

Case study 1: Matthew

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1. Context

The School

The school is a mixed secondary school for pupils aged 11-18 years and provides for a wide range of abilities. At the time of the research there were just over 2000 pupils on the school roll. The school is an academy¹ and is designated as an 'Apple' school signifying the high profile of technology, such as iPads and other Apple products, within teaching and learning, although it is not directly sponsored by Apple. The school is situated in a residential area on the outskirts of an industrial town. The percentage of pupils qualifying for free school meals is approximately 22%², which is below the national average and the school was judged to be good in its most recent Ofsted (Office of Standards in Education) inspection. Since the school is non-selective there are a wide range of abilities and therefore a significant number of low-attaining students within each year group. Year groups are divided into sets by ability from Year 10 onwards (age 14/15 years), on the basis of their overall attainment rather than their mathematical ability. This means that students with low-attainment in mathematics may be placed into a high set if their overall attainment is high and vice versa. The range of mathematical abilities within any particular class can therefore be wide and students may be classified as low-attaining either in comparison to their year group or relative to the performance of others in the same class or set or with respect to the material being taught.

From Year 10 onwards, all students in this school have individual iPads as part of their equipment for to use in each subject and at home. The students in the study were therefore very familiar with the technology and used to working on iPads in all their lessons, including mathematics. The school also has well-developed systems to support the use of technology.

Students use a wide range of apps and, from Year 10 onwards, iPads have largely replaced exercise books in the school. Amongst these *Showbie*³ is the most commonly used app, which allows students to complete work and save this into subject folders. Documents, images, instructions and comments can be added to the folders, which are shared between the teachers and the students. Students use their iPads for both classwork and homework. They are familiar with accessing work electronically, sending completed responses to their teachers and receiving feedback using their iPads.

The teacher (and the group of teachers)

Matthew is a young male mathematics teacher who has studied mathematics to degree level. He has been teaching for 5 years, all of those in his current school. He has responsibility within the school, as the learning technology coordinator (**check title**), for leading the development of technology as a learning tool and therefore the Fasted project aligned to his interests. The research was also attractive since the school had noticed an apparent decline in collaborative work between students in

¹ Academies are publicly funded independent schools. Academies don't have to follow the national curriculum and can set their own term times. They still have to follow the same rules on admissions, special educational needs and exclusions as other state schools. Academies get money direct from the government, not the local council. They're run by an academy trust that employs the staff. Some academies have sponsors such as businesses, universities, other schools, faith groups or voluntary groups. Sponsors are responsible for improving the performance of their schools.

² A measure of social and economic status

³ 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>.

mathematics classrooms when using iPads and Matthew was keen to explore ways in which the project could help address this issue.

Matthew acted as the lead teacher for the Fasmed project but worked closely with his other two colleagues to exchange ideas and plan lessons with the university team. There was a considerable amount of communication between this group of teachers and with the researchers. Feedback and reflections on lessons were quickly exchanged through emails and the development process was well supported by informal discussion between the teachers on suggested changes.

The class

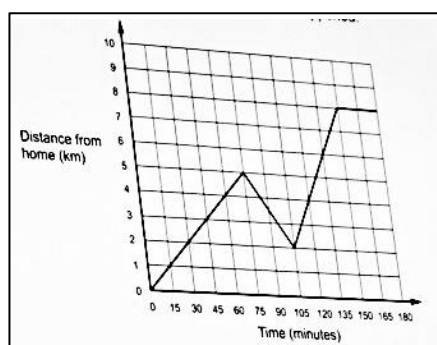
The particular class for the Fasmed project was a Year 10 group (age 14/15 years) and was Set 2. This meant that the pupils were not the most highly attaining in their year group but were reasonably able. This meant that there would be some evidence of difficulties with mathematics and comparisons of lower and higher attaining pupils within the group would be possible.

2. Tasks and resources used

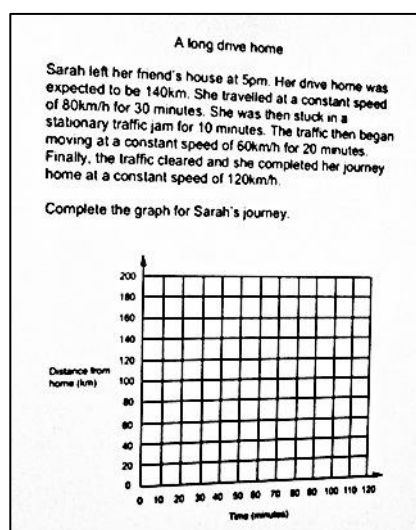
Only brief descriptions of the tasks and resources are provided in this section. Further details of the tasks and lesson plans are included in Appendix B.

Lesson 1: Distance-time Graphs

This first lesson was clearly a concept-development lesson. It was based around the distance-time graph lesson within the Mathematics Assessment Project (MAP) materials⁴ 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.



A walk to the shop



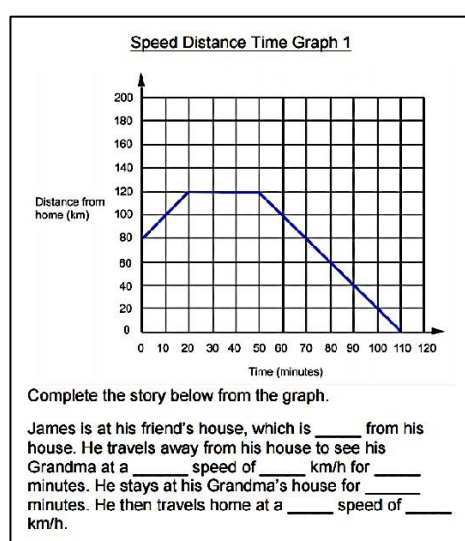
A long drive home

Firstly, instead of setting a preliminary question for homework, two questions 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

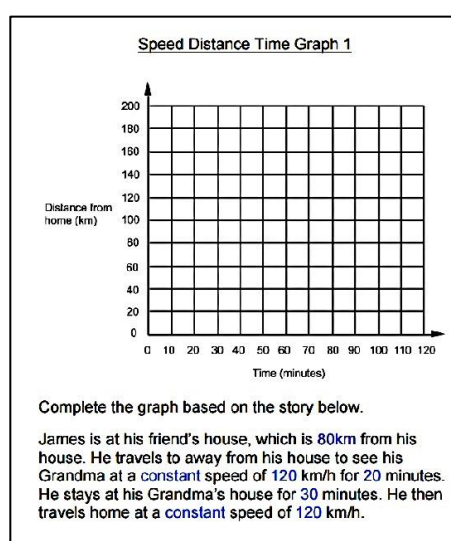
⁴ <http://map.mathshell.org/lessons.php?unit=8225&collection=8>

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*. 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.

In the second part of the lesson, students worked on activities that Matthew described as 'mirrored'. Students in one half of the classroom were asked to work on Set A questions and the other half on the complementary questions, Set B. 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).



Set A: Graph to story



Set B: Story to graph

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 reverse translation 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 accidental anomaly in one of the 'mirrored' pairs of questions served to prompt discussion even if students agreed about their other solutions.

Lesson 2: The meatballs problem

This was a semi-structured modeling task based on a lesson attributed to Dan Meyer that appears on his website [dy/dan](http://blog.mrmeyer.com/2013/makeover-meatballs/).⁵ Although the same basic format of the lesson was followed, several adaptations were made to incorporate different uses of technology that the teachers wanted to explore with respect to their effectiveness with certain aspects of this task. The purpose of the lesson, however remained. This was to enable students to pose and tackle a real-life problem, by identifying relevant questions, relevant variables and generating relationships between these variables.

⁵ <http://blog.mrmeyer.com/2013/makeover-meatballs/>

Firstly the class viewed a short video clip from the website in which meatballs were being added to a pan of tomato sauce. The teacher then suggested that the video showed something that used to be a textbook question and asked the students to suggest what that question might be.

Students made suggestions and these were displayed on the Interactive White Board (IWB). The display of suggestions was then used to initiate a class discussion about what particular question the class would adopt for investigation during this lesson. This discussion was guided by the teacher and led to the choice of a question that the teacher had actually decided in advance but was expecting to be the most common question suggested by students: *How many meatballs do you think will be needed in order for the sauce to overflow?*

The students were asked at this point to estimate their answers and send these to the teacher using a second Google form. These estimates would be revealed at the end of the lesson after students had spent time working out the answer more precisely.

The teacher started the students thinking about the problem by asking the class the open question “Since that is the question, what information would we need in order to work out the answer?” The students were asked to suggest items of information that they would require. This stage was a further adaptation to the original problem and also to the version of the lesson taught by Matthew’s colleague and observed by the researchers prior to this. In the previous versions this information had been provided and this seemed to guide the students towards a particular method for solving the problem. Asking the students to identify the information they needed was a strategy intended to remove constraints and allow them the freedom to investigate alternative approaches to the one implied from the given information.

A class discussion then followed about the information that might be required. The teacher challenged students about their suggestions in order to reach agreement as a class. For example, some students suggested that they needed surface area. Another disagreed, and tried to explain why volume was the measure needed. A further student suggested that the mass of the meatballs was needed. Again, another disagreed. Through questioning, Matthew eventually managed to get students to agree that volume was relevant, while surface area and mass were not.

The students worked collaboratively in pairs to work out an answer to the problem. They had the choice of working on a large sheet of paper or on their iPads. Towards the end of the session they are asked to open up a blank file, record their solutions and send these to the teacher so these could be used for class discussion. During the paired work the teacher went round the class, questioning students and answering their queries. This provided an opportunity to view student work and select which samples would be appropriate to display later for discussion. The lesson plan also included the possibility of displaying a sample of work from a different class if appropriate.

In the final part of the lesson, samples of student work were displayed on the IWB and there was class discussion regarding the methods used and their accuracy. The teacher revealed students’ initial estimates on the IWB and asked which assumptions were made at the beginning that had caused

some estimates to be a long way out. Further class discussion followed, to explore these assumptions and how they affected both estimates and solutions.

Lesson 3: Solving multi-step equations

The purpose of this lesson was to build student fluency with solving algebraic equations.

This lesson focused on the use of an electronic learning environment called *Mathspace*⁶ by students, for individual work on multistep equations. The tasks given to the students were selected by the teacher from a range of 'types' of activity supplied by the software but the program then generated a series of questions for each student, utilizing an adaptive system to suit their needs.

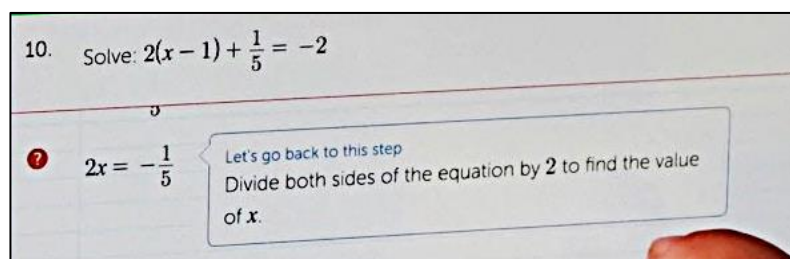
Firstly, students were provided with three equations to solve that were generated by the software. The teacher had preselected the 'type' of equation required (each involved at most three steps) and the software provided equations with different numerical coefficients for each student. Examples of the question types used are shown below.

Question 1: $\frac{x}{6} + 5 = 0$

Question 2: $\frac{8x + 40}{12} = -88$

Question 3: $5(x - 2) - 13 = -53$

Students were asked to write their solutions step-by-step using their fingers on the iPads. As they wrote a line of algebra, the app interpreted their handwriting and re-presented it in printed form. (This occasionally caused confusion when, for example, the iPad interpreted the student writing x as an instruction to multiply rather than as the name of the variable.) Each line of working was assessed by the system as correct or incorrect, and hints were provided electronically, should the line of working be incorrect. For example:



The teacher was able to monitor students' progress electronically and identify common errors that needed to be followed up by verbal questioning or class discussion.

⁶ An animation showing the functionality of *Mathspace* is shown here: <https://mathspace.co>

Student	Time	Grade	Progress	Q1	Q2	Q3
Raj	0m	100%	0/3			
Joshua	3m	100%	3/3	✓	✓	✓
EN Emily	4m	100%	3/3	✓	✓	✓
D. Hane	5m	100%	1/3	✗		
J. Joshua	2m	100%	1/3	✓		
Lee	0m	100%	0/3			
X. Will	4m	100%	1/3	✓		
M. Calum	4m	100%	1/3	✗		
Samuel	5m	100%	3/3	✓	✓	✓
R. Scott	-	100%	0/0			
FIELD Luke	0m	100%	0/3			
THS Patrick	4m	100%	1/3	✓		
WICK Imogen	-	100%	0/0			

After the students have attempted these three questions the teacher showed student responses on the IWB for discussion. There were two purposes for the class discussion. Firstly, since the software was new to most students, so the teacher used samples of work and questions to clarify the main features of the software and help students interpret the feedback correctly. Secondly the teacher showed samples of student work and discussed the common errors and misconceptions that this revealed.

The teacher then presented the main task for the lesson. This was to complete as many questions as possible. The software was adaptive. So if the student completed one equation incorrectly, the software would ensure that the next equation was of similar type and difficulty. If the student was successful, the software would generate a more difficult equation. Again, students had to show each line of working and have this checked by the system before proceeding to the next line. If lines of working were incorrect then students either corrected their own errors or asked the system for a 'hint'. When they had worked out sufficient solutions correctly, according to the criteria set for this task, they achieve a 'mastery' score of 100% even though the system continued to generate additional questions with increasingly more difficult numbers.

Finally, the students were provided with two worked examples containing some errors. The students had to assess each line and provide the 'hints' that they think *Mathspace* would provide in order to guide them towards a correct solution. For example, here is one where the very first line is incorrect.

Solve: $\frac{6x}{5} + 4 = -20$

$\frac{6x}{5} = -16$ ✗ -4 not +

$6x = -80$ ✗

$x = \frac{-80}{6}$ ✗

$x = \frac{-40}{3}$ ✗

3. Work with teachers

The way of working with teachers involved a multi-level collaborative approach. Within the school three teachers worked together on the lessons with support from the Fasmed research team at the University of Nottingham.

Three lessons were developed with this group of teachers at the school using a design research approach but with the aim of exploring different uses of technology within formative assessment rather than the production of well-refined tasks. The teachers took the role of partners in this design research process, contributing substantially to lesson design, implementation and review. The process involved a basic cycle that was repeated three times for each lesson with a different teacher each time: lesson design; implementation and observation; discussion and feedback; revisions to the design. For each lesson the sequence of teacher activity and support followed a similar pattern:

Cycle 1

- Teachers meet for initial discussion of lesson topic, content and approach with the researcher(s);
- The teachers work together on an initial lesson design;
- Discussion takes place with the researchers by email alongside collaborative work between teachers in the school and this leads to a revised lesson plan;
- Teacher 1 teaches the lesson and two researchers observe;
- The observers provide verbal feedback and the lesson is discussed with Teacher 1 immediately afterwards (where possible);
- Further feedback and suggested revisions are provided by email from the researchers;

Cycle 2

- Teacher 2 teaches the revised lesson and two researchers observe;
- The observers provide verbal feedback and the lesson is discussed with Teacher 2 immediately after the lesson (where possible);
- Further feedback and suggested revisions are provided by email from the researchers.

Cycle 3

- Teacher 3 teaches the revised lesson and two researchers observe;
- The observers provide verbal feedback and the lesson is discussed with Teacher 3 immediately after the lesson (where possible);
- Each teacher provides a brief written report on the lesson they taught;
- The teachers meet with the researcher(s) to discuss their reflections on the lesson.

Observations were carried out in pairs, whenever possible, by members of the Fasmed research team. Each of the three versions of the lesson was video-recorded on one occasion.

4. Classroom teaching

Matthew's experience of teaching had spanned only a few years but this was coupled with a high level of competency in using digital technology. In his interview (Appendix D), he explained that he

already used technology within formative assessment in several ways, such as “assigning little quizzes that provide feedback in terms of what each of the students know” and in order to “view students’ responses on the board in front of the class for discussion”. He talked about practices involving the use of iPads and apps, such as *Socrative*⁷, that allowed him to see responses from individual students. Although he was not explicit, there were implications that he explored students’ misconceptions through these methods, using class discussion and attempted to adapt his teaching to meet learners’ needs.

