Case study 2: Carol

Contents

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 approximately 1120 pupils on the school roll. The school is part of an Academy group[1] and is situated within an urban area in a large city. There is an extensive area of social housing within the immediate neighbourhood but the school also draws pupils from a wider area, mainly on the basis of its strong Catholic traditions. The proportion of pupils qualifying for free school meals, 11%[2], is below the national average and the school was judged to be outstanding in its most recent Ofsted (Office for Standards in Education) inspection. The wide range of abilities does mean that there are still a significant number of low-attaining students within each year group. The arrangements for mathematics teaching into sets based on ability means that that students may be classed as low-attaining if they are in lower sets or, alternatively, may be perceived as low-attaining within their particular set relative to the performance of others in the same class or with respect to the material being taught. Further data on the school context is provided in Appendix A.

The teacher (and the group of teachers)

Carol is an experienced female mathematics teacher who has studied mathematics to degree level. She has worked in schools as a teacher for 16 years, 13 of those in her current school. Carol represented a fairly typical case within the research of an experienced teacher who made only limited use of technology within her mathematics lessons. Class sets of iPads were available but not widely used within the school and the equipment had to be collected and distributed at the beginning of each lesson. In Carol's interview and informal discussions she indicated that her approach to using technology was cautious and that her engagement with the Fasmed project was a means to learn from others with greater expertise whilst evaluating the benefits of using technology within her own teaching.

Evidence from informal observations of the teacher group, from planning meetings and email correspondence, indicated several particular features of the way this particular group of teachers worked collaboratively and how Carol was positioned within the group. Firstly, the group at this school was led by a teacher with substantial experience and interest in the use of technology. Carol was the least confident with technology of the three teachers, although she was an experienced mathematics teacher with a motivation to explore new pedagogical approaches for teaching mathematics. Communication between this group of teachers and the university researchers was also mainly conducted through the lead teacher. This teacher therefore had a strong influence over the lesson designs due to his key role in communication and knowledge of the technology. Initially Carol made quite limited contributions to discussions about the design of the lessons since technology was not her area of expertise. Over time however, informal observations of meetings showed how the

[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 deprivation

interaction between these three teachers increased, with Carol and the third colleague within the group making a more significant contribution to the lesson plans. Carol's input into the research design process was often the result of reflection on how students would respond to the lesson elements, what difficulties they would have with the content and which common misconceptions could be anticipated, whilst the other two members of the group focused more on innovative uses of the technology. In this way Carol's existing teaching experience became the significant influence regarding her contributions to the group, whilst her professional development was focused on two main themes: increasing her technical knowledge and evaluating the benefits of different pedagogical approaches using technology.

The class

The particular class of Carol's that participated in the Fasmed project was a Year 9 group (age 13/14 years) with a fairly even balance of male and female students. This was a Set 2 group, so the pupils were not the most highly attaining in their year group but were reasonably able. The use of this group 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.

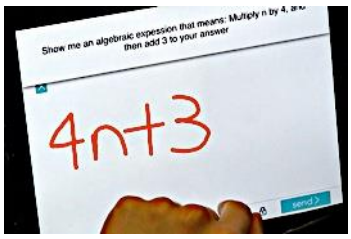
2. Tasks and resources used

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. Algebraic expressions

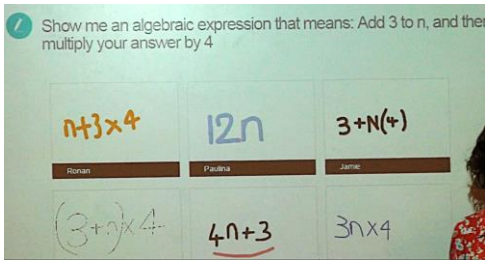
The lesson was based on a task developed at the University of Nottingham as part of a Mathematics Assessment Project[3]. The aim was to improve students' understanding of algebraic expressions, using connections to area to provide meaning for algebra, to aid understanding and demonstrate equivalencies.

In the lesson students first had to write algebraic expressions to match descriptions of expressions in mathematical language (e.g. write an expression for the following: add 5 to *n* and then multiply the answer by 4).



These were sent electronically, one at a time, for students to complete on their iPads. Students then sent in their individual solutions to the teacher who displayed a full set of student responses on the interactive whiteboard (IWB). The teacher selected one or more responses each time and asked questions to expose and discuss common misconceptions. For example, the responses shown were displayed to the question "Show me an algebraic expression that means: Add 3 to n then multiply your answer by 4".

[3] http://map.mathshell.org/download.php?fileid=1726



In the second part of the lesson a similar method of sending questions and sharing responses was used but students were provided with a diagram of a rectangle, square or composite shape with a combination of algebra and numbers to indicate the length of each side. Students were asked to write down an algebraic expression for the area.

The software *NearPod*[4] was used to perform the 'send and share' function transferring questions to students and student responses to the teacher.

Lesson 2. Directed numbers

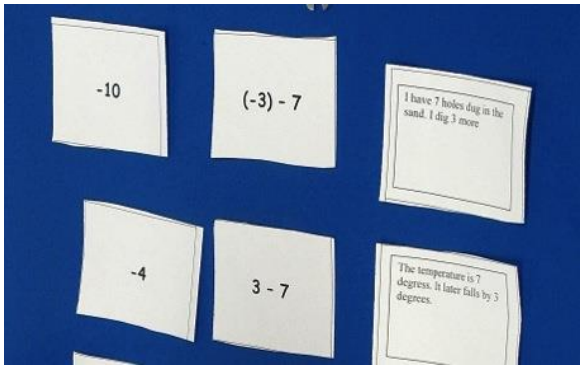
The lesson was, again based on the ideas within a task on directed numbers developed at the University of Nottingham as part of the Mathematics Assessment Project[5]. In the original lesson the conceptual difficulties associated with the addition and subtraction of directed numbers were discussed using a particular diagrammatic representation. This type of representation was incorporated into the Fasmed lesson for the purpose of explaining the concepts of addition and subtraction with negative numbers whilst a card-matching activity was used to connect different expressions, solutions and 'real life' examples of adding and subtracting negative numbers. These cards were devised by the teachers. So, for example, students had to match *"The sea level starts at 7 metres below sea level. It then rises 3 metres"* with a card that says: (-7) + (+3) and with a card that says: -4.

Prior to the lesson students were asked to complete a set of multiple-choice questions using the web-based app: diagnosticquestions.com. The app marked the students' work but also required then to give a reason for their answer and supplied a large bank of correct answers, with reasons, from other students so they could self reflect and adjust their thinking. The teacher had access to a large amount of data including a class summary and profile of responses.

On the basis of the pre-lesson work the teacher adjusted the questions planned for use in class. Firstly students attempted the three way card-matching exercise. This was done using actual cards and not iPads. In the example below, the student has his cards matched incorrectly.

[4] https://www.NearPod.com. NearPod is a simple lesson planning application. Pages are created in an 'editor' by the teacher and all the activities are constructed prior to the lesson. The lesson is started by the teacher and the pupils 'join' the class using a class code.

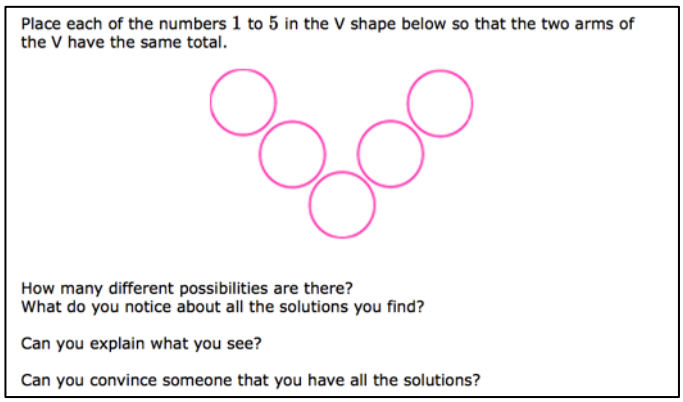
[5] http://map.mathshell.org/download.php?fileid=1596



In the second part of the lesson questions were again supplied using *NearPod*[6] and selected student responses were displayed for discussion. Solutions were provided and discussed using a pre-prepared PowerPoint presentation of slides showing possible diagrammatic representations and the solutions.

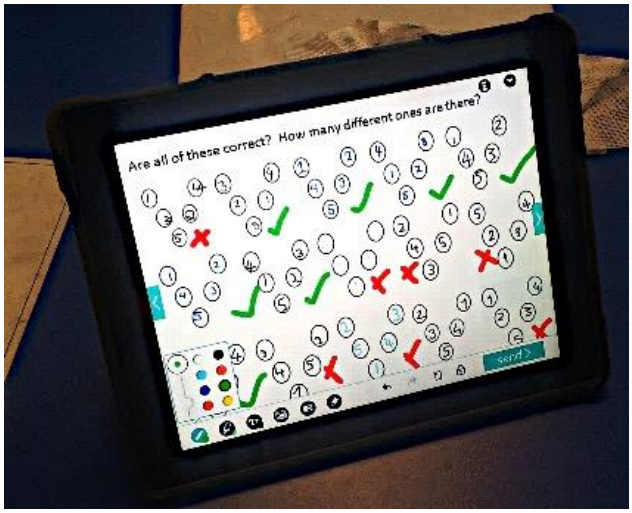
Lesson 3. 'Magic V' investigation

This lesson was an investigation based on selected questions from of problem referred to as the 'Magic V' on the NRICH website[7]. The aim of the lesson was to develop students' investigative skills, particularly with respect to identifying pattern and developing strategies to solve problems.



