussion in order to expose the common misconceptions, consider appropriate solutions to the questions and adjust students' thinking. The class discussion also helped clarify the criteria for success and establish for students the direction they should take in subsequent questions.

The first question required students to write a 'story' of a journey that may be depicted by a given distance-time graph and multiple responses were therefore acceptable. This encouraged some creative thinking rather than the recall of prior knowledge or the use of routine processes. When students' responses were displayed and discussed then students needed to read, understand and reflect on the thinking and reasoning of others so this was potentially a richer form of peer-assessment than would result from a comparison of answers to a closed question. The second question was closed and generally generated less discussion so formative assessment was more limited.

Class discussion was used at various points during the lesson to develop students' understanding. These class discussions also provided opportunities for students to compare responses their own responses to those of their peers, leading to some peer assessment and self-reflection that helped them individually assess where they were and how they might improve their work. We might view these formative assessment opportunities for students as being 'nested' within the broad teacher-led formative assessment process of receiving and using students' completed work in class discussion. Students engaged in peer-

assessment and self-reflection as they discussed the questions in pairs before submitting their individual answers and then again as they viewed work from other students on the IWB.

During paired and individual work the teachers spent time observing student work and questioning them to move their thinking forward or responding to queries from individual students. The teacher used this time within the lesson to provide appropriate and timely feedback to individuals whilst also gathering data about students' understanding which led to adjustments to the lesson such as occasional interventions for the whole class to deal with issues arising.

The final comparison of students' answers to the 'mirrored' questions, in pairs or small groups, potentially provided an interesting means of prompting rich discussion between peers. Students were required to assess the work of their peers and explain their own thinking but in practice the effectiveness of this activity varied between classes. In some cases students disagreed, challenged each other and spend time justifying their answers, leading to some rich discussion and adjustments to thinking. Other students simply exchanged iPads to mark the work and there was little discussion, either because the answers were all compatible, or due to students quickly agreeing about any errors. Although the activity was not as successful as anticipated, it did facilitate the engagement of all students in at least some peer assessment and, in some cases, students became useful instructors for their peers, explaining their own reasoning and helping others to rethink their approaches.

In this lesson the teacher received feedback on student work either through the sending of responses by students electronically or by direct observation during paired/group work. This helped the teachers make adjustments in several ways.

When students' responses were sent electronically to the teacher this provided feedback so the teacher could select appropriate work for class discussion and pose appropriate questions to expose the misconceptions. Having access to all the students' responses simultaneously provided an accessible overview and there was evidence in each of these lessons that teachers used this to select appropriate work to expose misconceptions. From the same feedback process teachers sometimes identified sample student work that indicated the criteria for success for other students.

There was also evidence of feedback that was not linked to the use of technology. Teachers adjusted their verbal questioning during the class discussion in responses to information gained from students' verbal answers to questions during the discussion. In some of the lessons teachers made adjustments to their intended lesson plan as a result of direct observations of student work. This sometimes took the form of an unplanned intervention during paired work in which they initiated a short additional class discussion about a common error or misconception that was becoming evident in student work.

Students received feedback directly from the teacher or their peers during the class discussions, particularly when their own work was displayed and used in discussion but also, less directly, when work similar to their own was displayed and discussed. This enabled students to adjust their thinking and identify how to achieve success.

During paired work individual students received feedback on their written work or ideas through verbal comments from their peers. This sometimes led to adjustments to their thinking following discussion within the pair or group. In the final discussion of the

'mirrored' questions however, it was evident that some students only engaged in a superficial peer assessment and feedback activity whilst others became involved in more 'in depth' debates about their written responses. During these discussions there was some evidence of students changing their thinking when challenged by their peers and gaining better understanding of the correct interpretations of the graphs.

3. Further Information

Feedback from the teachers indicated that the use of iPads in these lessons had been beneficial to them in their teaching. In particular, the speed and visibility of students' responses to written questions provided by the technology were considered beneficial, with one teacher stating that this had "a massive impact" on their lesson. This was strongly linked by teachers to the importance of class discussions in these lessons. Class discussion was a vital activity within the planned formative assessment processes for the lessons and the technology performed a useful function in facilitating these discussions. The participation of students, in both class and paired discussions, was however, essential to ensure the formative assessment processes were productive.

The teachers needed to predict students' misconceptions accurately when using the diagnostic tasks and were correct in expecting that the most common error would be starting at the wrong point on the graph. They were less successful in predicting students' difficulties with the speed calculations. Anticipation of the likely misconceptions and the use of carefully constructed questions to draw out students' thinking were two key elements of the lesson that affected the effectiveness in practice.

4. References

MAP resource available at http://map.mathshell.org/lessons.php?unit=8225&collection=8

Showbie available at https://www.showbie.com./

Black, P., & Wiliam, D. (1998). Assessment and classroom learning. *Assessment in education*, 5(1), 7-74.

Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. Educational Assessment, Evaluation and Accountability, 21(1), 5-31.

Wiliam, D. (1999). Formative assessment in mathematics Part 2: feedback. *Equals: Mathematics and Special Educational Needs*, *5*(3), 8-11.