Matthew identified, as one of the main benefits of technology, the speed with which he could obtain feedback from students and display student work on the IWB for discussion and comparison. He also mentioned the advantage of students having “instant feedback” on their work through using, for example, *Mathspace* (See lesson 3 above). Even though he usually received homework and sent feedback electronically (using *Showbie*) he valued a system that could do this even more quickly and saw the potential for students to make significant gains in understanding without teacher intervention. Speed and accessibility of information were two features that seemed important to him in his perception of formative assessment. He was clearly confident in using a range of apps and felt able to adapt if the technology failed in some way. This helped minimize technical disruptions and kept the focus of the Fasted lessons on how technology could be of benefit in formative assessment processes.

Matthew also identified personal benefits from his involvement in the research. These concerned the level of detail in the lesson planning, including the anticipation of likely responses from students. In his interview he mentioned how he was made to “think explicitly about the questions we were using” in class discussions, considering the “specific wording” and how the teachers were trying to predict students’ responses more than they would usually have done. His view of the design process was that they were generally taking lessons that worked well without technology, then considering how they could structure them differently to use technology and also “think about whether or not technology adds anything to the process”.

This suggests that Matthew had a clear focus on using his knowledge of technology to try and enhance lessons. This was made possible by the context of the school in which technology was readily available and working smoothly. He commented that teaching in a school without technology would now be very difficult for him, and our observations of his lessons suggest that digital technology is well embedded into his preferred approach to teaching.

5. Lessons

Matthew was involved in the development of the three lessons described in the previous section and taught each of these to the same Year 9 class. These lessons had three very different purposes: to develop mathematical concepts, modeling skills and technical fluency, respectively.

The first lesson was observed and video-recorded but Matthew’s second and third lessons were only observed. The video recording involved the use of three cameras: two static cameras on pairs of students and one mobile camera following the teacher.

⁷ *Socrative* is an application that facilitates the development and use of classroom tests. The app processes the results and presents summaries back to the teacher. See: <http://www.socrative.com>

Video analysis was carried out using specialist software developed at the University of Nottingham (Centre for Research in Mathematics Education) using an existing framework (see Appendix E) to identify formative assessment opportunities followed by further analysis of the role of technology in these examples. In this process the Fasmad framework was used first and then an additional coding scheme was developed from the data to further examine different types of formative assessment using technology. In the following section the main features from the analysis of each lesson are described first and these are then followed in the final section by a summary of the dominant themes that emerged from the series of lessons.

Lesson 1: Distance-time graphs

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 teacher to send the tasks to the students electronically, receive their responses and display selected student work for the whole class to review. In this case the teacher generally gained an overview of student work in progress by observation as he walked round the classroom supporting students. Using the information gained during this time, in conjunction with the completed responses sent electronically, he was able to identify common misconceptions and select appropriate samples of student work for display as a basis for class discussion. Directed questions and open questions were used to stimulate the class discussion and expose the misconceptions. Matthew explained informally that his choice of using his own observations of students' work alongside the data provided electronically seemed the most effective and provided further evidence of a critical approach to support the statements in his interview.

Anticipation of the likely misconceptions and the use of carefully constructed questions to draw out students' thinking were, however, two key elements of this process that affected the effectiveness in practice. Although Matthew accurately predicted some difficulties, such as finding the speed from the graph, it was difficult to elicit student contributions to class discussion and their explanations often lacked depth. Matthew provided hints, for example using words such as 'steady pace' and drawing attention to the slope of the graph, to prompt students but there was some reticence from the class suggesting that, in some instances, alternative questions or approaches may have been more effective.

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 discussion was more limited. The purpose of both questions was to assess the prior knowledge of students and expose common misconceptions. This purpose was fulfilled by the questions and the technology provided the data for display and discussion.

Nested within this teacher-led formative assessment process were opportunities for students to engage in peer-assessment and self-reflection, firstly as they discussed the questions in pairs before submitting their individual answers and, secondly, for a similar type of peer and self-assessment as they viewed work from other students on the IWB. In this lesson, however, students appeared

reluctant to discuss their work with each other and gave only brief verbal responses to Matthew's questions in the class discussion. After observing subsequent lessons with the same group it seemed likely that this lack of discussion was not typical and probably caused by the presence of the video cameras. Although this constrained the amount of formative assessment that resulted from the planned opportunities it did highlight the benefits of providing multiple opportunities in different forms. Class discussion may have had limited effect on students' learning in this enactment of the lesson but students were still engaging in some peer and self assessment as they considered the sample work displayed.

The 'mirrored' questions potentially provided an interesting means of prompting rich discussion between peers but, again, this was only partially successful in this particular lesson. Firstly the students were again inclined to be quiet and not engage in much discussion. Secondly, time seemed short for the discussion part of the task and thirdly there was variability in the way the pairings worked when students were comparing their Set A and Set B answers. Some 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. In a few cases students had more extensive discussions and did not quickly agree, particularly if they had interpreted the one ambiguity differently. These pairs did challenge each other and spend time justifying their answers. 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.

Lesson 2: The meatballs problem

A variety of different methods were used in this lesson to make use of digital technology in a 'send and share' function, some of which facilitated different types of formative assessment within the lesson. These involved the use of iPads with Google Forms and *Showbie* for students to send their responses to problems and their working to the teacher. The teacher used this information in several ways, as detailed below.

Responses to the initial request, for students to decide on the question that the video illustrated, were gathered, displayed and used in a class discussion. The aim of this short activity was to agree on a problem that students would then work through during the lesson. Although the teacher had already made a decision about the question to be used, he had predicted that this would be one of the most common suggestions from students and therefore gave the impression that he was acting in response to their own suggestions. This actually worked as anticipated and students commenced work with an increased sense of ownership of the problem.

Students then had to estimate the number of meatballs that would fit into the pan without it overflowing and a Google form was used to send this information to the teacher, although this was not displayed until later in the lesson. This short task led to a class discussion about the information students would need in order to work out an accurate solution. The students made various suggestions and the teacher asked follow-up questions to identify the significant variables, increase the precision of their descriptions and assess prior knowledge. For example, the first suggestion given by a student was the volume of the sauce. The teacher asked if there was information that they could use to work this out and the students suggested the diameter of pan. Using an image on the

IWB the teacher provided this information and asked if there was anything else. A student suggested the height and the teacher asks “What height?” The students then suggested the height of the pan and the height of sauce in the pan. (In fact, the volume of sauce is not the significant variable here, but the volume of the pan *unoccupied* by the sauce. However, this may be calculated by subtracting the volume of the sauce from the volume of the pan, and this is in fact what these students appeared to be doing). Using this approach the teacher ascertained their level of understanding about volume without providing the actual formula and left students to discuss the methods to be used in their pairs.

Nested within the activities in this lesson were several opportunities for discussion in pairs, with the problem-solving task stimulating extensive conversations. During this activity students discussed their strategies and had to justify their reasoning, which meant challenging others, adapting their own thinking or sometimes acting as instructors for each other.

In the final class discussion some students were asked to present their solutions. Digital technology was again used to perform a ‘send and share’ function but this was primarily to support a student-led explanation of their work rather than a teacher-led discussion. Other students had the opportunity to engage in peer assessment and self-reflection during this presentation and the technology provided a clear visible image for this purpose. Following this sample of students work from the class, the teacher displays a different solution from another group of students. This was been chosen in advance by the teacher to present a different approach to the problem that would cause students to reflect on their own work, consider alternative methods and further extend their thinking. The sample acted as a prompt to move their thinking forward, in terms of the value of exploring alternative methods when attempting problems in the future and helped clarify the criteria for success with this type of activity.

The final comparison of initial estimates to actual solutions was an opportunity for reflection regarding the assumptions made and the reasons for different answers. Although curtailed due to the lack of remaining time in the lesson, this was an example of a strategy to engage students in a critical appraisal of their own work, highlighting the effects of making assumptions and, again, clarifying the criteria that would lead to success with similar problems where students needed to make decisions and develop strategies.

Lesson 3: Solving multi-step equations

In each section of the lesson there was formative assessment in various forms that was facilitated by the information *Mathspace* provided. This provided students with an interactive learning environment where the *Mathspace* software was the means for students to receive questions, send responses and receive direct feedback as individuals. The technology in this lesson performed more than just a ‘send and share’ or a ‘process and analyse’ function because it generated adaptive questions and supplied feedback to individuals in a form that prompted them to adjust their thinking.

The marking and ‘hints’ provided by the system made students self-assess and correct their own errors. This shaped and guided their thinking towards a correct process.

This lesson also provides an interesting example of students' reactions and behavior with an unfamiliar piece of software. The system was designed so there were restrictions on how and what students write. Some students found this frustrating and others argue that they did not understand the feedback given by the system. For example the instruction "Move variables to one side and constant terms to the other" was not understood by some students and therefore the feedback was ineffective without teacher intervention. The teacher had to explain various features of the software during the lesson and deal with technical frustrations, although one student did comment towards the end of the lesson that it he now found it easier to use the app, although it had seemed difficult at first. This illustrates that students' unfamiliarity with technology or with specific apps can affect attitudes and impede initial progress, highlighting the need for careful planning of how to introduce technology into the classroom. This may be viewed as a change process, not only about the teacher's decisions about how to use technology formatively in lessons but how to introduce the technology so that students respond positively to the demands placed on them. In this lesson the demands were technical and mostly temporary but these had an impact on student progress despite the group's familiarity with technology in general.

Meanwhile the teacher was provided with information on student progress so this helped the teacher to identify common misconceptions and make decisions on when to intervene to support individuals or initiate a class discussion to deal with a widespread misconception. The accessibility of student work helped the teacher find suitable samples to display for discussion to deal with these misconceptions.

In the paired activity using worked examples, students acted as assessors, imitating the type of feedback given by *Mathspace*. This was a means of helping them clarify their own thinking and the criteria for success.

Main themes in the lessons

In these lessons technology was used in a variety of ways with different apps to suit the type of formative assessment process being planned. In the first two lessons the technology performed a 'send and share' function that allowed Matthew access to students' responses from which he could monitor progress and identify misconceptions. Being able to select and display students' responses on the IWB provided opportunities for Matthew to question students about their work and also ask students to make comments and thus generate purposeful class discussions. The display of student work also prompted some students to engage in peer assessment and self-reflection, whilst students who provided answers to Matthew's questions were sometimes acting as a resource to instruct others.

The effectiveness of these class discussions for formative assessment was, however, dependent on students being willing and able to critically review the samples of work and provide coherent explanations. This was a particular difficulty in the first lesson where students were reluctant to participate in the class discussions. The need to think about what misconceptions might arise in advance and exactly what questions to ask were identified as areas for this group of teachers to consider in subsequent lesson plans.

In the second lesson (meatballs) there was greater participation from students in the class discussions. The teachers had considered carefully what questions they would ask and had also planned strategies to give students greater ownership of their learning, such as asking them to suggest what the problem was that they would solve and what information they would need.

Collaboration and discussion between students was an area on which this team of teachers wanted to focus and several approaches were explored in the lessons, using iPads in different ways. When students were answering questions using their individual iPads they were encouraged to discuss their work and this had some value as peer and self-assessment activity was taking place. This student-focused formative process often took place as a 'nested' activity within a broader teacher-led process of sending questions, receiving students' responses and using these formatively. Other strategies were explored in these lessons that offered some potential for increased collaboration, such as the discussion of the 'mirrored' questions in lesson 1 and the group work on the 'meatballs' problem. Although these were not always as effective as expected, there was some evidence of increased collaboration and scope for more with further refinement.

The third lesson, in which *Mathspace* was used, provided an example of how students might work within a digital interactive learning environment to practice procedural skills in solving equations. In this lesson students mostly worked individually with little collaboration between peers except in the final paired activity. This is perhaps appropriate because the purpose was to develop fluency, rather than conceptual understanding or problem solving strategies. Individual students were engaged in formative assessment through the feedback and adaptive questions provided by the electronic system, rather than with their peers or the teacher. This also affected the teacher's activity in the classroom since the system provided detailed information on student progress that Matthew could monitor and use to plan where and when to intervene. In practice, Matthew also circulated around the class to observe, question and support students in a more integrated approach rather than solely relying on the technology

Matthew's technical knowledge and fluency with the use of various apps was a strong feature in his teaching and proved particularly useful during the research in various ways. On a practical level there were less disruptions to planned lessons due to technical problems because these were swiftly addressed. Possible technical difficulties were considered in lesson planning, solutions were found and contingency plans were often in place. Secondly his technical competency, coupled with the students' familiarity with iPads, provided an environment in which there was scope to creatively explore different approaches to using technology in formative assessment. Therefore, for Matthew there was more emphasis on the development of formative assessment processes during the research than on discovering how to use the technology.

Matthew's intention was to integrate the use of digital technology in a way that brought benefits to himself as a teacher and to the students. This aim was evident in both the planning of the lessons and in his reflections afterwards where benefits such as the speed of obtaining information and the accessibility of student data were highlighted. The questions raised informally in lesson planning meetings at this school were often about how the technology could be used to efficiently perform a specific function within a formative assessment process, leading to the selection of a specific app for a rather clear purpose. This contrasted with the approach in other schools where the software was sometimes decided before developing the lesson. Technology was integral part of Matthew's thinking and therefore was easily embedded into his lessons.

6. Pupil perceptions

There was evidence (Q sort activity) that this group of students were not particularly confident with mathematics and found the subject more difficult than the other case study group in the study (Case

study 2). Technology was however seen by these students as a useful tool to help them understand where they had gone wrong and to inform the teacher about their progress. They agreed with their teacher that technology was used frequently in mathematics lessons and was useful, although they expressed a preference for talking to the teacher rather than relying on the technology.

The three lessons designed and used with this class were clearly identified by students as being different from their normal mathematics lessons. From their perspective this was mainly due to the different structure of the lessons and to the amount of collaborative working involved, in pairs and small groups, rather than the use of technology.

The students described a normal lesson as falling into a fairly predictable pattern: class discussion first, then individual work on questions (with teacher support as required) and finally marking the answers. The meatballs and distance-time lessons were identified as having more variety in the use of different apps and more frequent changes of activity.

“But those lessons, it was less structured, not what we’re used to. So it was more like, we’re gonna do this for five minutes, then we’re gonna swap to this, I’m gonna use this app and you gotta do this. It was different from how we normally learn in our maths lessons.” (Annie)

In particular some students recognized that the meatballs lesson was about problem solving, although there was disagreement about how much they needed to develop these skills. For several students in the focus group the main purpose of mathematics lessons seemed to be to pass an examination and this was a priority that dominated their thinking. There were indications (from the Q sort activity) that students in this focus group generally found mathematics difficult, frustrating and repetitive, believing that the subject required right and wrong answers with little scope for self-expression. The meatballs lesson clearly contrasted with their normal expectations of lessons but raised doubts about whether the skills being developed were important within their established perceptions of the subject.

Secondly the students recognized that these lessons, particularly those on concept development (distance-time graphs) and modeling (meatballs), involved more collaborative work, as Annie commented, in the focus group “They were really, like, group-involved” (Appendix C). In this respect the students’ comments reflected the intentions of the teacher to explore more collaborative methods when using iPads and there was evidence (from the Q sort activity) that the students saw technology as a tool that supported them when working together. These comments were not entirely consistent with the lesson observations however, where it appeared that discussion between students was sometimes quite limited. The students contrasted these lessons with the one in which *Mathspace* was used to develop fluency with technical skills, explaining that this was more individual since they were always working on different questions and unable to confer. The difference appeared to be about having the opportunity for useful collaboration rather than how well the students actually used the time.

The students also discussed extensively how the first two lessons (the meatballs lesson in particular) had some connections to real life.

“When we did the meatball thing, it was more trivial, I suppose. It was, it just showed something, the ease in real life, whereas we’re used to being shown an equation and then we’ll just keep doing different versions of that equation”.
(Leonne)

The authenticity and the value of such types of activity were however debated between the students. Some appreciated the links to real life, claiming that this was “more practical”, highlighting how mathematics was useful outside the classroom and providing a purpose for learning the subject.

“I think that makes it better because you learn something. A couple of months ago, you think what’s the point in learning that? We’re not gonna use it, and then it reappeared in this scenario that you never thought would happen”.
(Edward)

Other students questioned whether they would ever calculate how many meatballs would fit into a pan and suggested that this would not help them with the prime aim of mathematics lessons which, in their opinion, was to pass an examination.