Students tackled the problem prior to the lesson, for homework. At the beginning of the lesson the teacher displayed some of the students' answers using the interactive whiteboard. Students were sent the solutions using *NearPod*, and they were asked to decide whether or not all of the solutions shown on their tablet screens were correct. Some students indicated their responses with ticks and crosses:

[6] https://www.NearPod.com.
[7] http://nrich.maths.org/6274



During the lesson they explored further questions and extensions to the original problem with some class discussion at times to share ideas on emerging patterns and generalisations.

The main use of technology involved students working on iPad's. From time to time the teacher also used the *NearPod* app to formatively to assess individual students' understanding and progress, and to compare different solutions and methods. When the teacher displayed a solution on the interactive whiteboard it was mainly to facilitate a whole class discussion about the need to think in more general terms about the conditions under which the rules or patterns suggested would work.

A different form of *NearPod* (homework mode) was used during the pre-lesson work and within the lesson. Students were also provided with small whiteboards for use alongside their iPads during the lesson to record their working.

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 at least one occasion.

As already highlighted, communication between this group of teachers and the researchers was mainly through the lead teacher, who had a strong influence over the lesson designs due to his expertise with technology. Over time however, the interaction between these three teachers did increase, with Carol and the third colleague of the group making a more significant contribution to lesson planning.

4. Classroom teaching

Although experienced as a mathematics teacher, Carol explained in her interview that she was not a frequent user of technology in the classroom, using the iPads "not a huge amount" (See Appendix C) attributing this partly to the barrier of technology being "an extra thing to learn". Although she did not appear in lessons to be particularly confident about using the iPads she stated informally that she wanted to learn more about how technology might be of benefit to her teaching. Her experience prior to working on the Fasmed project included some use of iPads with software such as *NearPod*. In addition she had used the *MyMaths* [8] website and the *Desmos* [9] program with groups of students.

When asked about her experience of formative assessment, Carol explained in her interview that she was familiar with the use of mini-whiteboards in class. She explained how these would be used as follows.

[8] http://www.mymaths.co.uk. MyMaths is a website providing a range of interactive resources for students with a teacher-controlled monitoring and management system.
[9] https://www.desmos.com. Desmos is a graphing calculator with many powerful features for drawing simple and complex graphs and manipulating functions.

> "I would give out open answer questions such as 'Show me a quadrilateral' or something, and then show me another one. That way it's fairly people directed. People can decide how many they'll end up doing. Or sometimes closed questions. It works well, although less well."
> (Appendix C)

Carol made a distinction between the effectiveness of open and closed questions without explaining this in detail. She also suggested that formative assessment was student-directed, indicating that strategies allowing students choice about how many questions they attempted were formative. These strategies were not explained further at the time but other observations in the school suggested that the use of mini-whiteboards might be to provide an overview of student responses for the teacher, that could indicate common misconceptions, leading to discussion aimed at dealing with these misconceptions or adaptations to the lesson plan.

Carol also stated that she used questioning, with a range of approaches for different purposes such as open and closed questions, questions to the class for volunteers to answer ('hands up' approach) or questions directed to individuals. Although these approaches may be a means of exposing and exploring students' misconceptions, Carol was not explicit about how these questioning approaches prompted or contributed to a process of formative assessment.

References to marking and exercise books in Carol's interview suggested that she also used students' responses to closed questions to gain an overview of progress. This might help the teacher assess the students' levels of understanding and identify common misconceptions, which could lead to an activity to deal with these difficulties although this was, again, not clearly stated.

5. Lessons

Carol 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. The first and third lessons were observed and video-recorded and the second lesson was observed but not recorded. In the first lesson the video recording involved the use of three cameras: two static cameras on two pairs of students and one mobile camera following the teacher. The third lesson was recorded using two static cameras by the school and the recordings were made available for the research.

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 Fasmed 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 emerge from the series of lessons.

Lesson 1: Algebraic expressions

The main type of formative assessment planned into the lesson involved the eliciting and discussion of student misconceptions using the 'send and share' features of the *NearPod* app on the iPads. From a teacher perspective, this enabled Carol to view all the students' responses simultaneously, display

these for the whole class to see and select examples for whole class discussion. The teacher thus gained an overview of students' thinking and could, theoretically, adapt her questioning to stimulate and focus class discussion on those misconceptions.

In fact, so many misconceptions were simultaneously presented to the teacher that this task proved far from straightforward. The range of student responses presented using the software revealed that students were starting from a less informed position than had been assumed by the teachers in their planning. The teacher had a difficult task in selecting student work to discuss and in posing suitable questions that would further learning. Only a few students were able to provide answers to questions that aided understanding for others. Opportunities to involve students in critical appraisal, of solutions and methods, were limited by this mismatch between the lesson content and the prior knowledge of students. Although there was the potential with this software to help teachers expose and address common misconceptions, the effectiveness was dependent on decisions made by the teacher on adaptations to the lesson plan, the choice of student work for discussion and the questions used in class discussion. The technology acted as a facilitator in the formative assessment process but Carol's skills as a teacher were essential for effective completion.

Nested within this teacher-focused formative assessment process were opportunities for formative assessment by students. During their work on the questions, before answers were sent, there was evidence that students often worked collaboratively, comparing and discussing how to work out their answers. Video analysis showed how discussions between students sometimes led to changes in thinking and understanding.

A second type of formative assessment occurred in the lesson when samples of student work were displayed. There was evidence from the lesson observation that some students compared their own answers to those from others, engaging in a mixed process of peer assessment, self-assessment and self-reflection that led to adjustments in their thinking and understanding.

There were issues however about the delays when answers were sent by students and also a lack of flexibility that meant students were unable to change an answer once it was sent, even if their thinking changed as a result of a continuing discussion with peers and/or self reflection. Students became passive and disengaged when they had sent a response and had to wait for others before any class discussion commenced. For other students, class discussion sometimes started before they had completed and submitted their answer. This presents a dilemma and a pedagogical challenge when an application such as *NearPod* is used to send short questions one at a time with delays before discussion. This particular software and use of technology seemed to disadvantage both high and low attaining students to some extent, which needed to be balanced against the benefits identified.

Carol's inexperience with iPads was evident within the lesson, not just due to the use of a rather simple app to 'send and share' only but through her occasional hesitancy and 'hedging' comments (e.g. "I think if you …") about iPads. This was particularly noticeable when giving instructions to students on how to set up and use the app. Her personal reservations about the effectiveness of the technology were evident when she drew attention to the weaknesses of the app, for example when she warned students that they would not be able to change their answers once they had been sent

In the implementation of the lesson plan there were some tensions between the sort of classroom culture in which collaboration and discussion were valued, which Carol was trying to create, and the prevailing school environment in which quietness and order were seen as important. In order to use formative assessment, there needs to be a culture in which students can express opinions, make

mistakes, collaborate and discuss. The school culture therefore presented an obstacle in this case to the formative assessment that the teacher wished to explore.

The planning of the lesson was part of a collaborative process involving teachers and researchers but the teachers produced the final written lesson plan. A lack of detail in the written plan was apparent and this was also reflected in the implementation. The move from diagnostic assessment to concept development was not clear in practice and the lesson seemed to become a sequence of questions without a clear overall structure. Although open and closed questions were used effectively in class discussion there were many unanticipated misconceptions. These provided some clear areas for further development in the subsequent lessons.

In this lesson, *NearPod* was used as a tool to facilitate a particular teacher-focused formative assessment process. There were clear benefits from the 'send and share' function that increased the speed of communication and the accessibility of data from a teacher perspective but the processing and interpretation of this data was carried out by the teacher. A similar function might be achievable without iPads (e.g. using a visualizer to display written samples of student work) but without the benefits of simultaneous display and speed that this approach provided.

Apart from exploring the use of technology there was a need to work on the accompanying action of the teachers in this school cluster. It was agreed with the group that thorough preparation of coherent and detailed plans was needed to make best use of the opportunities for formative assessment in subsequent lessons.

Lesson 2: Negative and positive numbers

The formative assessment planned into this lesson included both 'send and share' functions of the technology plus some use of a 'process and analyse' function. These were applied in different sections of the lesson and utilized different software.

Prior to the lesson a multiple choice test was devised by the teachers using the website diagnosticquestions.com. When students used the site it generated detailed summaries both of whole class performance (using graphs) and of individual students' answers, including explanations. This data offered the teacher the opportunity to gain an overview of students' prior knowledge, expose student misconceptions and so inform the lesson plan. Although Carol explained that this was her intention, we did not find evidence in the lesson to suggest that her teaching was adapted as a result. As in lesson 1, many difficulties and misconceptions about operations with negative numbers were apparent within the lesson and she found it difficult to address these satisfactorily. This highlights two important aspects of the formative process: firstly the need not just to extract information from students using technology but also to obtain appropriate data in useable forms, and secondly the dependency on a teacher's skills in using the opportunities afforded by the data.

In this case, prior to the lesson, a large amount of secondary data was generated by the web-based app. This increased the amount of information available for the teacher regarding students' prior knowledge and thinking but also made the process of using the data more complex. Although the technology provided useful reports in summary form, there was also the facility to 'drill down' to the individual student level for more detailed views of students' responses to questions. The teacher was faced with an extensive set of data that required a significant amount of mental processing and time in order to select and use the information effectively. Although these teachers commented on the usefulness of the summary data, they acknowledged that the app generated more information than

they could use. In order to use the pre-lesson data effectively a teacher must process and select data from multiple reports and then make decisions on appropriate actions to take.

The second use of technology in formative assessment in this lesson was again linked to the use of class discussion but this time Carol chose to photograph student work in progress using her iPad during the card-sorting activity and then display this on the interactive whiteboard for the class to view. The sample student work selected and displayed was then used to generate discussion. Carol questioned students about their own work, or that provided by other students, thereby encouraging students to engage in self-reflection and act as peer assessors. At times, when students were able to offer coherent explanations of their methods or solutions, students acted in effect as instructors for others but the difficulty of the three-way card sort and the multiplicity of misconceptions made these strategies challenging to implement.

There were also sections within this lesson where formative assessment was planned without the use of technology. In particular, collaborative work took place between groups of students during the card-sorting activity but this was a 'hands on' card sort rather than an exercise provided on the iPads. The teachers explained that they believed this to be a better way of using this type of activity, suggesting that they did not see the transfer of certain activities from a paper-based approach to the iPad as a simple replacement of one resource for another but a modification of the actual process which may not always be beneficial.

One of the particular difficulties with this lesson was the mixed approach to developing conceptual understanding with respect to the adding and subtracting of negative numbers, through the use of a combination of different models. In the planning of the lesson the teachers proposed to use the diagrammatic representation from the MAP project but in implementation they often used the number line alongside this as a means of explanation. This use of dual models led to some confusion. Carol, however, recognized that she had already used the number line with students and anticipated some difficulties for herself and students in introducing a different model. This recognition of the difficulty showed a level of reflection appropriate for an experienced teacher. There was however still evidence from the lesson observations that many students had difficulty understanding the concepts. In this lesson the planned formative assessment strategies were not as effective as anticipated by the teachers, suggesting that lesson planning required more thorough consideration of student's likely conceptual challenges and how these could be addressed. In particular, from observations of all three teachers it appeared that there were still issues regarding the anticipation of student difficulties, the development of appropriate teaching methods to address these and realistic time-planning so that lessons did not conclude with significant misconceptions still unaddressed.

Lesson 3: 'Magic V' investigation

The purpose of this lesson was to develop students' investigative skills and therefore the context was rather different to the previous lessons in which conceptual development was the focus. *NearPod* was used in two different modes as a 'send and share' function within formative assessment prior to and during the lesson.

Prior to the lesson the students completed a short homework task that was sent using *NearPod* in homework mode. This was used to ascertain whether students understood the basic task on which further investigations would be based and to enable the sharing of selected student solutions for their peers to assess. In this way the 'send and share' function was used both prior to the lesson and within the first stage of the lesson to establish the learning intentions and indicate some of the

criteria for success. This was largely a teacher-led formative assessment but, nested within this, were opportunities for peer assessment as students made decisions on which samples of student work were correct solutions to the initial problem.

During the lesson, students were provided with a series of further problems using *NearPod* to investigate at their own pace. These were in the form of extensions to the initial problem and involved finding solutions for questions with multiple answers or showing that there were no solutions. This contrasted with earlier lessons where short, closed questions were sent one at a time using *NearPod* and the teacher initiated a class discussion after the completion of each question. Carol allowed the students to work for some time before selecting a sample of student work for discussion and displaying this on the IWB. This encouraged continuous engagement with the problems and avoided the discontinuity when short questions were sent to students one at a time.

Whole class discussion was used at intervals to examine different possible solutions, to help students identify patterns and to encourage them to develop strategies for further investigation. This was clearly intended to help students develop particular investigative skills and indicated certain criteria for success. In practice, however, students were slow to respond to Carol's guidance. Many struggled to identify patterns and most continued to search for solutions without developing any productive strategies. Furthermore, when Carol asked students who had identified some patterns in their solutions to explain their observations to the class they found it difficult to provide coherent verbal accounts. The apparent limited ability of students to explain their work limited the benefits that could be gained from using peers as instructional resources in these class discussions.

The class discussions also presented additional difficulties that had not been fully explored during lesson planning. The lesson had a more flexible structure, with students working at their own pace to find solutions to the problems. This meant that students were at different stages in their investigations at any one point in time and whole class discussions were difficult to place within the lesson so that student needs were met effectively. In addition, some students were reluctant to stop their investigative work to engage in a class discussion whilst others lost concentration during periods of individual work and were hard to re-engage. Planning for lessons involving investigations and effective formative assessment presented new challenges, even though the basic processes and 'send and share' function of the technology appeared similar.

There were also indications that the teaching approaches used for the research by Carol and her colleagues were difficult to implement within the established school culture. Firstly, observations and discussions with the teachers revealed that students were unfamiliar with mathematical investigations. The departmental scheme of work provided few opportunities for investigations and teachers were expected to keep to the prescribed schedule. Furthermore, in the school culture, formality and structure in lessons were expected. In this particular lesson there was evidence that students were having some difficulties adjusting to a different way of working in the classroom and this added to the challenges for the mathematics teachers in the study.

Although the iPads and *NearPod* app were used in a similar manner to the earlier lessons, by utilizing the 'send and share' function to facilitate class discussion and encourage both peer and self-assessment, Carol used the function during student activity in this lesson rather than just when solutions had been completed. The function was also used to monitor progress but this was in conjunction with physically walking round the room to view student work. Similarly, although students did record and send work to the teacher using *NearPod*, they were also provided with mini-

whiteboards to record their interim working. There was therefore a dual approach, using both technology and physical methods during student activity for viewing student work, monitoring progress, selecting examples to display and using these in class discussion. This seemed to reflect Carol's own lack of confidence that technology could adequately provide the resources needed for the learning activities and formative assessment of students. For example, Carol explained to the students they may need to record their interim working on the whiteboard because there was a lack of space on the iPad screen. Her personal perception about this disadvantage of working on iPads was voiced in the classroom and influenced her implementation of the lesson plan. In other lessons within the study it became clear that teachers with more experience of technology did not share the same opinion as Carol and also that they were often more inclined to explore ways of overcoming any perceived limitations rather than resorting to alternative methods without technology.

Main themes in the lessons

Within these three lessons there were uses of both the 'send and share' function and the 'process and analyse' function of technology although sending and sharing was the more frequently used. These functions were used in conjunction with several different formative assessment strategies although some more often than others. There was extensive use of class discussion to elicit evidence of students' understanding and these discussions also provided opportunities to clarify the criteria for success, to give feedback and sometimes use peers as instructors. Although formative assessment processes were often teacher-focused, there were also opportunities for student-focused formative assessment and activity involving peers. These often occurred during informal paired discussions when working on iPads and were nested within the broader teacher-focused formative assessment processes planned into the lesson.

There was frequent use of whole class discussion in these lessons, using samples of student work which were displayed on the IWB. Students engaged in some peer and self-assessment as they compared the solutions displayed to their own but the use of questioning by the teacher meant their contributions to these class discussions were used both to expose misconceptions and to utilise students as instructors for others through their personal explanations. In this way their responses were a means of assessing understanding, clarifying meaning and also, sometimes, developing deeper understanding.

These formative assessment processes were, however, not always as effective as expected. A particular problem in these lessons was that students often had multiple misconceptions these were not always anticipated by the teacher prior to the lesson, resulting in too many difficulties to address within the lesson. Even when diagnostic assessment had taken place prior to the lesson there were still difficulties unless sufficient adaptations were made to the lesson plan. The need to assess prior knowledge was a strong theme that emerged from these lessons and Carol began to develop better strategies over time to anticipate, adapt and address misconceptions.

The emphasis on discussion, between pairs and as a whole class, was a feature of these lessons that contrasted with the dominant school culture. This made strategies that were dependent on student discussion more difficult to implement. For example, verbal explanations from students were not always coherent enough to be useful to others and Carol had to supply additional explanations.

Carol's own professional development journey was initially focused on how to use technology. This affected her position in the group of teachers and her confidence in the classroom. As time progressed, the inter-dependency of technology and teaching skills in developing effective formative

assessment processes became more apparent and Carol was able to use her teaching experience more confidently both in lesson planning and in the classroom.

Using the technology did, however, present pedagogical as well as technical challenges for Carol. Issues such as the fragmentation of learning when questions were sent one at a time using *Nearpod* and the need to quickly assess an array of student solutions displayed on the IWB were different to those normally encountered when using textbooks and paper. Using technology in formative assessment could have both positive and negative effects but the changes it makes mean teachers need to consider new issues and adjust their own practices appropriately.

6. Pupil perceptions

Carol explained in her interview how she felt that the students had responded positively to the technology and this was supported by indications from the students in the Q sort activity and the focus group that they enjoyed using technology in mathematics lessons. The factors that Carol believed might have contributed were that the group seemed keen to learn anyway, that they readily engaged in discussion and that they were used to talking about each other's work. From the students' perspective, collaboration was something they particularly valued in lessons and students in the focus group believed they understood better when they worked collaboratively with their friends. In a school environment that was fairly formal there was a noticeable contrast between students' values in this respect compared to the school culture.