Students’ responses to *Mathspace* were mixed. The technical difficulty of adjusting to a new electronic system was accompanied by other observations from the students about disadvantages of the structured approach. As Edward explained:

“... it was very structured and if you didn’t do the slightest thing absolutely right, to the “T”, it would make you re-do it over and over again.”

This was frustrating for students because it caused tensions with their existing practices in two ways. Some students were confident about solving equations but were not used to writing out their working line by line in the way expected by *Mathspace*. Although from a teacher’s viewpoint, this may be valuable as a means of developing good habits, it was an enforced discipline that some students resented. Secondly, the use of *Mathspace* followed from previous work on solving equations and sometimes the hints or explanations offered by the system conflicted with their established ways of thinking. Challenging existing practices can provide useful cognitive conflict, particularly when reasoning needs adjusting, but in this case the alternative approach offered by *Mathspace* seemed unproductive for students who were employing an appropriate, but different, method.

7. Key issues

A number of key issues arise from the above analysis, concerning both the lessons and the professional development of the teacher. These are briefly described below with reference to a framework of five key formative assessment strategies (A-E), three actors (teacher, student and peers) and three major functions of the technology (see Appendix E).

Within the lessons there was evidence of nested formative assessment processes over different time periods in which data on student responses to questions were used to modify teaching whilst the lesson was in progress. The formative strategies planned into the lessons included ones that were teacher-focused but consideration was also given to how student-led strategies could be employed, particularly through collaborative work.

Matthew frequently initiated and tried to develop class discussions to elicit evidence of students’ understanding (Strategy B), often using the ‘send and share’ function provided by a range of different apps to collect and display student work using iPads and the IWB. There was variety in the technology used but also evidence that the teachers at this school considered carefully which app would work best for the purpose intended in each lesson. Despite the strong emphasis on using iPads in the school and Matthew’s position as the lead for technology, he sometimes made decisions to use paper-based or verbal methods in situations where he assessed these as potentially being more effective. This critical approach to the use of technology to perform specific functions within a formative assessment process was a strong feature of the planning process.

By displaying samples of student work and asking students to explain their answers to the class, Matthew was able to initiate purposeful class discussions. Within these discussions there was some evidence of students being activated as instructional resources for one another (Strategy D) although students' explanations often lacked the accuracy and detail to be useful to others. In the video-recorded lesson there was an uncharacteristic reticence of students to engage in extended discussion and this limited the effectiveness of the planned formative strategy on this occasion.

In class Matthew often sent questions electronically for students to complete individually on their iPads, as means of eliciting evidence of understanding (Strategy B). Students were encouraged to discuss their work in progress before sending their individual responses and were sometimes acted as instructional resources for each other (Strategy D) during this informal collaboration and comparison of ideas. Additional opportunities for student collaboration were planned into some lessons where, for example, students worked on a problem together ('meatballs') or peer assessed their answers to 'mirrored' questions. These provided some opportunities for students to act as instructional resources for each other (Strategy D) and to increase ownership of their own learning (Strategy E). The approach taken in lesson 2 ('meatballs'), where students were asked to pose the initial question for investigation and suggest what information they needed to solve the problem, was strongly orientate towards increasing students' ownership of their own learning (Strategy E).

In all these lessons students received feedback to help them move forward (Strategy C) at intervals but this was generally provided by the teacher or their peers. In the third lesson students received feedback most frequently from the *Mathspace* system via their iPads through marked responses and hints. When the adaptive mode of questioning was used, this also became the main influence that guided their progression through the levels of difficulty within the program. The system provided two formative assessment assessment processes. In one function the technology posed the questions, received the student's responses, assessed these and provided feedback (Strategy C) that might also clarify the criteria for success (Strategy A). In addition the system used the student's sequence of responses to adapt the subsequent questions and, in effect, performed a similar function to that of a teacher when they assess students' understanding and respond by adapting the lesson plan.

In these lessons there were some clear examples where using the technology brought benefits for both the students and the teacher. Matthew's own conclusions, as explained in his interview, were that sometimes technology did add benefits but at other times it did not. With respect to increasing collaboration, which was one of the aspects Matthew wanted to explore, he remained undecided about the precise outcomes but believed that they had managed to use the tasks "fairly collaboratively".

Matthew also referred to gaining a greater understanding of the importance of formative assessment and the value of "displaying (student) solutions and discussing things" through his participation in the research. There was evidence that he and his colleagues better appreciated the value of detailed planning. As time progressed they began to more thoroughly anticipate possible student responses, potential misconceptions and plan questions to elicit useful responses from students in class discussion. The use of technology was not a problem for these teachers but their explorations during this research showed how the accompanying pedagogy was vital to ensuring formative assessment using technology was effective. The development and use of teaching skills that supported the technical functions provided electronically was a key element in planning formative assessment opportunities into these lessons.

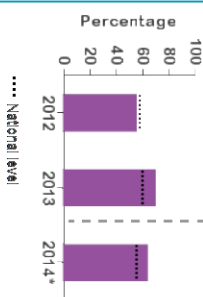
The group of teachers at this school worked in close collaboration with each other (and with the research team) to produce the lessons, taking a creative approach to solving problems and making useful adaptations to improve the lessons in the light of suggestions from the researchers. By sharing knowledge and supporting each other they acted as small but effective learning community in the school and this helped them to achieve some useful outcomes from their participation in the research.

How are pupils doing in exams? (Attainment)

Overall

In 2014, 63% of all pupils attained five GCSEs grade A*-C including English and mathematics.

Percentage of pupils who attained five GCSEs grade A*-C including English and mathematics



*2014 results are not comparable due to changes

In 2014, the school's result was in the top 40% of similar school results, and in the top 40% of all schools.

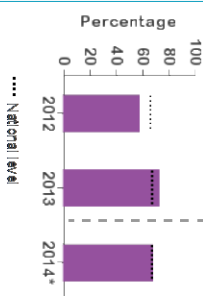
Comparison with other schools

Similar schools					All schools				
Highest					Highest				
2nd quintile					2nd quintile				
3rd quintile					3rd quintile				
4th quintile					4th quintile				
Lowest					Lowest				

English

In 2014, 67% of pupils attained grade A*-C in English (EBacc).

Percentage of pupils who attained grade A*-C in English (EBacc)



*2014 results are not comparable due to changes

In 2014, the school's result was in the bottom 40% of similar school results, and in the middle 20% of all schools.

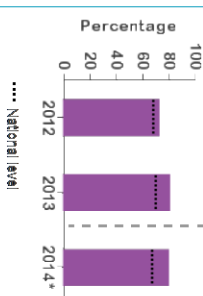
Comparison with other schools

Similar schools					All schools				
Highest					Highest				
2nd quintile					2nd quintile				
3rd quintile					3rd quintile				
4th quintile					4th quintile				
Lowest					Lowest				

Mathematics

In 2014, 79% of all pupils attained grade A*-C in mathematics (EBacc).

Percentage of pupils who attained grade A*-C in mathematics (EBacc)



*2014 results are not comparable due to changes

In 2014, the school's result was in the top 40% of similar school results, and in the top 20% of all schools.

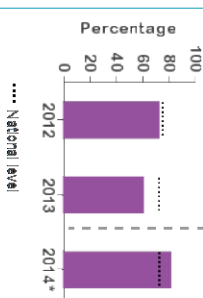
Comparison with other schools

Similar schools					All schools				
Highest					Highest				
2nd quintile					2nd quintile				
3rd quintile					3rd quintile				
4th quintile					4th quintile				
Lowest					Lowest				

Science

In 2014, 72% of pupils were entered for science (EBacc) and 61% of these attained grades A*-C.

Percentage of pupils who attained grade A*-C in science (EBacc)



*2014 results are not comparable due to changes

In 2014, the school's result was in the middle 20% of similar school results, and in the top 40% of all schools.

Comparison with other schools

Similar schools					All schools				
Highest					Highest				
2nd quintile					2nd quintile				
3rd quintile					3rd quintile				
4th quintile					4th quintile				
Lowest					Lowest				

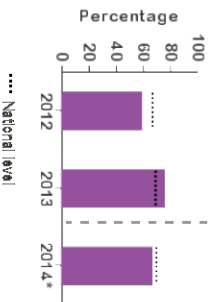
The data presented in this report are Key Stage 4 and are final. Data source: Department for Education. Similar schools are those schools which have a similar prior attainment score to this one.

Are pupils making progress?

English

In 2014, 98% of pupils achieved expected progress in English.

Percentage of pupils who achieved expected progress in English



*2014 results are not comparable due to changes

In 2014, the school's result was in the bottom 40% of similar schools' results, and in the bottom 40% of all schools.

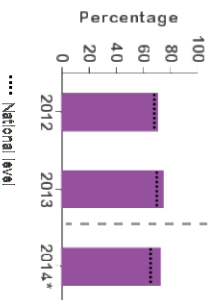
Comparison with other schools

Similar schools					All schools				
Highest					Highest				
2nd quintile					2nd quintile				
3rd quintile					3rd quintile				
4th quintile					4th quintile				
Lowest					Lowest				

Mathematics

In 2014, 72% of all pupils achieved expected progress in mathematics.

Percentage of pupils who achieved expected progress in mathematics



*2014 results are not comparable due to changes

In 2014, the school's result was in the top 40% of similar schools' results, and in the top 40% of all schools.

Comparison with other schools

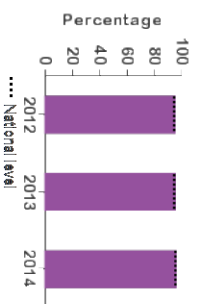
Similar schools					All schools				
Highest					Highest				
2nd quintile					2nd quintile				
3rd quintile					3rd quintile				
4th quintile					4th quintile				
Lowest					Lowest				

How good is attendance?

Overall attendance

In 2014, the attendance rate at this school was 85.3%. The attendance rate has increased by 0.3 percentage points since 2013. The attendance rate is in the top 40% of all schools

Level of attendance at this school



Comparison with other schools

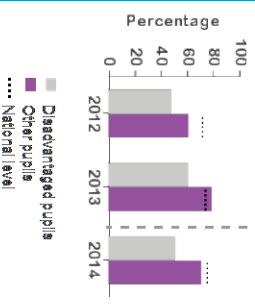
All schools				
Highest				
2nd quintile				
3rd quintile				
4th quintile				
Lowest				

Closing the gap between disadvantaged and other pupils

English Expected Progress

In 2014, 50% of disadvantaged pupils achieved expected progress, while 70% of other pupils achieved expected progress.

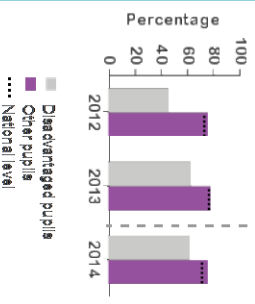
Percentage of pupils who achieved expected progress



Mathematics Expected Progress

In 2014, 61% of disadvantaged pupils achieved expected progress, while 75% of other pupils achieved expected progress.

Percentage of pupils who achieved expected progress



The data presented in this report are Key Stage 4 and are final. Data source: Department for Education. Similar schools are those schools which have a similar prior attainment score to this one.

Context

Contextual data are provided at school level and at year group level for those pupils reflected in the dashboard measures. Quintiles are provided for the latest year of data to enable users to view the school's position when compared nationally. The data presented in this section are taken from the January Schools Census.

2012 2013 2014

Comparing your school to the national picture in 2014

Number of pupils

School (All pupils)	1851	1860	1922
National average	990	978	957
Year 11 pupils (KS4)	308	308	305

Lowest	4th quintile	3rd quintile	2nd quintile	Highest
8 - 617	618 - 845	846 - 1047	1048 - 1289	1290 - 2690

% of girls

School (all pupils)	50.9	51.5	51.2
National average	49.6	49.6	49.7
Year 11 pupils (KS4)	48.7	58.1	54.4

Lowest	4th quintile	3rd quintile	2nd quintile	Highest
0.0 - 45.8	45.9 - 48.1	48.2 - 49.6	49.7 - 51.5	51.6 - 100.0

% of pupils eligible for Free School Meals (FSM) *please see note

School (all pupils)	21.9	22.7	23.5
National average	26.7	28.2	28.5
Year 11 pupils (KS4)	18.2	19.2	22

Lowest	4th quintile	3rd quintile	2nd quintile	Highest
0.9 - 14.4	14.5 - 21.6	21.7 - 30.6	30.7 - 44.2	44.3 - 94.1

% of pupils supported by school action plus or with a statement of SEN

School (all pupils)	5.0	5.0	4.7
National average	8.1	7.7	7.3
Year 11 pupils (KS4)	14.9	15.9	14.4

Lowest	4th quintile	3rd quintile	2nd quintile	Highest
0.0 - 4.1	4.2 - 6.0	6.1 - 7.9	8.0 - 10.8	10.9 - 43.1

SEN year group data includes school action, school action plus and statement of SEN. These data are not comparable to the school or national level data as they do not include school action pupils.

The data presented in this report are Key Stage 4 and are final. Data source: Department for Education. Similar schools are those schools which have a similar prior attainment score to this one.

Extracts from most recent inspection of Academy by OfStEd (November 2014)
Selected parts are relevant to FASMED.

Following my visit to the school on 7 November with Chris Chapman AI, I write on behalf of Her Majesty's Chief Inspector of Education, Children's Services and Skills to report the inspection findings. During the inspection, we spoke with the Principal and other senior staff, the head of science and head of sixth form, students from different year groups and the Chair of the Governing Body with three other governors. We visited classrooms and scrutinised students' books, and discussed the Academy's recent performance data. We noted the analysis of 186 recent responses to the Ofsted questionnaire, Parent View.

This Academy continues to be a good school.

The Academy has the following strengths.

- Effective strategic and senior leadership has continuously driven rising academic standards since the previous inspection in April 2012. The primary feature behind this improvement is the detailed, regular assessment and monitoring of student progress that informs teachers' planning and also additional individual student support.
- Inspectors noted effective teacher-student dialogue in the small sample of lessons observed, that promotes good or better learning. This allows teachers to adjust their input to accommodate different students' rates of progress. In the best examples, students have high levels of autonomy, coupled to challenging activities, that encourages students to apply their knowledge, skills and understanding to new situations.
- All Key Stage 4 and sixth form students are issued with iPads. These are in constant use, with some exceptionally innovative practice evident, for example, in mathematics. Students submit images of their handwritten work, which teachers electronically mark with developmental feedback; this can be spoken individual feedback explaining the steps to solve a problem. In other subjects, instant access to research and information accelerates learning and allows students to use the most up to date information to illustrate phenomena such as earthquakes and volcanoes.
- Students enjoy learning, know how to improve their work, try hard to do so and appreciate the mix of additional support available if they need it. All Year 11 students in 2014 moved into education or training.
- Attendance and other indicators of positive student behaviour are above average, including low levels of exclusion and consistent resolution of the rare bullying incidents.

Areas for further development

- Further improve the consistency of marking and feedback so that students take immediate action to correct, improve or complete their work.
- Ensure questions by teachers promote complex and well-thought out explanations by students, in a setting that ensures every student is participating in discussions.

I hope the short inspection will support your work to improve the Academy.

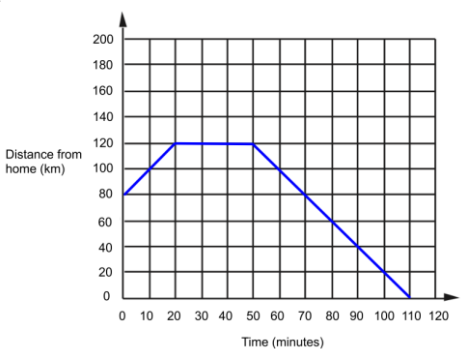
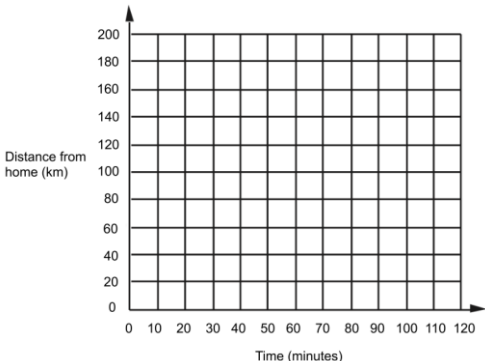
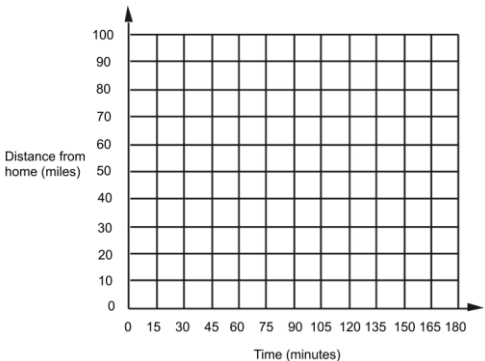
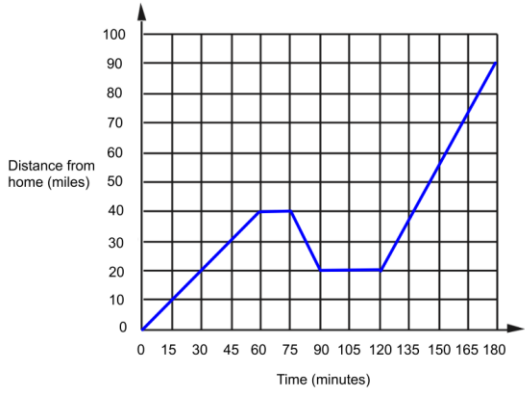
Yours sincerely

Brian Cartwright

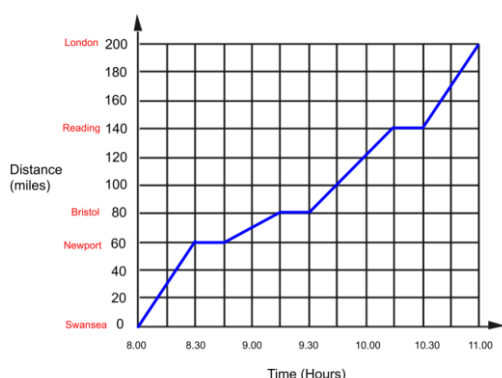
Her Majesty's Inspector

Appendix B: Tasks and lessons

Lesson 1: Distance - time graphs

Set A	Set B
<p><u>Speed Distance Time Graph 1</u></p>  <p>Complete the story below from the graph.</p> <p>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.</p>	<p><u>Speed Distance Time Graph 1</u></p>  <p>Complete the graph based on the story below.</p> <p>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.</p>
<p><u>Speed Distance Time Graph 2</u></p>  <p>Complete the graph based on the story below.</p> <p>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.</p>	<p><u>Speed Distance Time Graph 2</u></p>  <p>Complete the story below from the graph.</p> <p>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.</p>

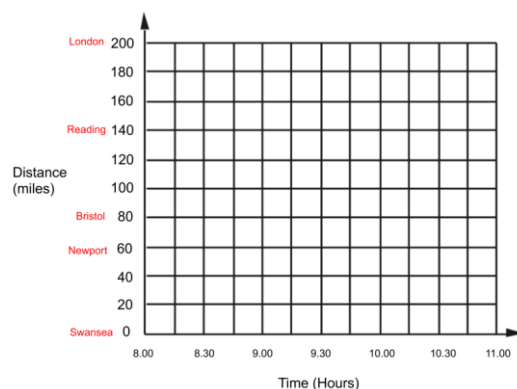
Speed Distance Time Graph 3



Complete the story below from the graph.

A train leaves _____ at 8.00am travelling to _____ at a _____ speed of _____. The train waits for _____ minutes at _____. The train then continues on to _____ at a constant speed of _____, where it is _____ for _____ minutes. The train then departs for _____, travelling at a _____ speed of _____ for _____ minutes. After waiting in _____ for _____ minutes, the train then completes its journey to _____, travelling at a _____ speed of _____.

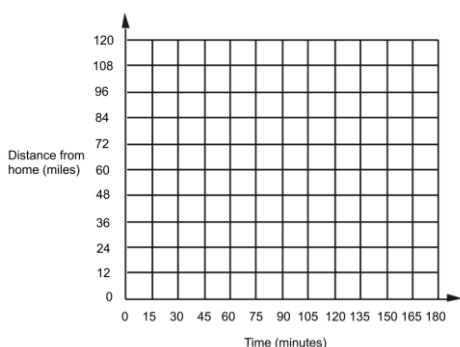
Speed Distance Time Graph 3



Complete the graph based on the story below.

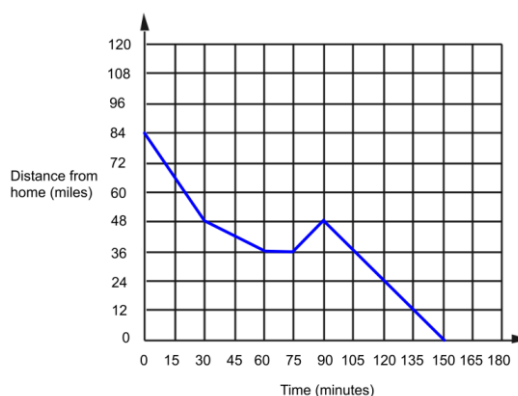
A train leaves **Swansea** at 8.00am travelling to **Newport** at a **constant** speed of **120 mph**. The train waits for **15** minutes at **Newport**. The train then continues on to **Bristol** at a **constant** speed of **40 mph**, where it is **stationary** for **15** minutes. The train then departs for **Reading**, travelling at a **constant** speed of **60 mph** for **45** minutes. After waiting in **Reading** for **15** minutes, the train then completes its journey to **London**, travelling at a **constant** speed of **120 mph**.

Speed Distance Time Graph 4



Sonia is driving home from her friend's house. She begins her journey at a **constant** speed of **72 mph** for **30** minutes. She then hits some traffic and her speed slows to **24 mph** for **30** minutes. The traffic then becomes stationary for **15** minutes. Sonia decides to take a detour and drives away from home at a **constant** speed of **48 mph** for **15** minutes. She then takes a different route home, travelling at a constant speed of **48 mph** for **60** minutes.

Speed Distance Time Graph 4

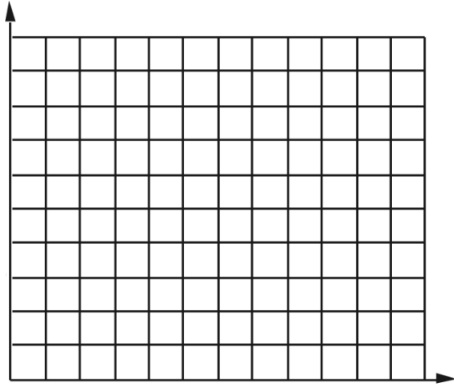


Write a story to match this graph. Try to use key information similar to that used in earlier stories.

Speed Distance Time Graph 5

Use the graph below and space below to design a distance time graph and a matching story.

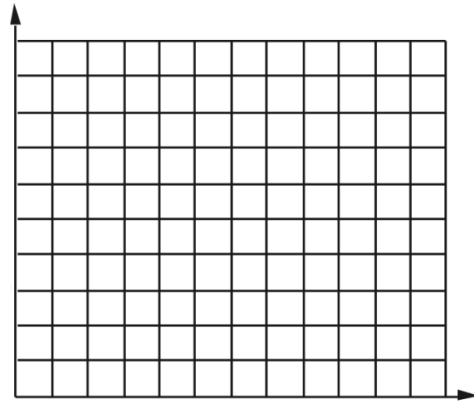
Your journey must include at least 3 different speeds of travel and a minimum of two stationary points. Time travel is not allowed.



Speed Distance Time Graph 5

Use the graph below and space below to design a distance time graph and a matching story.

Your journey must include at least 3 different speeds of travel and a minimum of two stationary points. Time travel is not allowed.



CONTEXT

School	Academy A			Observer	Diane Dalby	
Class	Year and set	Year 10		Teacher	MATTHEW	
Date & time	Date	26/02/15	Start	8.50	End	9.50
Student numbers	Present	24	Male	8	Female	16
Room layout	Students all seated in pairs at desks.					

LESSON STRUCTURE

Time	Activity	T	FA
8.50	Introduction. Students asked to open up Showbee and look at graph and write story. Teacher circulates to check progress. Students work on iPads individually. Fairly quiet.	T1 T2	TMG
9.00	Teacher shows example where story does not quite match and is incomplete. Asks if any student disagrees. Turns back to student who explains. Teacher also interprets. Second example shown and students asked to comment. Teacher asks further question about slope of graph. Student explains student has decided he needs to walk faster and speed up. Teacher picks up implication of quicker speed and asks for more explanation. Student mentions gradient (reinforced as good use of terminology). Teacher asks for more and student explains how they could calculate speeds. Students provide answers and asked to explain how they got these. Class still quiet, raising hands to offer answers or responding to directed questions. Students also raised hands to offer extra comments. Third example selected. Teacher suggests there's a word here that was not in the others. Student selects 'steady' and asked for further explanation. Teacher introduces term constant speed.	T3	TWC TSW
9.12	Students given second task to draw graph from story. Teacher intervenes and suggests reading question carefully. Prompts such as where is the line starting from? Teacher intervenes and suggests many have an error. Draws on board. What is the error? Student explains and explanation is reinforced by teacher. Students continue with the task in pairs. Some work individually and then compare. Others work together.	T2	TWC
9.22	Teacher shows one example on board. Students are asked if any disagree with the graph, apart from difficult of drawing straight line. No disagreement. So one student asked to explain how they did the first part. Teacher talks about second section, asks how students calculate this. Did anyone do this another way? Another method suggested by	T3	TSW TWC

	student.		
9.28	<p>Students work in pairs on Set A or Set B questions. Not told these match up but that they will have chance to discuss them later. Teacher picks up on some errors individually, questions and explains. Not much discussion in pairs.</p> <p>Students handle zooming in and out easily. Tend to count squares and calculate without paper or calculator quite readily. Constantly scrolling up or down, zooming in and out to complete questions but doesn't seem to be a problem for them.</p>	T2	SPG TMG
9.42	<p>Students swop places into new pairs or small groups to compare answers. Teacher suggests that they should look at question 2, see if they agree or disagree.</p> <p>Teacher selects a sample student answer that disagrees with the given graph and shows this on the IWB. Students are asked to comment. The teacher argues about the case briefly with one student in the following discussion and suggests her answer may be better.</p>	T2 T3	SPG TWC TSW

TWC = Whole class intervention and questioning

SPG = Student interaction with peers during group work

TMG = Monitoring and assisting individual students

STG = Student interaction with teacher during group work

TSW = Using sample student work

USES OF TECHNOLOGY

Code	iPad/laptop/IWB	Software	Activity	Link to formative assessment
T1	IWB		Display	Diagnostic questions
T2	iPad	Showbie	Students work on tasks and record answers.	Some collaboration between peers.
T3	iPad and IWB	Showbie	Selected student work	Possibility of highlighting and discussing misconceptions

REFLECTION

In the first part of the lesson the initial two questions were used diagnostically to expose misconceptions and discuss these to correct student thinking. The common misconceptions that arose had been anticipated by the teacher and were addressed by selecting and displaying samples of students' responses for class discussion. This was hampered by some reluctance to speak aloud that may have been caused by the presence of the cameras and observers. The class discussion was therefore limited in its effectiveness and more dominated by explanations from the teacher rather than students. Discussion between pairs of student during their work on the questions, which had been expected by the teacher and encouraged, also seemed limited, perhaps for the same reason.

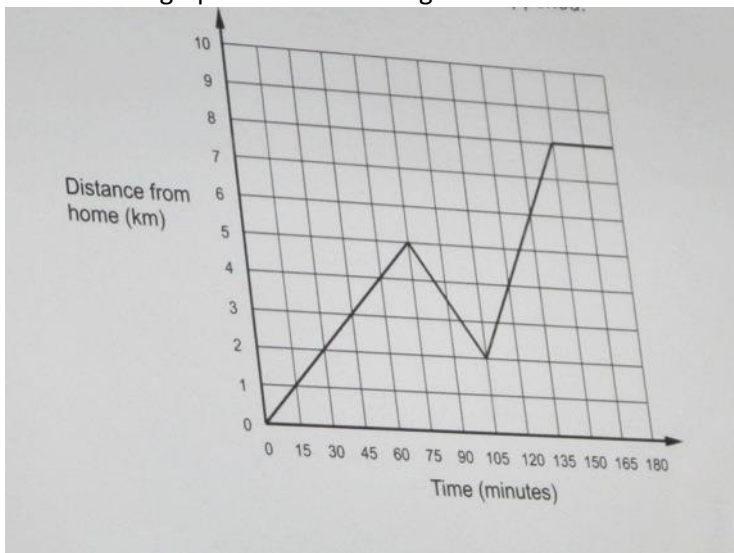
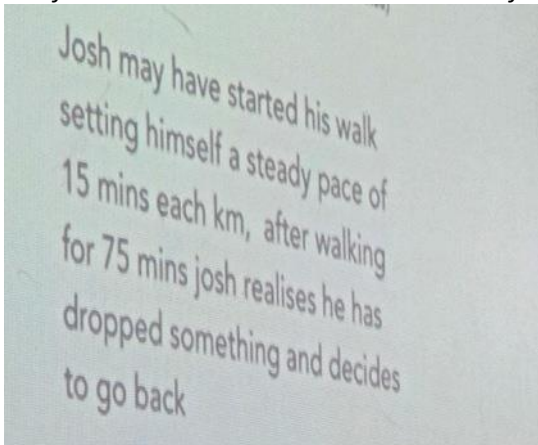
The Set A and B questions were carried out in a similar way with some interaction and discussion between pairs. The comparison of solutions between students in their new pairs/groups generated some discussion and students did engage in peer assessment although sometimes this was only by marking work with a tick or cross. In some pairs/groups there was more discussion, particularly about question 2 where there was an anomaly in the question.

CONTEXT

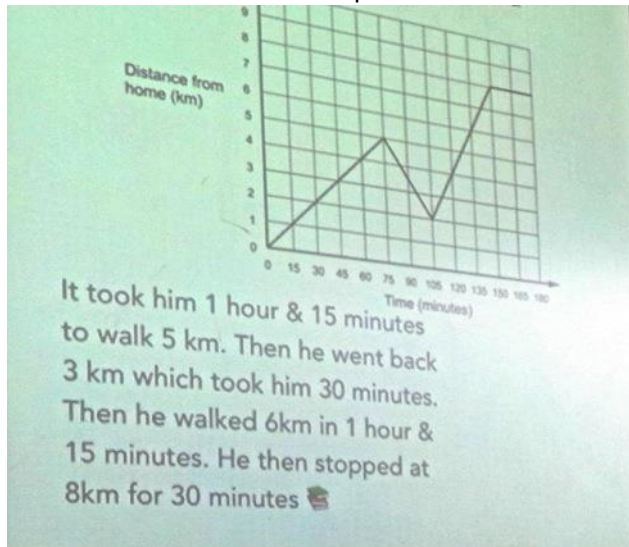
School	Academy A			Observer	Malcolm Swan	
Class	Year and set	10		Teacher	MATTHEW	
Date & time	Date	26/2/15	Start	8.55	End	9.57
Student numbers	Present	24	Male	8	Female	16
Room layout						

LESSON STRUCTURE

T = Teacher; P = Pupil

Time	Activity	T	FA
8.55	<p>T: In Showbie I've put 4 things. Open up the file called Writing a story. Complete it in Showbie so that I can see it on the board in a few minutes. Write something that matches the graph. That would be great.</p>  <p>T: You have 2 minutes max. <i>Then, a little later:</i> T: 30 seconds to finish your journeys off.</p>		
9.00	<p>T: If you could all press "done" so that is sent in to me. <i>The file is now loaded on the screen at the front of the room.</i></p>  <p><i>Teacher projects the first story.</i></p>		

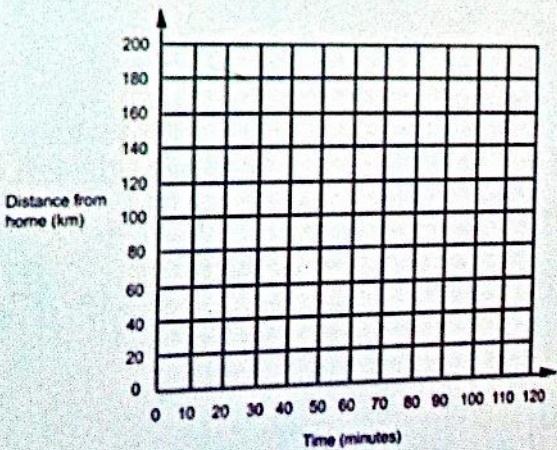
T: Anyone got anything they disagree with?
 Alex: He didn't go all the way back to the house.
Lucy justifies her answer.
 T: I think the information in here is all correct.
 Lets look at another example.