There was a suggestion from Carol and other teachers in this school that the technology had some 'novelty value' for students since it was not widely used in lessons but students' perceptions were not the same. They stated that they often used technology in their lessons and that this was useful (Q sort activity) for individual learning and for collaboration. The difference in these three lessons, therefore, was more likely to be due to using iPads rather than other forms of technology and in how these were actually used within the lessons.

From the lesson observations, it became clearer that the students were not particularly familiar with using iPads but they were confident in other ways. Their attitudes were generally positive, showing greater resilience and confidence with learning mathematics compared to other students (Case study 1) and believing it was a subject everyone could learn.

Providing variety in lessons was something Carol mentioned in her interview as being important so technology was one way of contributing to what she believed to be a desirable feature of students' classroom experiences. There was some agreement from students in the focus group that the use of iPads provided something "different from what we do normally in lessons" (Appendix D) and this was perceived to be enjoyable, although not all the students agreed. The difficulties of setting up the iPads and logging on, plus experiences of technical failures were also frustrating for pupils. Students observed that "It does take quite a long time to work and set them up, but once we're actually doing it, it's straight forward" suggesting that the initial setting up may be a temporary frustration but working with the iPads generally was not problematic. For this class, using iPads in their mathematics lessons was a fairly new experience and there appeared to be more technical issues to resolve. The time taken to commence work on the iPads was certainly longer than that observed in some other lessons where students already had their own iPads. This was partly due to the need to collect and distribute the class set of tablets before logging in could commence but lack of familiarity with the technology also contributed.

Pupils identified clear benefits, however, in using the iPads for the main activities. For example students could see how being able to display answers from all the class simultaneously on the interactive whiteboard (IWB) helped them to compare answers and methods:

> "…They've got everyone's screen on the board and then you can see everyone's answer and you can compare. And different answers from different people and how they worked it out. And if you got it wrong you can see."

> "You can share your different ways to work out the question. You can see how people work their answers out and compare it to yours and learn different ways to work out a question because of someone else's different way of working it out". (Appendix C)

Students saw this as a way of learning from their mistakes and identifying where they had gone wrong as well as understanding alternative methods. Students valued this visibility and transparency, suggesting that this helped them learn from each other in a more collaborative and open learning environment. These students were clearly not seeing the display of their work as part of a teacher-led activity but rather an opportunity for active self-assessment and peer-assessment from which they were developing better understanding of mathematics.

Although these students focused mainly on their own engagement with the set of solutions displayed, they also mentioned that the visibility allowed the teacher to use their work when providing explanations. It was suggested that the accessibility of student work through visual display on the IWB helped students' opinions and thinking to become more central, thereby changing the nature of the lesson. The focus on student work, with opportunities for self and peer-assessment contributed to what students referred to as a "new way of learning" that clearly contrasted to their normal way of working in class.

There were suggestions, however, that not all the class engaged so positively with the iPads. The focus group suggested that some students "just messed around" by drawing on their iPads or submitting false names. Whether this was due to the 'novelty' value of using iPads or a more general lack of responsibility in class on the part of these students remains unclear.

Overall the students identified more benefits than disadvantages in using the 'send and share' functions and the advantages were clearly linked to an enhanced use of formative assessment in these particular lessons. The students expressed views that iPads could help them with mathematics and referred to the wide number of applications available, including a graphing program they had used before. Despite some technical and practical difficulties with these lessons they could clearly identify benefits and further potential for wider use in mathematics lessons.

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 in which data on student responses to questions were used to either adapt lesson plans in advance, or modify teaching methods whilst the lesson was in progress.

Examples within this case study included processes with and without the use of technology. The dominant actor in these formative assessment processes was often the teacher who initiated, structured and planned formative assessment opportunities into the lessons. For example, Carol engineered class discussions to elicit evidence of students' understanding (Strategy B) using the 'send and share' function of the technology to collect and display student work. By asking students to explain their answers to questions to the class within these discussions there was some evidence of students being activated as instructional resources for one another (Strategy D) although somewhat limited and controlled by the teacher. Similarly, the teacher often sent questions electronically for students to complete individually on their iPads, as means of eliciting evidence of understanding (Strategy B) but discussion between peers sometimes took place before students sent their completed solutions back to the teacher. In this way students acted as instructional resources for each other (Strategy D) during an informal collaboration and comparison of ideas.

In two of the lessons technology was used to 'send and share' pre-lesson tasks. In the second lesson the technology (diagnosticquestions.com) also performed a 'process and analyse' function that was intended to assist the teacher further in eliciting evidence of student understanding (Strategy B). However, the quantity of the raw data made available to the teacher by the technology left her with the major task of analysis and synthesis if she was to respond adaptively. Too much data is not useful to the teacher.

For the 'Magic V' investigation there was some evidence that the teacher clarified learning intentions and criteria for success (Strategy A) through the use of the pre-lesson task and the 'send and share' function of the technology. This strategy was also reinforced at intervals during the lesson using sample student work and class discussion. Here Carol also utilised strategies of providing feedback herself to move students forward (Strategy C) with questions that encouraged students to act as instructional resources for each other (Strategy D). Strategy C was also often evident in one-to-one conversations, usually initiated by the teacher, during observation of student work in progress.

Several of the class activities were instrumental in shifting ownership and agency towards students thereby activating them as the owners of their own learning (Strategy E). Students' own comments about how displaying samples of work from the class enabled them to see and compare methods or solutions indicate how increased personal responsibility for their own learning was being developed. This also occurred at times during collaborative work in pairs when students compared, discussed and adjusted their thinking without teacher intervention.

Class discussions and feedback to individuals were particularly important within the formative assessment processes planned and implemented in these lessons. Although the technology provided useful data and an efficient means of communication, the success of these strategies was dependent on the skills of the teacher in anticipating misconceptions, selecting appropriate work for discussion and generating purposeful discussion through effective questioning.

Carol's challenges in these lessons were due to a number of factors. Firstly the culture of the school was formal and quiet classrooms were seen as desirable. The formative assessment processes that she was trying to build into these lessons required a culture that encouraged student discussion and collaboration so Carol was trying to work in a way that contrasted with the school norm. Establishing an alternative culture in her mathematics classroom for these lessons was difficult within a school environment where other values were firmly established.

Secondly, Carol's lack of confidence in using the technology was not helped by the existing rather limited used of iPads in the school, available only as class sets that had to be collected and issued each lesson. Although some technical support was available in the school, Carol also had to take responsibility for dealing with technical failures and having alternative strategies if these could not be resolved.

Within the lessons there were however some particular elements that proved challenging. In the second lesson attempts to establish students' prior knowledge were facilitated by the use of the diagnostic questions web-based app but in both the first and second lessons the wide range of misconceptions evident in students' work was not easy to deal with in one lesson. This suggests that adjustments to the lesson in response to the assessment of prior knowledge were insufficient and that this particular formative assessment process was not particularly effective in these lessons.

In all the lessons the teacher used the 'send and share' function to collect and display student work for class discussion but sometimes students were slow to respond or unable to articulate their reasoning coherently. Students' unfamiliarity with these methods and the effects of the school culture may have contributed to this problem but the decisions made by the teacher about the samples to select and the questions to ask were essential to constructing a purposeful discussion. This aspect of the formative assessment process became more prominent in lesson planning as the research study progressed and teachers began to understand the importance of these decisions alongside the use of technology.

Carol's professional development journey through the design and implementation of these three lessons was largely characterised by her limited technical knowledge and desire to evaluate the possible benefits of using iPads in her lessons. This influenced both her participation in the teacher group and her teaching of the planned lessons. Limited use of technology in the past had an impact on personal confidence in the classroom and the ways in which she used the technology, although, as the research progressed, she was able to draw on her general teaching experience to make useful contributions to the planning process. The use of technology dominated the early discourse within this group of teachers but the importance of other teaching skills in the formative assessment process became apparent with time and this allowed Carol to adopt an integrated approach with increasing confidence although doubts about the benefits were still evident in her comments, both in class and in her interview.

The case study of Carol provides insight into the challenges and professional development of an experienced mathematics teacher who lacks confidence with technology and works in a school culture that is not conducive to many of the formative assessment strategies she is trying to adopt. Her journey towards a pedagogy that integrates technology and teacher skills into formative assessment processes highlights some key aspects for consideration when teachers in a similar situation are aiming to develop formative assessment strategies using technology.

Appendix A: School information

School Data Dashboard

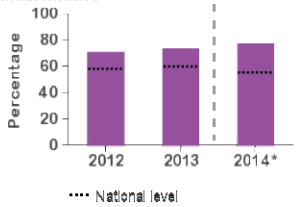
Ofsted

How are pupils doing in exams? (Attainment)

Overall

In 2014, 77% 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 20% of similar schools' results, and in the top 20% of all schools.

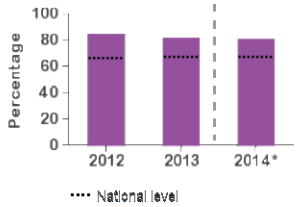
Comparison with other schools

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

English

In 2014, 60% 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 top 40% of similar schools' results, and in the top 40% of all schools.

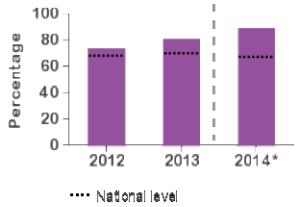
Comparison with other schools

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

Mathematics

In 2014, 66% 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 20% of similar schools' results, and in the top 20% of all schools.