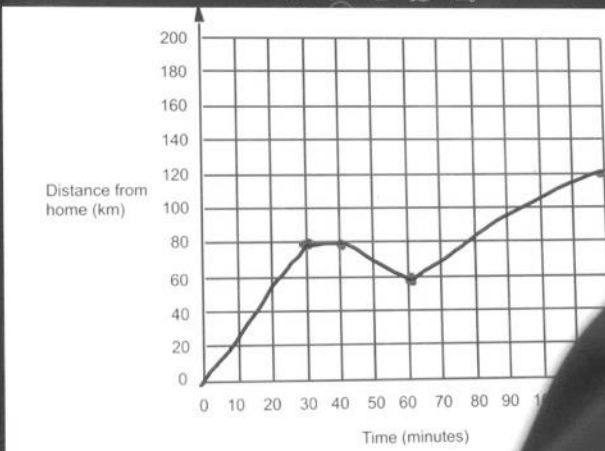
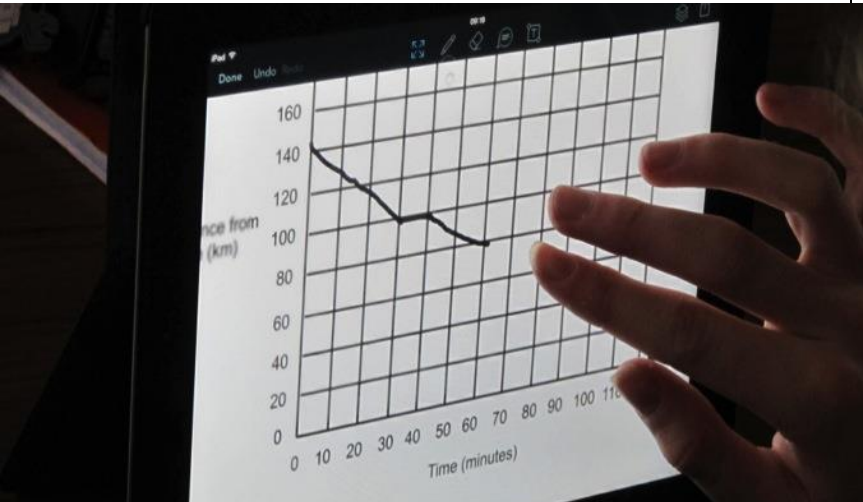


T: Any disagree? How do we know it stopped at end.
 P: Goes straight.
 T: What extra information could be given? Are the three lines as steep as each other?
 P: Some are less steep.
 T: What is that telling me?
 C: He realised he needed to speed up a little bit because he has lost time. The line has a higher gradient.
 T: Nice use of the word. Take further? How fast is he traveling?
 Charlie: The gradient is 1, on the second it's two. 1 km every 15 minutes, on the second one its 2 km every 15 minutes. 4 km per hour.
 T: You just read it from 60 didn't you. That is a key piece of information? Imogen is only one. She didn't use specific units, but did say that he sped up a bit.
 T: How many km In how many minutes?
 Luke 3 km in 30 minutes.
 T: How would I say speed with proper units? 6 km/h. How would I get the speed of the last part? Patrick?
 P: Find out how far in total. 45 minutes. 6 minutes.
 T: So if I travel 6 km in 45 minutes (corrects himself). 2 km in 15 minutes, either add together or times by 4, 8km per hour. Could I have done this easier way? Josh?
 J: No
 T: Will?
 W: the first has gradient of 1, second is gradient of two.

T explains how using the different ways. Something else that was mentioned. Talya.

T: Which word here has not been included so far?

	<p>P: Steady.</p> <p>T: Because he goes at a specific pace. There is an argument as to whether or not that is possible, but this is a key phrase – this has to be there.</p> <p>T: Your next task is to open up a story, you have to have a good read of it and then try to provide me with a picture of the graph – as accurately as you can.</p> <div data-bbox="373 400 1061 1261" data-label="Figure"> <p style="text-align: center;">A long drive home</p> <p>Sarah left her friend's house at 5pm. Her drive home was expected to be 140km. She travelled at a constant speed of 80km/h for 30 minutes. She was then stuck in a stationary traffic jam for 10 minutes. The traffic then began moving at a constant speed of 60km/h for 20 minutes. Finally, the traffic cleared and she completed her journey home at a constant speed of 120km/h.</p> <p>Complete the graph for Sarah's journey.</p>  </div>		
9.13	<p><i>Students work silently.</i></p> <p><i>Then they chat quietly.</i></p> <p><i>Most make the mistake that the graph should begin at the origin.</i></p> <p><i>For example:</i></p>		

	<p style="text-align: center;">A long drive home</p> <p>Sarah left her friend's house at 5pm. Her drive home was expected to be 140km. She travelled at a constant speed of 80km/h for 30 minutes. She was then stuck in a stationary traffic jam for 10 minutes. The traffic then began moving at a constant speed of 60km/h for 20 minutes. Finally, the traffic cleared and she completed her journey home at a constant speed of 120km/h.</p> <p>Complete the graph for Sarah's journey.</p> 	
9.20	Tom intervenes to point out the mistake.	
	<p>Students continue working, producing a variety of graphs, they struggle with the downward gradient.</p> <p>T: Press “done” again and have those sent in so we can have a look. Lets ignore the wobbly line. Any disagreements?</p> <p>P: No</p> 	

	<p>T: Lets talk about how we got there then? How did you decide down 40 km in 30 minutes?</p> <p>P: In first half hour 40 km. Then stuck in stationary jam for 10 minutes. Traffic then started to move.</p> <p>T: Some of us have had an issue that the graph has gone up. What would this mean? Back to where she would have begun. I don't think that is suggesting that. Emily, 60 km/h in 20 minutes, what distance would be covered?</p> <p>T: How many 20 minutes, 20.</p>		
	<p>The graph shows distance from home in kilometers on the y-axis (0 to 200 in increments of 20) and time in minutes on the x-axis (0 to 120 in increments of 10). The line starts at (0, 140), decreases linearly to (40, 100), remains horizontal at 100 km from 40 to 50 minutes, and then decreases linearly to (100, 0).</p>		
	<p>T: The last bit is the interesting bit here. Few issues. It tells me she gets home. But how do you discover how long it will take her? How do I fill in this last bit?</p> <p>Charlie. 120 km/h means in 10 minutes 20 km. She has 80 to get home, so if every 20 minutes she does ... 40 minutes.</p>		
9.29	<p>T: The next task is a bit different. Every one on left side complete A. (Graph to story) Everyone on right side complete B. (Story to Graph) Then do match up and compare. 15 minutes or so to have a go.</p>		

	<p>Speed Distance Time Graph 1</p> <p>Distance from home (km)</p> <p>Time (minutes)</p> <p>Complete the story below from the graph.</p> <p>James is at his friend's house, which is <u>80 km</u> from his house. He travels away from his house to see his Grandma at a <u>Constant</u> speed of <u>20</u> km/h for <u>20</u> minutes. He stays at his Grandma's house for <u>20</u> minutes. He then travels home at a <u>Constant</u> speed of <u>20</u> km/h.</p>		
9.45	<p>T: What I would like now is the tricky bit. Out of every couple sat on each table. One person switch with someone else from the other side of the room. Then, I want you to compare your answers. You have been comparing the graph the other way round. Graph to story and story to graph.</p> <p><i>The class move and students correct each others' work:</i></p>		

9.50	<p>T: I made an English error. "He travels away to his house".</p> <p>T: Hugh you did set A.</p> <p><i>Projects his on screen.</i></p> <p><i>He discusses a disagreement between one student and his own solution.</i></p> <p><i>And decides that the student solution is better.</i></p>		
9.57	<i>Lesson ends.</i>		

USES OF TECHNOLOGY

Code	iPad/laptop/IWB	Software	Activity	Link to formative assessment

Lesson 2: Meatballs

Lesson objective:

To use and apply appropriate mathematical skills to solve volume problems

- 1) Introduce lesson with tagline 'this used to be a textbook question, what was the question?'. Watch [video](#) on IWB.
- 2) Google Form to collect responses. Display on board and discuss the responses with the class. Agree on a principle question 'How many meatballs will it take to overflow?' (various numbers anticipated)
- 3) Google Form, 'estimate how many meatballs you think will be needed in order for the sauce to overflow'. Keep results private (to reveal later), but ask for students names in form.
- 4) 'Since that is the question, what information would we need in order to work out the answer?' Give 5 minutes for discussion on this question, ask them to make a list for discussion and ask them to make a plan for answering the question.

Possible responses:

- Size of the pot - 'What do you mean by size?'
- The volume of sauce - 'Do we need to know the volume of sauce in order to work out how many more meatballs would fit in?'
- Height of the saucepan - 'Do we need to know the height of the saucepan in order to work out how many more meatballs would fit in?'
- Volume of pan - 'What information would we need in order to work out the volume of the pan?'
- Size of meatball - 'What do you mean by size?'
- The volume of the meatball - 'What information would we need in order to work out the volume of the meatball?'

After each piece of information is agreed upon, pass on the required information. Students to make notes on A3 sheet provided. Leave on IWB.

- 5) Students to work out the answer to the problem.
- 6) Once answers are complete, students to create a presentation in Explain Everything explaining their solution (give directions). EXTENSION: if all of the required meatballs were rolled up into one giant meatball, would it have fit in the pan? A few groups will be selected to display their presentation and explain each point - class to critique. Selected by observation.
- 7) Display Act 3. 'Did anyone get it right?' 'Why does the Maths not work?' Discuss the assumptions that were made that caused the answer to be wrong.
- 8) Reveal original guesses for discussion.

Conclusion:

Example work displayed

Discussion of why inaccuracies arise and need to be identified

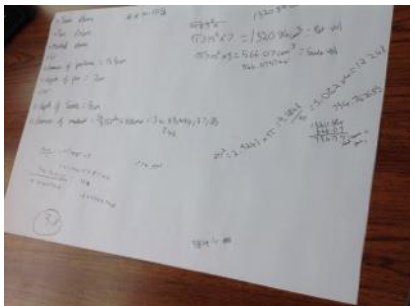
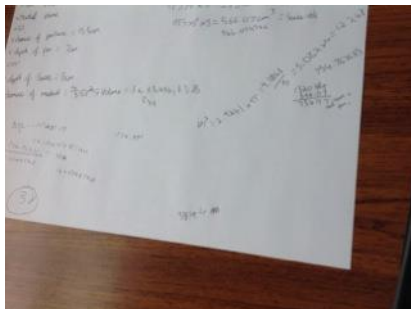
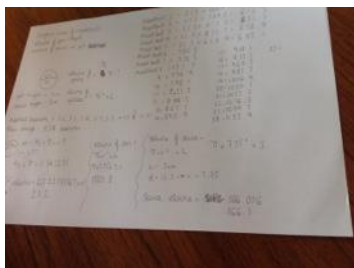
Use of appropriate Maths to solve real life problems to do with meatballs

CONTEXT

School	Academy A			Observer	Diane Dalby	
Class	Year and set	Year 10		Teacher	MATTHEW	
Date & time	Date	14/05/15	Start	08:50	End	09:50
Student numbers	Present	28	Male	14	Female	14
Room layout	Students are seated in rows facing the front of the classroom. Outside rows have desks that seat two students each and the middle column has two desks together so these seat four students.					

LESSON STRUCTURE

Time	Activity	T	FA
08:52	The teacher introduces the lesson by showing the video clip of the meatballs about to be added to the sauce in the pan. Teacher explains that this was a textbook question and asks the students to discuss what the question was? One pair start talking about if there are x meatballs then ...? Others take the approach that they would be asked to calculate something.	T1	
08:56	The teacher asks for a volunteer to offer a question. A student suggests the question was how many meatballs can you add before the pan overflows? The teacher asks for another suggestion. A student offers: How many does it take before it does not overflow? Some other suggestions are made before the teacher explains that most of them will be pleased because the question was how meatballs does it take before the sauce overflows?		
08:58	The teacher asks them to discuss with each other how many meatballs will be needed to make the sauce overflow. Each pair is to make an estimate that they can then submit on Showbie using a Google form. The teacher circulates during the paired discussion and intervenes at one point to state that they can assume they have an infinite supply of meatballs, or at least a freezer full.	T2	
09:01	The teacher explains that they will look at the estimates later but the task now is to work out more accurately the number of meatballs it takes and they must first decide what information they need. The students again work in pairs on this. Most decide on volume or height or diameter but some have surface area or circumference on their list of information required.		
09:08	The teacher starts a class discussion about what information they want. Firstly he directs the question to a particular student. The teacher explains they will get the information they request or, at least, the information that they <i>agree</i> they need. The first suggestion given is the volume of the sauce. The teacher suggests he would like it to make the question more difficult than that and asks if there is information they could use to work this out? Students suggest diameter of pan and teacher provides this using an image on the IWB. Is there anything else? A student suggests the height. The teacher asks: What height? Students suggest the height of the pan and the height of sauce in the pan. The teacher comments that he has seen an idea from some students that they need surface area. He asks what other students think about this idea. One student says they don't need it and tries to explain that volume is the measure they need to calculate because it is the space inside. One student suggests that they need either mass or diameter. The teacher asks if it makes a difference how much the meatballs weigh? One student suggests it does not, but they are not		

	<p>sure. The teacher asks for students to comment either way on this. There is some further discussion and students agree they need the volume of the meatballs and therefore diameter.</p> <p>Questions are now asked by the teacher to establish how they intend to work out the volumes. Students recall the correct formulae. The teacher provides an image of five meatballs of different sizes and their diameters. One student asks if they can have the average. The teacher says they can do this themselves and work out whatever sort of average they want. (During this time the information requested by students and the formulae are being written up on the whiteboard as they are agreed).</p>	T3	
09:19	<p>Students begin work in pairs on the problem. Most work out the mean diameter of a meatball, the volume of meatballs, the volume of the pan and volume of sauce first. There is lots of paired discussion. Some see errors in their own work and correct these.</p>   <p>One pair decide to find the space left by subtracting the height of sauce from the height of the pan and then calculate the volume of the empty space rather than doing two separate volume calculations and then subtracting. The teacher circulates to check on progress and asks some students extra questions about why they have taken certain approaches.</p>		
09:27	<p>Students are beginning to finalise their solutions. The teacher asks them to open up a blank file and record their solutions. Most now seem to have taken the same approach although some did think about calculating the height of the space left.</p> 		
09:42	<p>One pair are asked to present their solution. The answer they give is 33 meatballs and some get excited because they have got the same so it must be right. The teacher explains that most have used this approach or something similar.</p> <p>The teacher displays a different solution (a sample of work from a different class) and asks for comments. One student explains what has been done. The teacher also explains that there are slight variations in answers. Why? Students suggest this is due to rounding errors and different ways of calculating averages.</p> <p>The teacher shows the students' initial estimates on the IWB and then shows the video of how many meatballs actually fitted in the pot. There is some excitement because two students estimated the right number. The teacher asks why, if the maths is right, the answer from the video is different? Is the maths right? One student suggests meatballs are not the same size so there could be variation. Also, the rounding off of numerical values in the calculation is suggested as a source of error. The method of calculating the average is another suggestion. The teacher asks again: Is there anything else that might have gone wrong? The teacher suggests the lip on the pan allows a bit more volume.</p>	<p>T4</p> <p>T5 T6</p>	

USES OF TECHNOLOGY

Code	iPad/laptop/IWB	Software	Activity	Link to formative assessment
T1	IWB	Video	Video shown to introduce task for lesson.	Presentations provide opportunity for peer assessment and discussion of student work.
T2	iPad and IWB	Showbie with Google doc	Students send estimates to teacher for display later in lesson.	
	IWB and iPad	Showbie	Teacher provides information for students to work with.	
T3	iPad and IWB	Notability	Student record their solutions and explanations for presentation to the class.	
T4	iPad and IWB	Showbie	Estimates from earlier are displayed.	Challenges students to review their own solutions and self diagnose areas for improvement.
T5	IWB	Video	Video is shown to provide correct answer to problem.	
T6				

REFLECTION

As in the previous two observations, the lesson provided an interesting application of work on volume and a different approach to a problem. This captured the interest of the students. Despite the time constraints there was space for some effective collaborative work in pairs and good class discussion that explored students' understanding of the concepts involved and their application to the problem. The technology was used to send and receive information efficiently between the students and the teacher (and vice versa). In some cases the exchange of information helped support formative assessment by presenting student work that was then used for class discussion, peer assessment and self-assessment.