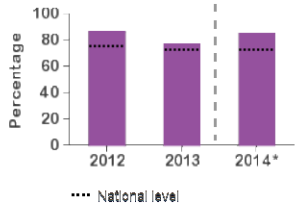
Comparison with other schools

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

Science

In 2014, 97% of pupils were entered for science (EBacc) and 95% of these attained grades A*-C.

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



*2014 results are not comparable due to changes

In 2014, the school's result was in the top 20% 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	

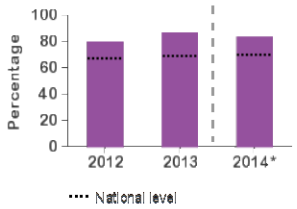
The data presented in this report are Key Stage 4 and are final. Data source: Department for Education.
Similar schools are those schools which have a similar prior attainment score to this one.

Are pupils making progress?

English

In 2014, 83% 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 top 40% of similar schools' results, and in the top 40% of all schools.

Comparison with other schools

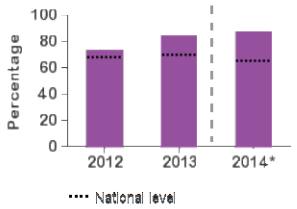
Similar schools	
Highest	
2nd quintile	
3rd quintile	
4th quintile	
Lowest	

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

Mathematics

In 2014, 87% 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 20% of similar schools' results, and in the top 20% of all schools.

Comparison with other schools

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

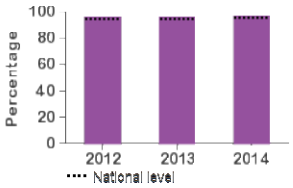
All schools	
Highest	
2nd quintile	
3rd quintile	
4th quintile	
Lowest	

How good is attendance?

Overall attendance

In 2014, the attendance rate at this school was 96.6%.The attendance rate has increased by 0.9 percentage points since 2013. The attendance rate is in the top 20% of all schools

Level of attendance at this school



Comparison with other schools

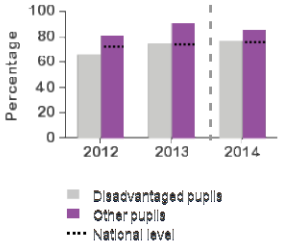
All schools	
Highest	
2nd quintile	
3rd quintile	
4th quintile	
Lowest	

Closing the gap between disadvantaged and other pupils

English Expected Progress

In 2014, 76% of disadvantaged pupils achieved expected progress, while 85% of other pupils achieved expected progress.

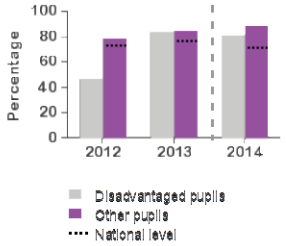
Percentage of pupils who achieved expected progress



Mathematics Expected Progress

In 2014, 81% of disadvantaged pupils achieved expected progress, while 88% 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.

Number of pupils

	2012	2013	2014
School (All pupils)	1134	1145	1122
National average	990	978	957
Year 11 pupils (KS4)	171	178	179

Comparing your school to the national picture in 2014

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

% of girls

	2012	2013	2014
School (all pupils)	51.7	50.0	49.9
National average	49.6	49.6	49.7
Year 11 pupils (KS4)	53.8	53.9	51.4

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

	2012	2013	2014
School (all pupils)	20.0	21.8	22.0
National average	26.7	28.2	28.5
Year 11 pupils (KS4)	15.2	23.6	20.1

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

	2012	2013	2014
School (all pupils)	2.2	1.0	0.7
National average	8.1	7.7	7.3
Year 11 pupils (KS4)	5.3	8.4	7.3

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.

Appendix B: Tasks and lessons

Lesson 1: Algebraic expressions

CONTEXT

School	Academy B			Observer	Diane Dalby	
Class	Year and set	Year 9		Teacher	CAROL	
Date & time	Date	12/03/15	Start	2.30	End	3.30
Student numbers	Present	21	Male	12	Female	9
Room layout	Students all seated in rows of four at desks with central aisle.					

LESSON STRUCTURE

Time	Activity	T	FA
2.40	iPads given out, one each, directed to Nearpod log in. Some delay getting all to input their names. One not working and replaced. Reminder on IWB of instructions and also reminded to see algebra only in students' responses. First question given: write expression for add 3 to n and then multiply your answer by 4. One student has 3n times 4, another has (3 + n)4. Reminder to think before sending since cannot be retrieved. Teacher displays all answers and asks whole class question: what should we apply in this case? Directs question to student who thinks add, then corrects to multiply. Teacher highlights "and then" in question and asks what do brackets mean? Students provide some answers.	T1	TWC TSW
2.50	New question: show me an algebraic expression that means multiply n by 4 and then add 3 to your answer. Students respond. Teacher displays answers and asks one student how she could simplify her 4 times n.		
2.53	New question: add 5 to n and then divide your answer by 3. Teacher displays answers and asks students to point out any that do not fit. Student suggests one and teacher explains this is alright. Teacher suggests a different one and asks if this is the same as another? Students answer and teacher emphasises that some expressions that look different are also correct. They mean the same. Student asks about another variation.		TWC TSW
2.56	Next question: add 5 to n and then square the answer. Most answer correctly. Teacher explains briefly why. Next question: multiply n by n and then multiply your answer by 5. One student asks neighbour if you need the brackets. Variety of answers. Teacher asks which is the shortest way without brackets?		SPG

	Next question: multiply n by 5 and then square your answer. Student tries (5n) then hesitates about squaring. Some answers of $5n^2$ and $(5n)^2$ so teacher asks of these are the same. What is this square telling us to square? Students gives wrong answer and teacher corrects.		
3.03	Area questions introduced as different form of question. First question is a square of side n and width 4. Answers 4n, $4n^2$, $(4n)^2$ and 4 times n. Teacher displays students' responses and asks for one that is not correct.		TWC TSW
	Next question is a rectangle with side 2 and width n, 3. Some discussion between students about this one. Range of answers: (2n) + 6 , (2n) + 3, 2n + 3, $2n + 3^2$, … Teacher scrolls down answers and selects one. Asks class about how to work out the area of a square. Explains how one answer is correct. Asks class if they can find another answer that is the same? Writes an answer on whiteboard and asks how this could be written differently? Uses to show an expansion and equivalent expressions.		TWC TSW
3.15	Composite shape. Discussion between students about splitting into two rectangles. First one is 2 times n so 2n. One suggests (2n) + (3 x 1) and explains to neighbour why. Another already has 2n + 3. Class discussion. Teacher suggests some obviously cannot be the same as each other. Suggests treat as two separate rectangles. Teacher selects 2(n + 3) and asks why this cannot be correct. Student comes out to explain how the sides of the two pieces are not the same. Teacher follows up with further explanation.		TWC TSW
3.21	Question has square of side n. Write any correct way, not necessary in simplified form. Answers n x n, n^2 so teacher moves on. Question has side n and width n + n + n + n + n. Conversation beween students: Isn't that n squared? Other says has to do the adding first. Class answers show some n^5 and some 5n x n or $5(n^2)$. Teacher explains why some of these are the same.		TSW
3.27	Students asked to log off and pack iPads away.		

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	iPad	Nearpod	Questions are sent to students electronically.	Students sometimes discuss in pairs before sending answers.
T2	iPads	Nearpod	Students send their responses to the teacher.	Teacher gains an overview, identifies common misconceptions and can adjust lesson to address these.
T3	iPad and IWB	Nearpod	Teacher selects student work and displays this.	Class discussion about sample student work is used to exposes and deal with misconceptions.

REFLECTION

The level of student understanding of directed numbers gained prior to the lesson seemed to be less than expected by the teacher and therefore the students struggled with the content of the lesson. Although the teacher sent questions one at a time to the students and used their responses to simulate discussion and expose misconceptions there were too many to deal with within one lesson. Explanations offered by the students in class discussion sometimes exposed further misconceptions and were ineffective as sources of instruction for others.

Displaying all the students' responses simultaneously allowed the teacher to gain an overview of their answers and identify common misconceptions. Students also engaged in some peer assessment and self-reflection as they compared other students' answers to their own. However, sending questions one at a time meant some students responded quickly and had nothing to do for a while. Others waited until they could see other answers on the board before deciding on their own response.

Careful assessment of student prior knowledge may have helped the teacher adjust the lesson plan to better address the most common misconceptions.

Lesson 2: Negative numbers

Lesson plan

FASMED Lesson Plan: Year 9 Developing Understanding Of Positive And Negative Numbers
Date: 6th and 7th May 2015

This lesson's objective is that students develop their skills to:

- Add and subtract directed numbers (positive, negative and zero) with understanding.
- Address common misconceptions about the addition and subtraction of directed numbers.
- Explain their reasoning using diagrams.

What is the story for this lesson?

- The lesson begins with a card sort starter activity where students match up various +/- problems to matching contexts and diagrams.
- The outcomes of this activity are then discussed as a whole class, utilising iPad technology to highlight individual group decisions that expose understanding or misconceptions.
- Students then answer a series of whiteboard questions from ks4 toolkit.
- Students then attempt to make their own card sort creating their own combinations of problems, diagrams and contexts.
- Finally students swap created card sorts and / or as a class certain card sorts are attempted.