Lesson 3: Solving equations

CONTEXT

School	Academy A			Observer	Diane Dalby	
Class	Year and set	Year 10		Teacher	MATTHEW	
Date & time	Date	16/06/15	Start	11:25	End	12:25
Student numbers	Present	29	Male	15	Female	14
Room layout	The students are all seated at desks facing the front. The outside columns of desks seat two at each. The middle column seats 4 students in each row. The room is full except for 3 spaces in the back corners.					

LESSON STRUCTURE

Time	Activity	T	FA
11:28	The teacher gives students instructions for login to Mathspace whilst the register is taken. Students are directed to the front page and then to a section where three questions are provided for them to complete. These are linear equations that they have to solve and show their working, step by step on the screen. The system will mark each line before they proceed to the next step and will provide hints if they want these to help self-correct their errors.		
11:32	Students commence work on the three questions. The first is $x/6 + 2 = 2$. The students discuss their work quietly with each other but produce individual work on their own iPads. The first question the answer is 0, which causes some concern, but the Mathspace system confirms this is the correct answer so students are reassured. One student is confused because they only wrote down the answer and the system does not accept this. They have to write an equation. The teacher explains that they can write down some working out on the screen and not have it checked but the lines of working that they have checked must be equations or the system will not recognise them.	T1	
11:38	The teacher shows one student response on the IWB to show some of the features of the system and deal with any student dissatisfaction, such as having to write a full equation or finding some text is not recognised e.g. the need to write x in letter form and not use the 'times' icon on the keyboard. The teacher shows a student example that is good but asks the class to suggest an intermediate line of working that could have been added. A student responds and the teacher moves on to show another example of question one. He asks the student who wrote this what they had tried to do that was wrong and there is some discussion about what was wrong and why. The teacher scrolls through to see if there are any other errors that need class discussion but does not select any more and moves on to the next task. This involves students working through a set of adaptive questions. These are referred to a 'three step equations' and the teacher explains that they are aiming to achieve a 'mastery' score of 100% as indicated on the system. Again, students should show each line of working and have this checked by the system before proceeding to the next line. As	T2	

	<p>before, if lines of working are incorrect then they might correct their own errors or ask the system for a 'hint'. Progress is monitored by the system and students can see this how they are proceeding towards the mastery score of 100% on these equations. This is not directly related to how many questions they have done but to what they have got right and indicates that they appear competent with the processes at a set level.</p>		
11:45	<p>Students commence the questions that are adaptive. All start with the same question but when they make errors in their lines of working then the following question will be different to a student who gets the question right first time. Some students correct work when it is marked incorrectly and others use the hints. One comments that it is easier now they are used to how the app works although it seemed a bit difficult to use at first.</p> <div data-bbox="330 696 681 1162" data-label="Image"> </div> <div data-bbox="884 387 1235 853" data-label="Image"> </div> <div data-bbox="740 887 1094 1359" data-label="Image"> </div>	T3	
12:00	<p>The teacher intervenes and draws the attention of the class to a sample response that he displays on the IWB. This shows a recurring error in the students' work. In the sample response the student has moved from $16x = 1$ to $x = 16$. The teacher asks the class what sort of value you have to multiply by 16 to get 1. A student responds that it cannot be 16 and the teacher asks what should be written down as the next line of working. A student provides the answer and the point is emphasised by the teacher before students return to their own work.</p>	T4?	
12:02	<p>The students continue to work on their own personalised questions. Some explain when questioned that they can see the value of instant feedback when working in class, and how they might use this app at home to get instant feedback rather than wait to have worked marked by the teacher.</p>		
12:11	<p>The teacher asks students to stop their individual work and explains further features of Mathspace to the class. Once mastery has been achieved students can continue and the system then provides harder questions beyond the level of 100% mastery. The teacher also comments that the app may be helpful for revision and extra work at home. He then shows the overview of class progress on the IWB. Some have achieved 100% and others 67% upwards. The teacher explains how he can see all their working for all the questions they have done.</p>		

12:12	The teacher introduces the next task. This involves students marking two worked examples that contain some errors. The students have to mark each line and provide the hints that Mathspace has been doing for them. There is some dispute about whether to mark subsequent lines wrong that follow from an incorrect line early on.	T5	
12:19	<p>The teacher shows a student's attempt at marking on of the examples for class discussion. He asks if the student has checked and substituted back in? Their response is 'No'. The teacher suggests that this might be a good check to use. The teacher questions whether the correction is valid and then asks what the next line is? A couple of students make suggestions.</p> <p>Another response is shown to question 1. The student is asked to explain their thinking and their conclusion. The student has commented in writing that the sample student can't subtract. They have a made similar comment that the sample student can't add on the next question. The teacher suggests this may not be the most helpful hint.</p> <p>The teacher then draws attention to a step where there could be an intermediate line and asks what has happened and how it could be explained. There is some brief discussion and then the lesson ends.</p>	T6	

USES OF TECHNOLOGY

REFLECTION

Code	iPad/laptop/IWB	Software	Activity	Link to formative assessment
T1	iPad	Mathspace	Diagnostic questions for students to complete.	Students work on questions, using the marking system and hints, which help them assess their own work and make adjustments to their thinking.
T2	iPad and IWB	Mathspace	Selection and display of sample responses from students.	Teacher has access to student responses and uses these to identify common misconceptions. Teacher chooses samples of student work to display for discussion to address these misconceptions.
T3	iPad	Mathspace	Adaptive questions for students to complete.	Students work on questions, using the marking system and hints, which help them assess their own work and make adjustments to their thinking.
T4	iPad	Mathspace	Teacher monitors progress of individuals in the class towards 'mastery'.	Teacher has access to all student work and can identify common misconceptions that need to be addressed.
T5	iPad	Showbie	Students mark a set of worked examples and identify errors.	Students assess sample work, identify misconceptions and how to address these.
T6	iPad and IWB	Showbie	Teacher selects and displays samples of students' assessment of the examples for discussion.	Students assess the assessments made by other students and discuss misconceptions.

The lesson had three clear sections with different aims: diagnostic questions to identify common misconceptions and address these; personalised sets of questions and two sample 'student' responses for students to comment on. Some time had to be spent explaining the Mathspace system to students but they quickly adapted and, although some were initially critical, once they had got used to how the app worked and

what text it recognised they settled to working with it comfortably. Some students commented, when asked, on how the system gave them valuable instant feedback and would allow them to make more progress independently outside class without having to wait for feedback from the teacher.

In each section of the lesson there was formative assessment in various forms that was facilitated by the information Mathspace provided:

- marking and 'hints' made students self-assess and correct their own errors or guide their thinking towards a correct process;
- the information on student progress helped the teacher know when to intervene and what common misconceptions needed dealing with;
- the accessibility of student work helped the teacher find suitable samples to display for discussion to deal with misconceptions;
- the worked examples helped students act as assessors (imitating Mathspace) and clarify their own thinking.

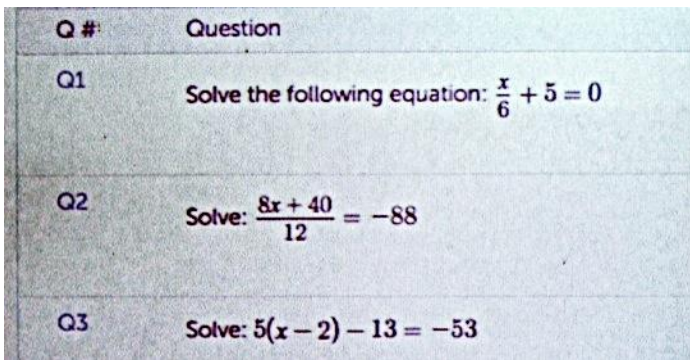
LESSON OBSERVATION REPORT

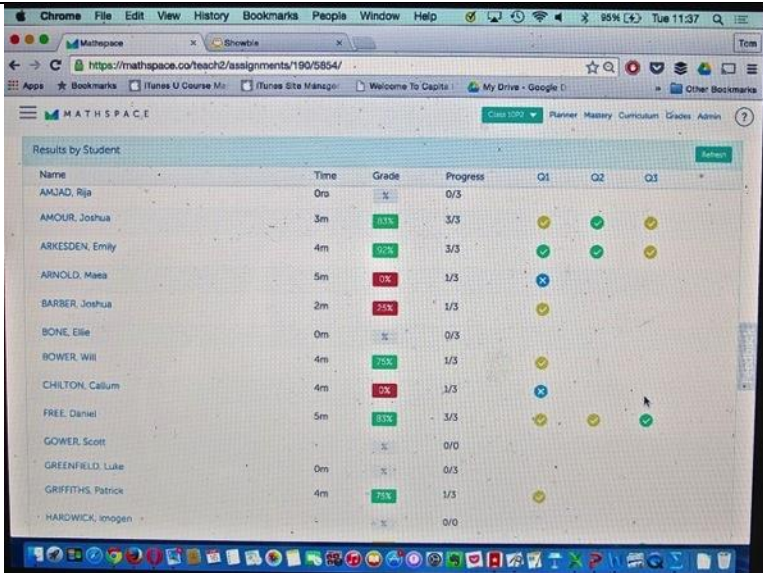
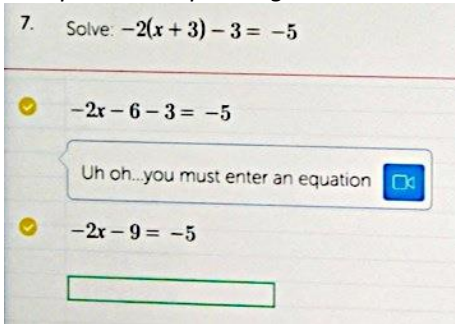
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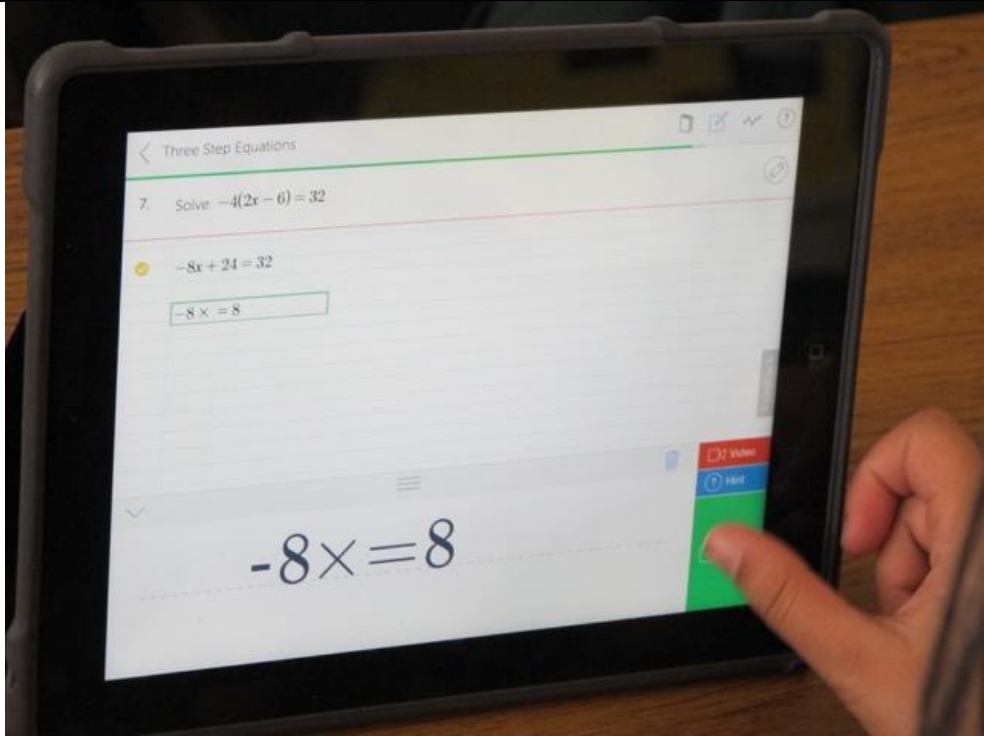
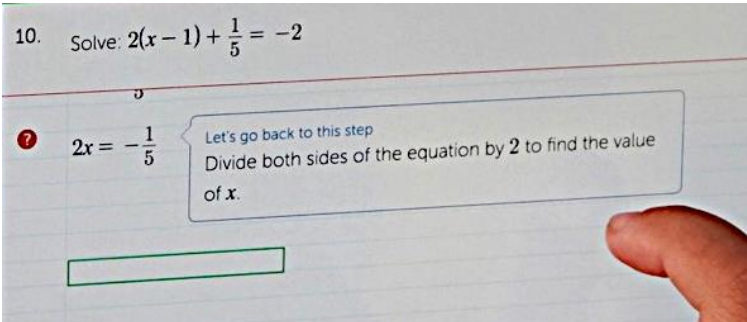
CONTEXT

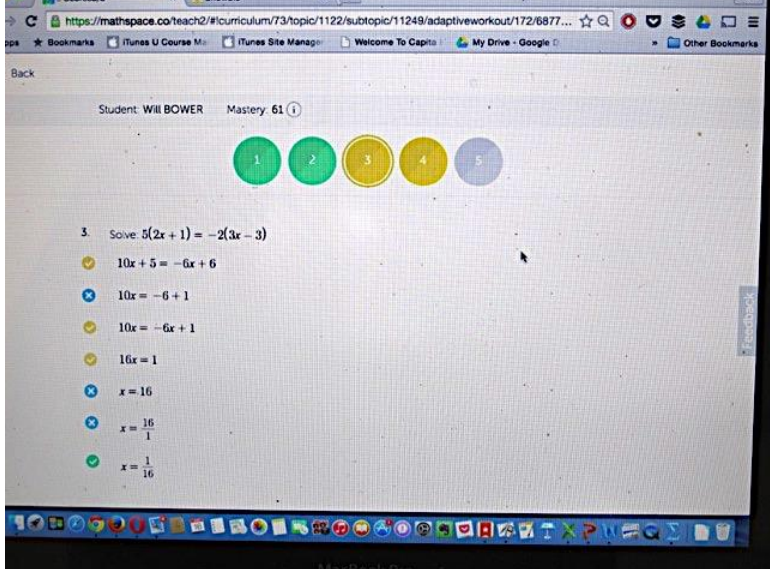
School	Academy A			Observer	Malcolm Swan	
Class	Year and set	10 P2		Teacher	MATTHEW	
Date & time	Date	16/06/2015	Start	11.25	End	12.25
Student numbers	Present	29	Male	15	Female	14
Room layout	Students in pairs facing front of room:					