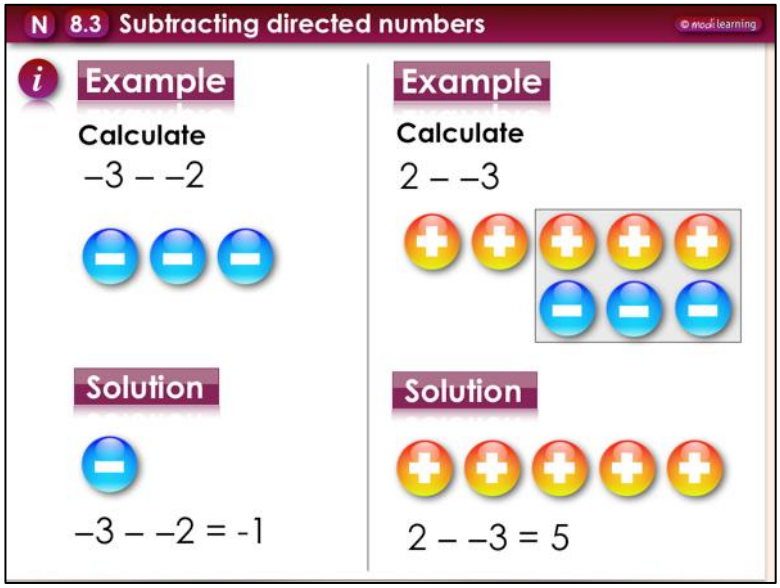
Resources required:

- Starter Card Sort
- iPad or visualiser connected to main classroom screen
- 2nd Card Sort Set
- Mini Whiteboards and Pens for each student
- Scissors

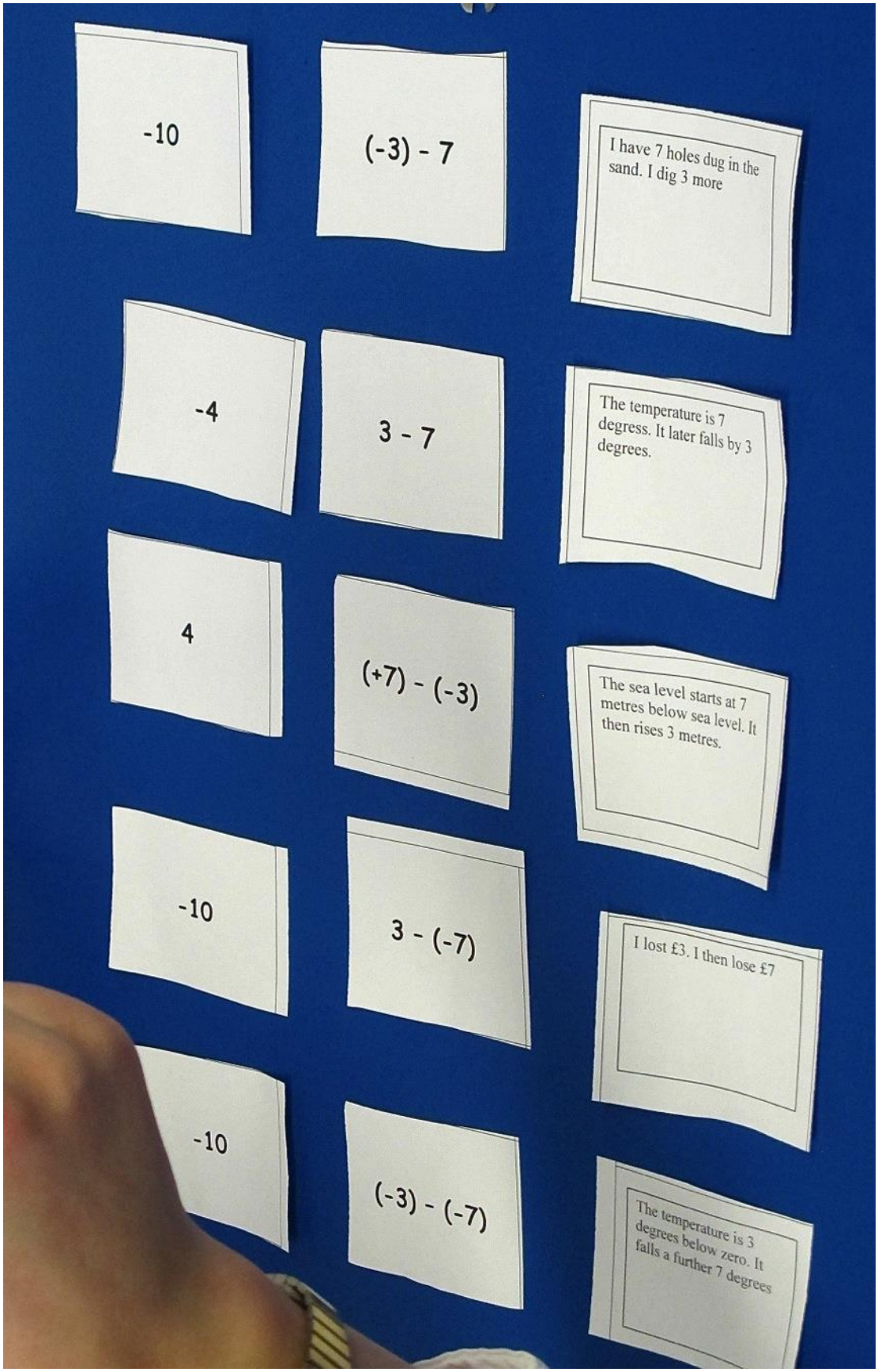
Time (mins)	Activity	Misconceptions	Key Questions and Responses
	Entering the classroom and sitting in their usual (paired) places. Some students may need to be placed into pairs		
+05	(15 min activity) Students are given the starter card sort of **X** card triples and asked to match as many cards as they can. Questions upon the cards are designed to expose misconceptions and challenge understanding. Many questions are equivalent to those in the MAP Adding and Subtracting Directed numbers questions, initial assessment task. **Students who complete work early to create cards for the 'missing blanks' in the card sorts.**	Students interprets brackets in questions as leading to multiplication. **EXAMPLE** Student writes '**24' or '-24'** as the answer to (a). Student confuses the sign of the numbers with the operation. **E.g. (+3)-(+5) = 8** Student subtracts the wrong way round in order to obtain a positive answer. Student interprets 'addition' to a negative number as subtraction. E.g. (-3) + (+8) = -11 Student applies 'two minuses make a plus' inappropriately. E.g. (-3)-(+8)=11 Student interprets subtraction of a negative number as	Response: What is the answer to (+8) x (+3)? Do you think you should obtain the same answer for (a) and (+8) + (+3)? Do you think you should obtain the same answer for (a) and (b)? What is the answer to (-3) - (+8)? What is the answer to (+8) + (+3)? • What is the answer to (+8) + (-3)?

		subtraction of a positive number. E.g. (+8)-(-3)= 5	(In extension) creating contexts. Can you use number lines or writes about 'journeys' backwards/forwards or up/down? Can you talk about the numbers in terms of charges or makes reference to ideas of debit/credit or temperature.
+20	(5 mins) Photos taken of starter match ups are displayed upon the board and discussed. Students are encouraged to articulate their reasons why certain combinations work and do not work. Students are encouraged to offer examples.	See above	
+25	NOTE: SOME TEACHERS MAY PREFER TO AT THIS STAGE INSTEAD USE THE SANDCASTLES DIRECTED NUMBERS POWERSPOINT (2nd half) (5mins) **IF students were seen to be weak upon adding directed numbers** the MODILEARNING adding directed numbers pdf is put upon the board Activeinspire is used to doodle over the board. Starter card sort is collected in.	See above	What is (+1)+(-1)? Slide 3: is 3+-1=(+3)+(-1)
+30	(5 mins) modilearning subtracting negative numbers whiteboard questions Activeinspire is used to doodle over the board. Informations slide is left upon the board Starter card sort is collected in.		KEY UNDERSTANDING OBJECTIVE: Students can apply the logic that (+1)+(-1)=0 to the idea that 3 = 3 + 0 + 0 + 0= 3 +1-1+1-1+1-1 So 3 - - 3 = 6
+35	(10min) Students work upon filling in the missing boxes in the second card sort. The teacher rotates around the room asking students to explain why their diagram links		
+45	(10mins) NOTE: SOME TEACHERS MAY PREFER TO AT THIS STAGE TO INSTEAD SIMPLY COMPARE TAKEN PHOTOS AS IN THE STARTER CARD SORT		Can you think of a context where this works in the real world – how would this work if we were talking about money? / a balloon ? /

	Using a video feed the teacher chooses good examples from around the classroom of well created card sorts / card sorts displaying misconceptions and students around the classroom are encouraged to match pairs.		
+55	Students pack away + Homework.		



Example of a PowerPoint slide from the Modilearning website

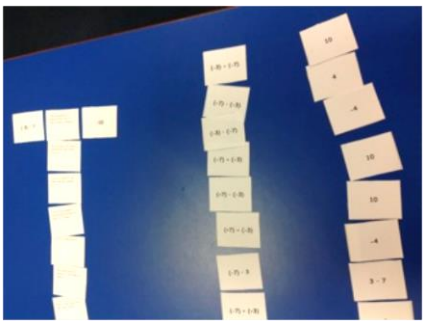


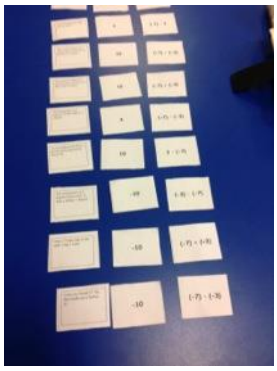
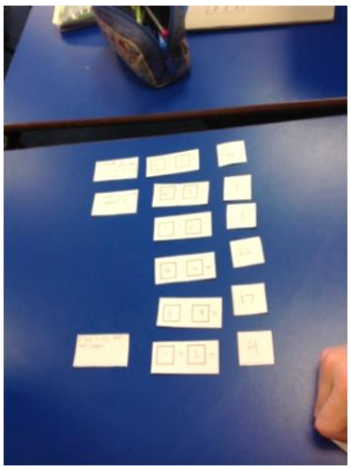
Sample cards for sorting

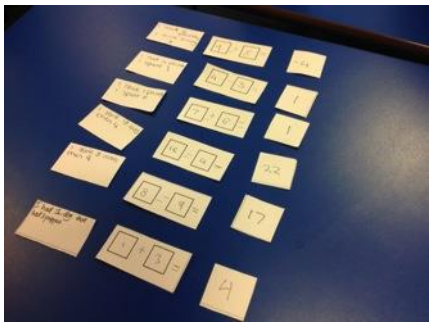
CONTEXT

School	Academy B			Observer	Diane Dalby	
Class	Year and set	Year 9		Teacher	CAROL	
Date & time	Date	07/05/15	Start	14.30	End	15.30
Student numbers	Present	21	Male	12	Female	9
Room layout	Desks in four rows with four seats at each side of a central aisle. Students are directed by the teacher work in pairs and some are directed to particular seats.					

LESSON STRUCTURE

Time	Activity	T	FA
14:35	Introduction to lesson - a third lesson on negative numbers. Directions given to students to work in pairs with a three-way card sort of 33 cards. Students help give out sets of cards to each pair and the pairs begin to sort these. Some sort these into types first (context, numerical expression, answer) and then try matching pairs from two different types. Others spread them all out. The teacher suggests to some that sorting into types is a good way to start.  Some choose to match numbers to calculations first. Most do a mixture of each, trying to match pairs of these for a while and then add the third card, the context.  Some find it easier to get the answer for a context question than to identify the calculation that produces the answer so they concentrate on matching context and answer, leaving the calculation cards until later. Most pairs engage in discussion and question each other about what is right and wrong. Students attempt explanations to each other. Several pairs talk about and try to use the 'rule' of two minuses make a plus but often use this incorrectly. One pair believes two plusses make a minus and work on this basis without considering what this means in a context. Using ideas of debt and cancelling debt seems to help with some of the misconceptions evident from the card sort.		SPG

	Progress is variable and there are multiple errors even when students do get the cards matched together. The teacher circulates and intervenes by asking pairs to explain their matching or responds to questions from students to clarify their understanding. 		STG
15:00	Teacher projects an image of part of a student card sort on IWB. The context is about holes in sand: there are 7 and 3 more are added. Teacher shows how to write an expression and simplify this to explain. One student is invited to explain their thinking and suggests you could interpret holes as negative or positive numbers, implying there are different possible expressions. This is not discussed further. Another example from student work is used and steps in the calculation are written out on the whiteboard by hand. Teacher questions whether -7 + 3 and -7 + (+3) are the same and then asks why we have the brackets. One student suggests you work out the bracket first which is acknowledged as an appropriate answer but not in this case. Another suggestion is that it is put round a negative number to show it clearly. Teacher explains how expressions may mean the same but be written differently. The teacher asks when you use the rule that a minus followed by a minus is a plus. This is a common problem revealed by the card sort. The teacher uses the context of having a debt of £3 and being 'let off' the debt as an example of subtracting a negative number. Also uses the number line to explain how you deal with some of the calculations. There are some problems with the technology during this time, e.g. losing the image that the teacher wants to show or displaying it upside down. This is not a large distraction but does interrupt the class discussion.	T1	TSW
15:10	 The card sort is taken in ready for next activity. Students are given templates to design their own card sort in pairs using any numbers ("be creative or boring"). One set has boxes, e.g. ❑ + - ❑ so students have to fill in expressions of different types. One set of cards is larger and is for the context and the smaller cards are for the answers. Students work in pairs on this task. Some students still have difficulty with interpretation of contexts and of expressions in the form (+3) + (-5). Three way matching is challenging. Many find two way is easier and can design some accurate pairs but still struggle with the third component. The accuracy overall seems slightly better but there are still errors and students seem to find it more difficult to create word descriptions (contexts) for some of their answers		SPG

	 than they did to interpret these earlier. Contexts for subtracting negative numbers prove particularly challenging.		
15:26	The teacher shows some examples of student work on the IWB and asks questions about these but time is limited. It is unclear what common misconceptions remain and there is insufficient time to address these anyway. The main focus in the examples shown is on interesting contexts rather than interpretation and meaning.	T1	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	iPad and IWB	iPad photo	Teacher photos student work and projects for discussion.	Exposes some common misconceptions and facilitates discussion about these.

REFLECTION

There were multiple challenges for the students in the card-sorting and designing activities despite two previous lessons on negative numbers. There were misconceptions about the meaning of adding and subtracting negative numbers that led to frequent errors in interpretation of contexts, in matching these to numerical expressions and in evaluating expressions. This was difficult to handle because of the number of misconceptions arising.

The technology provided a quick and convenient way of displaying student progress with the card sort since the images could be taken and used during the activity. This was more useful than the possible alternative of waiting until the matching was completed and students had stuck on to a sheet of paper. This meant that after a short period of time student work could be used to discuss and address common misconceptions. However, this opportunity was not fully explored in the lesson. Student work was displayed and some misconceptions with expressions and use of 'rules' (e.g. two minuses make a plus) were discussed but the discussion was brief and mainly teacher-focussed. More use of student explanations and open questions inviting students to assess work from their peers would have helped explore and address misconceptions more effectively.

The design activity showed that many students were still having difficulty with interpretations of contexts and expressions, suggesting that more time could have been spent to adequately deal with the misconceptions evident in the initial card sorting before using the design activity to check on learning. Alternatively, the initial card sorting activity might have been reduced and used more diagnostically, or diagnostic work done prior to the lesson to provide information from which the most common misconceptions could have been more clearly identified. The main part of the lesson could then have been more focused on the common misconceptions, with the design activity used to check on learning.

Lesson 2: Negative numbers

Fasmed

CONTEXT

School	Academy B			Observer	Steve Rhine	
Class	Year and set	Year 9		Teacher	CAROL	
Date & time	Date	07/05/2015	Start	2:30	End	3:30
Student numbers	Present	21	Male	12	Female	9
Room layout	Two columns of tables for four students facing the front of the classroom.					

LESSON STRUCTURE

Time	Activity	T	FA
2:30	Description of activity: Context, question, answer.		TWC
2:35	Students in pairs work with the card sort. Most students appear to be engaged and discussing the combinations. Teacher moving around and taking pictures of work, answering some questions. (Which direction do students go in order to figure this out? That is, start with the text? Expression? Answer?) Some students try putting equivalent expressions in pairs rather than an expression and an answer. S's arguing about -7-3. T: Come to some agreement. Continues by trying to use an analogy of a hole in the ground to help them think about it. (this is the only instance in which I observed the teacher pushing students to think through something on their own) All pairs of students have at least one combination incorrect. One pairing is 3-7 and 3- -7 Subtraction problems tend to be the ones students get incorrect most. i.e. -7-3 (Lots of students stopping at this point (2:59). Consider having two groups compare their answers?)	T1	SPG TMG STG STG
3:00	Teacher regains students' attention for whole group. T notices students' difficulties and shows pictures of student work for discussion. Picture: "I have 7 holes dug in the sand. I dig 3 more" is paired with -10 and (-7) + (+3) T: What do you think? S: 7 + 3 S: -7 + -3 (Interesting how this idea of holes is confusing the students. Holes are often used in helping students understand negatives, with people digging two feet down to demonstrate -2. In this case, however, it is intended to simply be an object to count. Teacher appears a bit confused with this as well.) Moves on to next one without resolution. Picture: "I owe my friend 7. She lets me off 3." And a student has paired it with (-7) – 3	T1	TWC TSW STG

	T: Is this the correct representation of that situation. S: (-7) + (+3) T: If we have a plus plus 3 is that the same as plus 3. Not resolved. T: If we don't have the brackets, does it make any difference? (a bit of a leading question in her tone) T: Why do we use brackets here? S: discusses order of operations T: What happens here? -7 - -3 S: The debt question T: Why? S: Taking away a debt? (What did she notice about students' thinking with these problems and why did she choose to bring up those two examples for the class? What did students get out of the discussion? What was the objective of the discussion?)		
3:12	Transition to assessment activity takes a few minutes. T explains next activity. Has cut up the worksheet used in Andy's class so students need to create pairings in another card sort, but with their own numbers. (What is the value of cutting up the pieces?)		TWC
3:16	Students take a bit longer to get started here. Some students arguing about what each paper represents. S: These are the answers. (trying to figure out which cards represent which information) At least half of the class is pretty distracted at this point.		SPG
3:19	T notes some confusion and stops class to clarify. Shows original worksheet.		TWC
3:20	Students appear to get a little more focused. In a number of cases, one student dominating the work on this task. (Again, it would be interesting to know how students go about this task, in what direction. Start with the expression first or context? Should teachers be more directive in how to approach the task?) Most students appear to start with an expression in this case. Not as much discussion with this task.		SPG TMG
3:26	T chooses some student work to discuss from pictures on her iPad. T: What would you say about this one? -4 – 5 S: 1 T: Is it one? Start on the number line. Which direction do I go in? S: It would be -9 T: I owe my friend Megan 8, I borrow a further 2 from her. How much do I owe her altogether. Is this the correct representation? S: 10 Does this mean students are confused with -10 versus 10? Or is that just staying owing 10 pounds? End		TWC TSW STG

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	iPad	Screenshot	Teacher takes photos of students work and projects these on the IWB.	Opportunity to discuss student thinking.