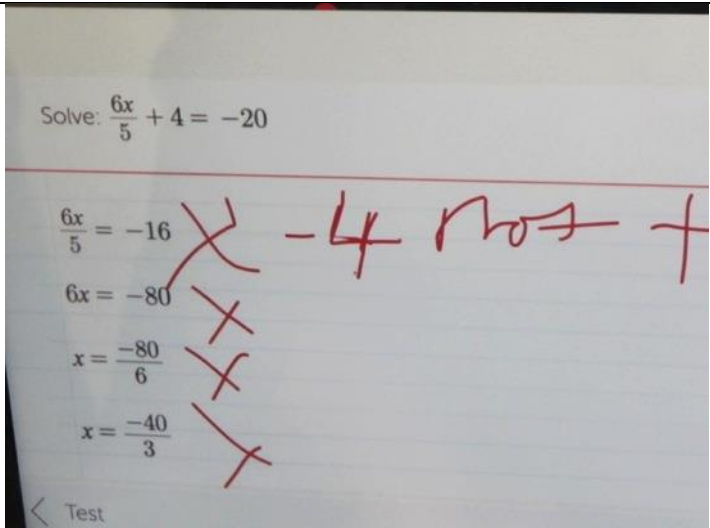
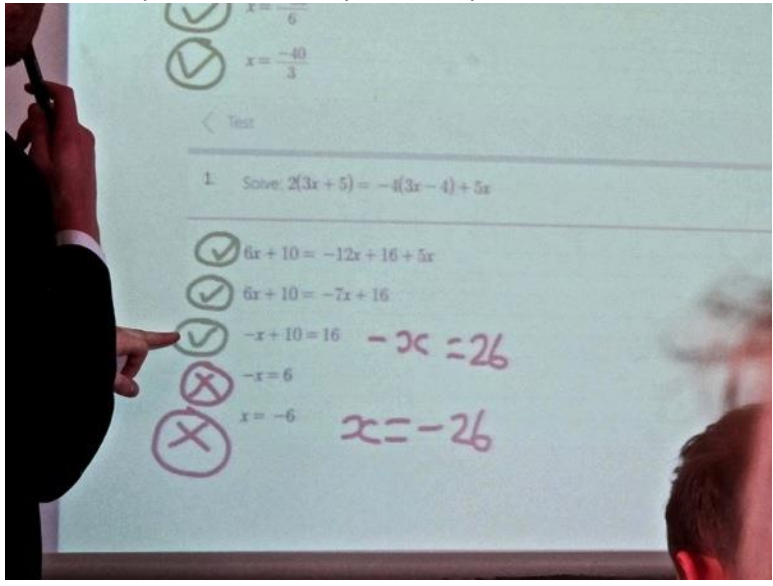
LESSON STRUCTURE

Time	Activity	T	FA
11.26	<p><i>Teacher loads Mathspace onto screen at front of the room.</i></p> <p><i>Students log in on iPads. (These are attached to Showbie)</i></p> <p><i>The teacher assembled a diagnostic test.</i></p> <p><i>The software adapts to student answers giving more practice at the types students fail at.</i></p>		
11.29	<p>T: You will log into a front page that will show you this.</p> <p>T: Your first task is called "start". There are three questions there – answer those.</p> <p>You won't all get the same questions.</p> <p><i>The following three questions were displayed.</i></p>  <p><i>The teacher could monitor how they were getting on with these questions:</i></p>		

			
11.37	<p>T: This is going to make you write down the working out in a different way. Don't panic it's a lovely tool. If you want to work in your book and check each line of the working out that's fine. It doesn't check working that you write such as "Add 3 to both sides".</p> <p><i>Tom demonstrates how the Mathspace gives feedback: It requires an equals sign etc.</i></p> 		
11.40	<p>Charlie: It doesn't recognise -2 x -5. It doesn't recognize x (multiply) instead of x (variable).</p> <p><i>T displays Emily's correct work. Comments that it's perfect. T displays Georgia's work: Georgia typed 11x-3 when she wanted to multiply 11 by -3 and it came out as 11x - 3 and was marked incorrect.</i></p> <p><i>The following screen shows that sometimes the multiplication sign and the variable are interpreted wrongly by the iPad. One wonders why other variable names were not used.</i></p>		

	 <p>T: The next part is going to be adaptive. It will fire questions at you if you found the first one adaptive. You are aiming at a mastery score of 100. If it does that, you can click on I want to make sure. I want you to do the one called 3 step equations.</p>	
	<p>As students work, a number of issues arise.</p> <ul style="list-style-type: none"> - some do not understand feedback given by iPad. E.g. "Move variables to one side and constant terms to the other". T had to explain this one. - when they get one wrong, the iPad doesn't always go back to the last correct answer, it sometimes goes back two steps? [See video] - some like to show working so have to switch to the pencil tool. This works well. (E.g. expanding brackets) - some struggle with entering fractional answers. - 	
12.00	<p>Teacher projects the answer obtained by one student. He has identified that students are not expecting fractional answers:</p>	

	 <p>Student: Will BOWER Mastery: 61</p> <p>3. Solve $5(2x+1) = -2(3x-3)$</p> <ul style="list-style-type: none"> ✓ $10x + 5 = -6x + 6$ ✗ $10x = -6 + 1$ ✓ $10x = -6x + 1$ ✓ $16x = 1$ ✗ $x = 16$ ✗ $x = \frac{16}{1}$ ✓ $x = \frac{1}{16}$ 		
	<p><i>16x = 1.</i></p> <p>T: What's the next step? Is that number going to be big or small. 16 lots of something equals 1? What should have been the next line here? How would I remove the 16? My automatic next line would be to divide both sides by 16.</p> <p><i>It is interesting to see what the tablet accepts as correct. - - 12 is accepted as well as +12.</i></p> <p><i>Students are moving to a calculator app to deal with the negative numbers. The calculator gives decimals as answers that sometimes prove tricky to enter.</i></p>		
12.10	<p><i>The teacher explained why the progress chart showed 100%, yet still continued to give them examples to do.</i></p> <p>T: It doesn't stop until it is happy you can do the hardest possible examples. Some of you have done well. Others can continue to do this for homework.</p> <p>T: I'd like you for the next couple of minutes to be maths space. A student has answered this question. Your job is to mark each line with a tick or cross and the hint that will go next to it.</p> <p>Do it in Showbie so that it can be shared.</p> <p><i>Some students simply rework the incorrect answer alongside. Others put ticks and crosses and write comments.</i></p>		

			
12.16	<p>T: Can you press done so I can see your marked work please?</p> <p>T: Some were asking, If a question was wrong in the first line is it wrong throughout?</p> <p>He projects up one piece.</p>		
	<p>Have t=you checked the answer in the question?</p> <p>T refers to questions but they are barely visible on the screen.</p>  <p>Alex's is projected. Negative number mistake is spotted.</p> <p>T: This is a good activity for those of you who want to be maths teachers. <i>The feedback from one student was: "You cant subtract"; "You cant add". Everyone laughs.</i></p> <p><i>T goes through it.</i></p> <p>T: What about the trick at the end: $-x=6$ to $x=-6$. Is that a trick that can always be pulled? Technically that is multiply both sides by -1. You could have added x to both sides also.</p>		

12.24	Bell goes.		
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USES OF TECHNOLOGY

This lesson used mathspace: <https://mathspace.co/#section2>.

Code	iPad/laptop/IWB	Software	Activity	Link to formative assessment
	iPad	Mathspace	Sharing tasks with students.	<p>Tasks were adaptive and chosen to fit attainment of students.</p> <p>Feedback to teacher via class overview, showing time on task, grade, progress.</p> <p>Teacher could select and display all working by any student on any question for whole class discussion.</p> <p>Students could assess the work that teacher had devised and give comments using pencil tool.</p>

(An animation of the software is shown at the website).

Appendix C: Interview with teacher

DIANE: You've already explained to me that you have got some use of using formative assessments within lessons. Could you just explain that for the benefit of the recording? So your use of formative assessment within lessons in the past has been what sort?

MATTHEW: So that (???) to be assigning little quizzes that provide feedback in terms of what each of the students know, so using an app like Socrative that would allow each student to give their response and the teacher to view their responses afterwards. And then also, we've got things sort of like we demonstrated in (???) where we can view students' responses on the board in front of the class for discussion and demonstrate sort of different approaches to answering problems.

DIANE: Right, and that's the sort of things you've done before?

MATTHEW: Yeah, that's the kind of things we did before, yeah.

DIANE: Okay. And your use of technology within lessons?

MATTHEW: Yeah, well, it's my job here to lead the use of technology in the academy so I suppose it comes as a second nature to use technology alongside my teaching.

DIANE: Okay, but you haven't been working on a research project before?

MATTHEW: No.

DIANE: Okay. So could you explain how you first became involved in the FaSMEd project and what attracted you, or whether you were forced to do it, asked to do it, sorry?

MATTHEW: We were, I think. I'm not sure exactly how we came to be connected, but I assumed there's some kind of link with Geoff and he contacted Greg Hughes (?) I think, somewhere along the line, which led to the meeting happening, where it was suggested that we look into some aspects of using iPads in the classroom. And we said that we had a few issues with group work and collaboration, that kind of thing, and it could be useful to sort of look into how we can improve that.

DIANE: Yeah. So it was something you, that was in line with your interests?

MATTHEW: Absolutely.

DIANE: Okay. Now can you tell me then about the sort of professional development aspect of being involved with FaSMEd? Has this help you in any way that you would call professional development, and if so, how?

MATTHEW: I think that one of the things that we've all noticed is the extent to which considering the lessons for the project has made us think explicitly about the questions that we were using and the specific wording that we were using, whereas in a normal lesson, previously, it would be a little more ad hoc. And it was interesting, the extent to which, because of the way the tasks were designed, we were sort of predicting students' responses far more than we usually would have done. So I think that was a really interesting thing that we got out of it, as a sort of development.

DIANE: Right. So could you just tell me a bit more about your experience of the FaSMEd project then? What have you done and how have you worked here at The academy?

MATTHEW: So, looking at the ways in which iPads were used formatively in the math lessons. So we've used them in a variety of ways, I suppose. We've looked at using them to collect quick pieces of information. We've looked at using them to... A lot of it is focused on the sheer speed at which we can do things, the ways in which we can quickly put students' answers on the

board and then bring another solution for comparison, probably far more recently than we've ever done before. And then we got to use math space with writing instant feedback again in a way which we've certainly never been able to do previously, and about how that comes to enhance outcomes for students who are using that technology.

DIANE: Right. And how have you worked together, because there have been three of you here at the academy on the FaSMEd project? How has that worked for you together?

MATTHEW: We tend to work together quite a lot anyway so we've tended to meet after school and on a Thursday to discuss the proposals for the next elements of the project, so... Typically, if we got a lesson we're working on, we would get together a couple of times on a Thursday afternoon and then ping a few emails back and forth after that too until we're happy that we've got something suitable.

DIANE: Right. And have you worked with any teachers outside the school in any way?

MATTHEW: No. (indistinct)

DIANE: Because, we've had... There have been two other FaSMEd groups through the University of Nottingham.

MATTHEW: Other than, obviously, the trip to Nottingham to discuss things afterwards, but in terms of actual development of the lessons and the tasks themselves, that was mostly done in house.

DIANE: Okay. Can we just think about how you've worked with what we call the FaSMEd toolkit? There've been quite a lot of resources that we've, from time to time, drawn on, brought to your attention. Could you explain how that has worked in the project and what sort of things have been useful?

MATTHEW: So I suppose, a few times, resources have been suggested, that we've looked at. And it's interesting to see how different people will structure those things and how a lot of tasks obviously didn't involve technology at all, that we looked at. It was interesting to see how we could structure those differently so we could use technology. And conversely also to think about whether or not technology adds anything to the process, sometimes it did, but sometimes it didn't; and then again, because a lot of the tasks we've looked at were naturally involving collaboration, whether or not we could actually use the technology to increase the collaboration. Which is something we don't really entirely know the answer to but we've used them fairly collaboratively,

DIANE: You mentioned looking at resources where technology was not part of the lesson and you mentioned you had to re-structure things. Did you have to re-structure the lesson when you used technology?

MATTHEW: Well it's not necessarily about restructuring, I suppose. It was about taking elements of what we suspected were to constitute a good lesson and figure out how we could enhance each elements with the use of technology. So it wasn't thinking "well we've got to use technology, how do we change the whole lesson?" It was more thinking "well this is a good task, this will work. How will we get it better?"

DIANE: Right. So you were trying to improve things, really?

MATTHEW: Yeah.

DIANE: Okay. What about the support? What kind of support did you have from outside the school, sort of from the University or any other source that you've had, during FaSMEd? And has it been useful?

MATTHEW: Definitely. So we've had a lot of contact by email throughout, with, as we just mentioned, suggested resources that you shared with us and ways in which we can enhance things. Also I

think it's been useful to have feedback sort of given promptly after every time we taught a lesson which has allowed us to quickly act on that. So let's say (???) on Tuesday there will be an email going around fairly soon which allow us then to think about how we might want to change that lesson for Wednesday, and that's certainly somewhere where the prompt feedback has been useful.

DIANE: Right. And would any further support have been useful? Is there anything else that you would have done or liked?

MATTHEW: I suppose the issue is time there, isn't it? At a sort of fundamental level, more support is always great but unfortunately there are time constraints on both sides undoubtedly. And I think at the same I think it's good that we most of us who work on this, we are thinking about it as well, rather than sort of being told what to do. So I don't think that's necessarily a bad thing the way it's been.

DIANE: Okay. Can I just ask you then how, or in what ways has the project impacted on your teaching practices, do you think? In long term or short term.

MATTHEW: I think it's made me aware, more acutely, of how some strategies can actually have a large impact without really considering it, so I take some things for granted, such as the ability to just put students' answers on the board, when actually not very many people have the technology to do that. So it makes you realise the value of those things. And actually I should probably do that more and I think it just makes you realise that there are... the importance of formative assessment, the importance of displaying solutions and discussing things is possibly greater than I believed when I started the project.

DIANE: So do you think the value is short term or long term in terms of its impact, on your teaching practices?

MATTHEW: Well I suppose in the short term there's definitely impact in terms of each individual lessons and considering question tactics and working how technology can be used to enhance processes. In the long term, I suppose that would depend on what technology I have available to me and whichever... wherever I am and what the job is. I certainly think it would be very difficult to suddenly go and teach in a school where there would be no technology available now. I think I would find that really quite difficult.

DIANE: Can you envision using these resources based on the toolkit in your future practice? Would you recommend it to fellow teachers?

MATTHEW: Yeah, I don't see any reason why not, provided we got the tools available to perform them. I don't see any reason why sharing resources that have been made isn't a good idea. That's definitely something I could look to in the future.

DIANE: And how do you think the students have responded to the methods that you've used, particularly these three lessons?

MATTHEW: For the most part, I don't think they've noticed any difference. It's just a continuation. I know it's been sort of commented on how naturally the students use their iPads, flip between apps like it's not an issue to them. It's slightly different with the math space thing, because that's something that doesn't come as a second nature to them, that's not something that they've used lots of times so... I think in that respect it's slightly different. I suppose if you came back in another six months or so, it may appear as though they are a second nature in the same way as using something like Showbee is second nature to them at the moment. So I would be interested to track that over time, see how that changes things.

DIANE: Okay. So my final question is really what has worked well in the project? What has been difficult? And what would you do differently?

MATTHEW: Is it going to be too noisy in a minute?

DIANE repeats the question.

MATTHEW: I'll start with the one "What has been difficult?". I think difficult is... Because teaching different classes, different years, it's been difficult to sort of planning a progression in a sequence of lessons. I think the lesson that probably worked the best is the lesson that was in the middle of the sequence of lessons for all of us, because otherwise it just felt a little bit like it was shoe-horned in and was sort of noticeably different. So that is certainly something for consideration, but it is very difficult to make sure that you falls (???) in that sort of way. Maybe in a mixed ability environment it would have been an easier thing to pull off. In terms of what's worked well, I think the teachers involved collaborated well on the project. And I think we've all, when we look back, we'll think that actually the lessons that we taught didn't take us no more time to plan together and that actually they were probably some of the best lessons we've taught all year if we're being honest. So I think in that respect it has made us look back and think about what made them good and hopefully we'll continue to use the things we've learned.

DIANE: Anything you'd do differently?

MATTHEW: I mean it's... I think about, trying to ensure... I think if we really had thought about it earlier, we could have made sure the lessons were a little bit more sequenced, which I think would have been better.

DIANE: The last question if we got time is do you intend to work with colleagues using the FaSMEd tools and the FaSMEd approach in the future in your school or elsewhere?

MATTHEW: I think, if given the opportunity, I'm quite lucky in that I get to go around and talk to various schools about the use of iPads and technology in math so it's definitely something that, if the toolkit is available to others, I can happily go around and share that and the ways in which you can impact on teaching.

DIANE: Okay, well thank you very much, I think we've covered everything.

END OF RECORDING

Appendix D: Focus group discussion

DIANE: So I want you to tell me, if you can, what you think of your experience of these FaSMEd lessons for this FaSMEd project. That's the three lessons in particular that you've done, the distance-graph lesson, the meatballs lesson, and the last one where you did equations using Mathspace. So can you tell me anything about these lessons? Anything at all?

ANNIE: They were really like group-involved. So we did it all in pairs or in small groups. There's not much individual work apart from when we did the Mathspace thing because that was on our iPads and we couldn't do that in groups, but the other stuff was working out on paper and using apps and our iPads on research.

LIAM: I think they're quite fun. I think they got us to work a lot to find out what the correct answer was.

ETHAN: I personally didn't like Mathspace because it was very structured and if you didn't do the slightest thing absolutely right to the t, it would make you re-do it over and over again. Whereas, and sometimes it couldn't read what you'd written on there so it would say it was wrong even though it was right because...

LEONNE: Yeah Mathspace was quite hard. It was quite hard to use.

SAM: Yeah I didn't like Mathspace.

EDWARD: It's sort of very structured and you had to follow a pattern you had to structure it.

LIAM: There were a lot of it so I got used to it. I think the questions were getting harder progressively, made you work harder.

LEONNE: Yeah but if then if you get the stages of work wrong it says the whole thing was wrong at the end, and then it penalises you because you only get 60% because you didn't get it right the first time.

ANNIE: If you compare it to the other lessons, like the meatballs, it just shows how everybody is just a different learner. I personally thought that was more of a fun lesson just because it had food and you see pictures and it's not all numbers.

SAM: It's more practical.

ANNIE: It was more practical, and you could see, it finally explained, you know, why this happened.

LIAM: Because we're always talking about how we won't ever use any of the maths outside of school.

EDWARD: It just showed how practical it was.

LIAM: At the same time, I'm not gonna really get a five pound pan of meatballs.

DIANE: Do you think those three lessons have been different to other lessons, your normal lessons, other lessons that you've done, and if so how?

LIAM: Yes.

ANNIE: Our normal lessons have quite similar structures we'll like talk for the first twenty minutes and then he'll say well you have this work on iTunes, YouTube or Showbee and we'll do that till the end and we'll check the answers. And he'll come around and help us and tell us what we're doing wrong and what we're doing right. But those lessons, it was less structured, not what we're used to. So it was more like, we're gonna do this for five minutes, then we're gonna swap to this, I'm gonna use this app and you gotta do this. It was different from how we normally learn in our maths lessons.

LEONNE: We do the same thing, every maths lesson, so when we did these different lessons it was kinda, it was different, definitely. We felt a little bit more open to something different, because we always have the same structure, every single lesson.

LIAM: Working with someone else in bigger groups than what we normally do helped, because normally you kind of work with the person next to you and that's it. You're not about to turn around and talk to people behind you so working in big groups was different.

ETHAN: (the beginning here is unclear) an app called Notability (?) which is a lot more, it basically is a pen and paper on an iPad really. It's not that different from how it would be in a maths book, because you can put the maths files into a file, and then you know where they are.

DIANE: Anything else that was different?

LIAM: Just people being stuck at the back of the classroom working.

ANNIE: It was just kind of silly compared to what we normally do.

LIAM: Yeah.

LEONNE: The maths

LIAM: There's less pressure.

LEONNE: When we did the meatball thing, it was more trivial, I suppose. It was, it just showed something, the ease in real life, whereas we're used to being shown an equation and then we'll just keep doing different versions of that equation. Whereas we were given one thing we had to figure out. It was just one task.

SAM: That's problem solving.

LEONNE: Yeah.

SAM: That finally felt important. Like, we always think how are we going to use surds or Pythagoras. When we were doing these activities, like the meatball thing, you know, we used a few of those things. And we used surface area and all that and it made you realise, you know, there are things... because we never talk about what we can use it for. It's just, we get told, you need to do this for the exam so that we know what your basic knowledge is, how intellectual you are.

ANNIE: It did incorporate different areas of maths as well, like using different things to figure the answers out.

LIAM: Yeah, instead of doing just one subject.

EDWARD: I think that makes it better because you learn something. A couple of months ago, you think what's the point in learning that? We're not gonna use it, and then it reappeared in this scenario that you never thought would happen.

LIAM: You're learning a life skill and a maths skill.

DIANE: Was there anything else, was anything useful, or difficult?

EDWARD: I guess all areas of maths are technically useful in some form, some way or another. Some ways are more important than others and are probably gonna be used more than other things you learn in maths books...

LIAM: I would think, why sit there and do that thing, like, in your head or Pythagoras, or (???) discussed, a ruler out or a compass or a calculator and don't own a calculator, when after school, in real life you wouldn't need to do all this work now that you do.

LEONNE: I always used to think that as well, when, why am I gonna use this? But then, the main... you just sort of realise that the main reason we just do this is to show how much knowledge we

can... because everybody can like sort of hold different knowledge, and it just shows you in an example now that this person is better at maths than this person, and how intelligent they are in maths. So sometimes, I think that's what they try to focus on, the exams.

EDWARD: And not everybody is good at everything. No one's perfect.

LEONNE: Yeah some people have like a more logical brain.

ANNIE: Some people just naturally think like that.

EDWARD: Some people are more hands on... (indistinct overlap)

ANNIE: The truth is that some people, they see maths differently than other people. Most people see numbers and then... I don't know... You see numbers and you see it differently, whereas people see words and if people are writing down, then they can get inspired by writing and then they can write something on a paper, whereas people who are going to maths won't necessarily do that. They might think, the price of this is this, on stock shelves and everyone just thinks differently.

DIANE: Can you just think about what you did in those lessons. Were they interesting? Were they boring? Were they difficult? Were there things that were difficult? And can you also just think about whether you were working... you talked about collaboration earlier. Were you working more... was it more self-assessments of what you were doing or were you assessing each other's work? Were you talking to each other? Were you talking more with Mr. Brown as a class? Can you just think about those things and give me your experience on how it was working? Whether that was different in any way and how well it worked?

ANNIE: With Mathspace it's quite individual and so we sat there, we did the question, but I personally found it quite difficult, because it's really structured and you couldn't get one thing wrong, or you couldn't do it any different way or you had to do it the way the Mathspace wanted you to do it. And so I found that quite annoying because if I had a different way of doing it, it wouldn't let me do it, it would just say it's wrong. So I think that lesson was very independent. I mean, we could talk to our partner and get advice from our partner, but it wasn't really paired work. And we could ask Mr Brown where we were going wrong but Mathspace would sort of give you hints.

SAM: I think there's a difference between Mathspace telling you this is wrong and then a teacher telling you this is wrong, because the teacher can elaborate more and they can say, you know, this is wrong because you've done this, whereas with Mathspace it's this step is wrong, try again, this step is wrong, just try again, and it's kind of individual.

LIAM: I think it gets very individual because you've always got a different question from what your partner's got so you can't turn around to them and say like, what's this? What's that? Or what's the next step so you got a different question. They're more fun though, because you're sort of doing something straight from the go rather than sitting there for twenty minutes listening to what you've got to do, falling into a day dream or something like that, then not knowing what you've got to do when served with a piece of paper and you look at it and you think, I've never even heard of this before.

DIANE: What about the other two lessons then?

ANNIE: With the meatball lesson, we were working in pairs, so that was on a big piece of paper. We could do that with the calculator on our iPads if we needed to, because you had to times something by three quarters, and you can't do that mentally. So it was more like dishing out, so okay, so you work out the surface area of the panel, I'll work out the surface area of the meatball, then we'll do the source, then we'll add it all together. So it was like working individually but as a pair so you would be splitting up the work more than working together to

find, to both find the area of the meatball. I can't remember what happened in the distance time one though.

LIAM: There was a problem with the meatball one. You got the question off the Internet so I got the answer from the Internet. So I did nothing for an hour.

SAM: With ETHAN, we just kept guessing.

ETHAN: It wasn't guessing. It was...

SAM: It was educated guesses.

ETHAN: Yeah.

SAM: We just kept putting the... submitting the answer we came up with in the thing until we got one right.

EDWARD: The time-graph one. It was like real life, because, I can remember the time graph one, like, you're put in real life scenario so not only were you working out the answer to the time-graph, you're working out the question to go with it. So you're explaining how fast and how far the person travelled, not just working out the answer and just leaving it and going to the next question.

SAM: Yeah but when do you draw a graph of how far you've travelled.

EDWARD: You don't but...

SAM: It says I travelled twenty minutes, that's what it says on this graph. I travelled twenty minutes this way and then I was stationary for ten minutes.

EDWARD: Yeah, but you're still putting it in a real life situation and explaining how far.

SAM: (Indistinct overlapping) some professionals, maybe some athletes might do it.

ANNIE: Maybe the Tour de France, maybe they do that.

SAM: Yeah, there must be some point to it. There's a job for everything so they probably...

DIANE: I've got another question then, if you could think about this one. Do you feel like these lessons have helped your learning mathematics and in what ways has it helped?

ETHAN: The Mathspace might, because we do that without it, and I think because we all got used to doing it that way, and then Mathspace would tell us almost a different way. We didn't really want to know from it so we... I didn't really learn anything from that lesson, because I already had a method of doing that before, and I'd rather stick to that method, rather than doing the way that Mathspace did.

SAM: I think the meatball lesson was really useful, because alright maybe not in real life you'll pour meatballs into a pan, you'll just pour it in until it nearly falls over, but if you're like an architect or something, you're designing a pond and you want to put something in it, you're gonna have to work out the surface area of the pond and stuff so you know you're not gonna flood over and ruin the perimeter and the area around it.

LEONNE: I think Mathspace's intentions were good, you know. The idea was to try and help you, make sure you don't miss any steps, because a lot of people jump steps. But I think a lot of people, especially in that class, they're really used to maybe not writing everything down, which I guess it can be okay, I think, it just depends on the person.

ANNIE: I think Mathspace is good for preparing you for exams, because obviously in exams they want to see you working out the right answer, using the right formulas in the right way. And so Mathspace is telling you how to do that and get each step perfect. But it's not good for in real

life whereas the meatball one is good in real life, because you don't have to say how, in a specific way each time.

LIAM: I just think it made me realise how pointless maths is outside of school. I think the meatball one is alright but I still won't get meatballs and count how many LIAM go in, I'll just put them in. Fair enough for the pond, if you're a builder, but I still would have dig it in the shape that they wanted it and fill it up to the highest point.

ETHAN: Yeah.

LIAM: It just made me realise how pointless maths is.

ETHAN: Unless I was forced to use my maths again, I wouldn't use it again.

LIAM: Someone get their iPads out and google how much maths you learn at school, you actually take out with you.

DIANE: Can we do that in a bit? Otherwise we're gonna run out of time.

EDWARD: But what about a job that involves maths constantly? Like an accountant or, like you said, an architect?

LIAM: Fair enough. Take that at A-Level, go to university and study maths. I don't think we should be doing that in primary school and secondary school.

ANNIE: We should be learning maths but maybe not histograms

SAM: Maybe more basic stuff (overlapping comments).

LIAM: Yeah I think you should learn the basics of maths, but I don't think we should go into time-graphs and histograms.

SAM: We could be doing things that you use in life, like accounting... (overlapping voices)

LIAM: You see that's business, isn't it? You have to take business to be doing that. We all in some way, we're like (indistinct) or something like that, so we should learn that in maths rather than...

LEONNE: Yeah because we're all gonna pay bills some day but we're not all gonna be mathematicians.

LIAM: Not all of us are gonna understand where that bill comes from, so we're gonna have to work it out in some way.

DIANE: This is really interesting but I'm going to have to bring you back to the lesson for a minute, before we get to the end. So, a simple question, would you like to do these kinds of lessons in the future; the three that we talked about?

EDWARD: Yeah. I would. I think it makes it look more practical.

SAM: I don't know. We didn't learn loads. I mean it's okay once in a while, maybe like at the end of the module on the topic and we do something practical with it. But I don't think it would work for every lesson. I don't think we'd get anything done.

LIAM: Yes.

ETHAN: That's true.

EDWARD: I would.

SAM: I think we could use a mixture of both, because, obviously we need to be prepared by next year, we need to be prepared for these exams, and so using Mathspace is going to help us to do that. And to prepare us for later life, using like the meatball lesson I think that's quite good because it's giving us skills for later life.

LIAM: I don't think we should, because I know I keep talking about it, but we've got our GCSEs next year and I don't think working out how many meatballs can go in a pan is going to help us with getting an A.

SAM: Yeah but sometimes they have questions like that though.

ANNIE: Yeah they do have silly questions like that.

DIANE: So have you discussed these lessons with other teachers or students in school, and if so, in what ways?

ANNIE: Well we'd go like "oh we did a lesson on meatballs" just then ha ha ha. We don't like...

LIAM: I went around telling all the other classes just go on the internet and find the answers straight away.

LEONNE: I remember complaining about Mathsspace and what that was about.

(overlapping agreement)

LIAM: We still do complain about Mathspace.

DIANE: Any other opinions on that? Any discussions you've had?

ANNIE: Just complaining about maths in general.

DIANE: Have you discussed this with parents or family members and in what ways?

LIAM: We ran out of time I think (there was a blip on the recording at this point).

LIAM: Yes I have, talking with my mother about how many meatballs can go on the frying pan!

ETHAN: I didn't.

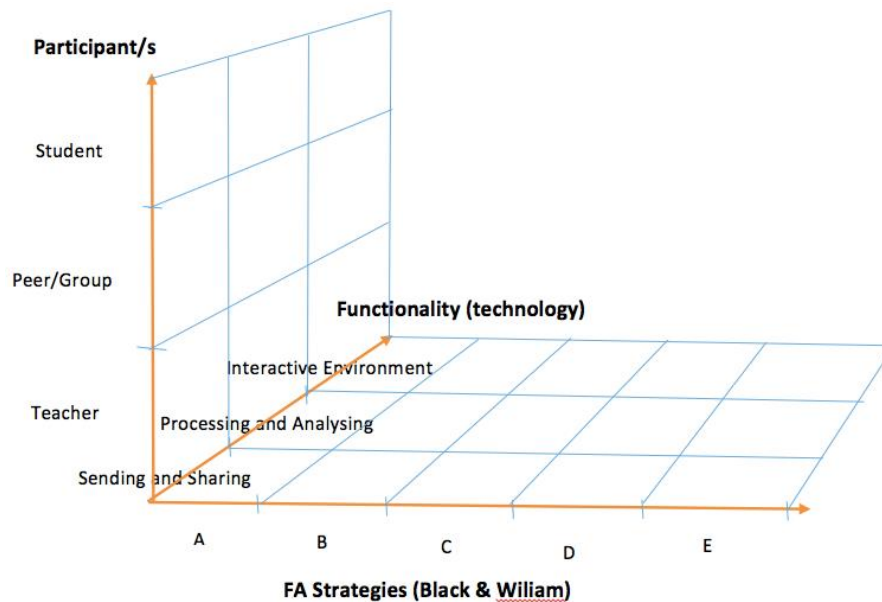
SAM: I didn't because I was like, because we were doing it for this one off thing, I thought, oh we're not gonna do it everyday so it's not really of much consequence so I didn't mention it.

ANNIE: If it was having a really big impact on my life, I'd probably discuss it with parents and say, oh this is happening in school and this is really good or bad but, yeah, it was just a one-off thing so...

END OF RECORDING

Appendix E: Frameworks

FaSMEd Framework



The FaSMEd Framework represents categories in three different dimensions:

- the participant responsible for the formative assessment
- the strategies of formative assessment
- the function of technology within the formative assessment.

Participants

This dimension describes the party responsible for the formative assessment:

- teacher
- peer/group
- student.

Formative assessment strategies

This dimension represents the five strategies as described by Thompson & Wiliam (2007) to conceptualize formative assessment:

- A. Clarifying, sharing, and understanding learning intentions and criteria for success
- B. Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding
- C. Providing feedback that moves learners forward
- D. Activating students as instructional resources for one another
- E. Activating students as the owners of their own learning.

Functionality of Technology

This dimension is structured into three categories based the function that the technology performs in the formative assessment:

- Sending & Displaying
- Processing & Analysing
- Providing an interactive environment.

Thompson and Wiliam framework (2007)

	Where the learner is going	Where the learner is right now	How to get there
Teacher	A. Clarifying learning intentions and criteria for success	B. Engineering effective class-room discussions and other learning tasks that elicit evidence of student understanding	C. Providing feedback that moves learners forward
Peer	Understanding and sharing learning intentions and criteria for success	D. Activating students as instructional resources for one another	
Learner	Understanding and sharing learning intentions and criteria for success	E. Activating students as the owners of their own learning	