REFLECTION

Overall, students displayed a tremendous amount of confusion regarding negatives here. The task brings out quite a bit of their misconceptions, but the teacher did not push students towards much learning. After the class, she said that she felt the lesson was not well enacted but that students learned something. From my observation, students made numerous misconceptions evident, but most were not addressed through teacher interaction or through student to student interaction. The teacher tried to point out some difficulties students were having with symbolic representation and what to do with the negatives when she brought the whole class together, but would start on an idea and not follow through to resolution. Students did have the opportunity to have some good discussion in pairs, but at no point did they get a sense of whether their conclusions were accurate. It seemed like a pretty well structured task, that elicited multiple areas of confusion for students. However the teacher did not facilitate any significant learning about negatives and operations. Did she believe that the task would teach the students on its own? In conversation with her afterwards, she discussed how the students were learning negatives over the past couple of days and were doing pretty well with them. This activity provided good formative assessment data that seemed to conflict with that perspective. In the end, the teacher seemed unaware of the level of confusion of the class.

Lesson 3: Magic V investigation

The task and lesson plan

Fasmed ' 'Lesson'3'

!

Inves' ga' on!into!number!pa2 erns3!Magic!V's!

!

Outcomes:'

!

Find!solu' ons!to!a!number!pa2 ern!problem!

Be!able!to!explain!a!mathema' cal!solu' on!

Be!able!to!comment!on!and!correct!other!student's!work!

!

Resources:'

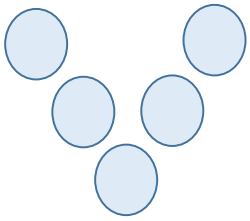
!

iPads!

Nearpod!

Fasmed Lesson 3

Investigation into number patterns- Magic V's



Introduction:

Magic V's are where you place numbers in a V shape so that each arm of the V add's up to the same number.

Questions:

1. Can you place the numbers 1,2,3,4,5 in the V shape so that the numbers in each arm add up to the same number?
2. Is there a solution to this problem when 2 is placed in the bottom of the V? Give reasons for your answer
3. Have we found all the possibilities? How can we be sure?
4. What are the solutions when you use the numbers 2,3,4,5,6
5. Can you give a way of solving the problem if there are 4 circles in each arm of the V and using the numbers 1,2,3,4,5,6,7?
6. Can you find a solution to a magic W with the numbers 1,2,3,4,5,6,7,8,9?
7. What would be a general algebraic solution using n,n+1,n+2,n+3,n+4 ?

Fasmed ' 'Lesson'3'

!

Lesson!Plan:!

!

Homework'

Homework!task!–!find!one!solu' on!to!the!problem!

!

Overall'Lesson'Structure'

Part!1:!!look!at!the!homework!results!–!can!you!find!a!different!solu' on?!

Part!2:!!Look!at!Ques' on!2!and!inves' gate!!

Part!3:!!Look!at!ques' on!3!and!inves' gate!

Part!4:!!Use!one!of!the!extension!ques' ons!if!there!is!' me!

!

Organisa5on'

Pupils!are!organise!in!pairs!with!an!iPad!shared!between!them!

Teacher!has!Nearpod!set!up!with!a!'homework!mode'!lesson!code.!

!

Fasmed ' 'Lesson'3'

!

Lesson!Part!1!

!

Look!at!the!homework!results!on!screen!using!the!different!solu' ons!gathered!from!the!homework.!

!

Task:!

!

Using!Nearpod!see!if!you!can!find!another!solu' on!

!

Which!solu' ons!are!the!same!and!which!are!different?!

!

Share!these!as!a!class!

!

Fasmed ' 'Lesson'3'

!

Lesson!Part!2:!!

!

Ques=on$2:$Is$there$a$solu=on$to$this$problem$when$2isplaced$in$the$boAom$of$ the$V?$$Give$reasons$for$your$answer$

!

Task:!

!

In!pairs!try!and!find!a!solu' on!

If!you!have!found!a!solu' on!give!an!example!

If!you!think!it!is!impossible!then!explain!why!

!

Share!the!explana' ons!and!discuss!as!a!class.!

!

Do!you!agree!with!the!answers!given!by!someone!else?!

!

Fasmed ' 'Lesson'3'

!

Lesson!Part!3:!

!

Ques=on$3:$Havewefound$all$the$possibili=es?$$Howcanwebesure?$

!

Task:!

!

In!pairs!try!and!find!another!solu' on!and!write!it!down!on!the!iPad!

Can!you!find!some!more?!

How!can!we!be!sure!that!you!have!found!all!the!answers?!

!

!

Gather!the!answers!together!as!a!class!and!use!to!s' mulate!discussions.!

!

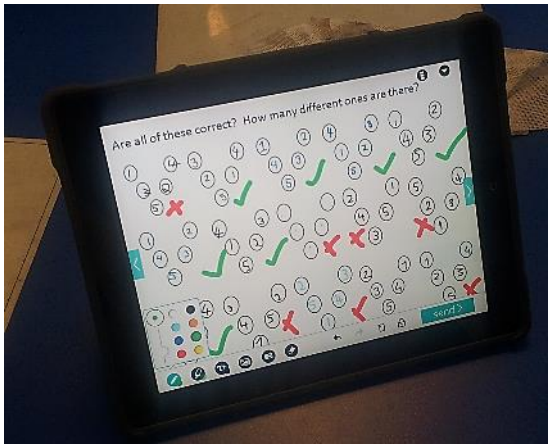
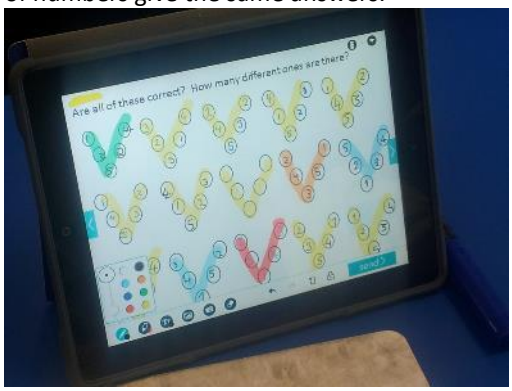
CONTEXT

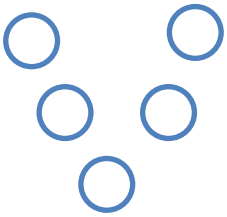
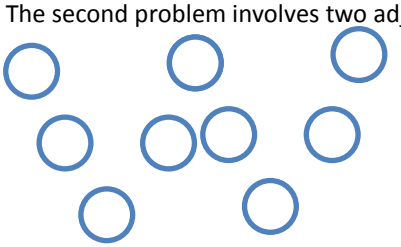
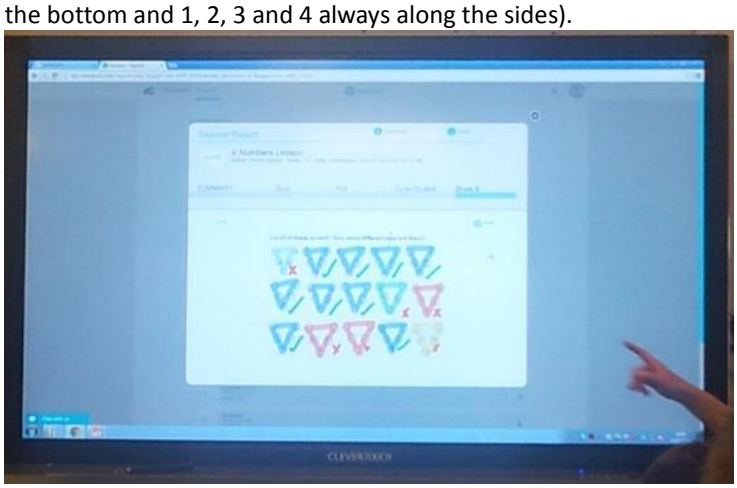
School	Academy B			Observer	Marc North	
Class	Year and set	Year 5		Teacher	CAROL	
Date & time	Date	15/07/15	Start	13:30	End	14:30
Student numbers	Present	24	Male	13	Female	11
Room layout	Long desks, two students per desk all facing the front of the class. No groups. Teacher standing at the front of the class near the classroom desktop computer.					
Background information	The lesson started at 13:30. Lucy had walked up from the other campus wheeling a crate full of i-Pads. It took a couple of minutes for her to distribute the i-Pads to each desk. The class started arrived on time 13:30 but it took approximately 10 minutes for them to settle and log on to Nearpod.					

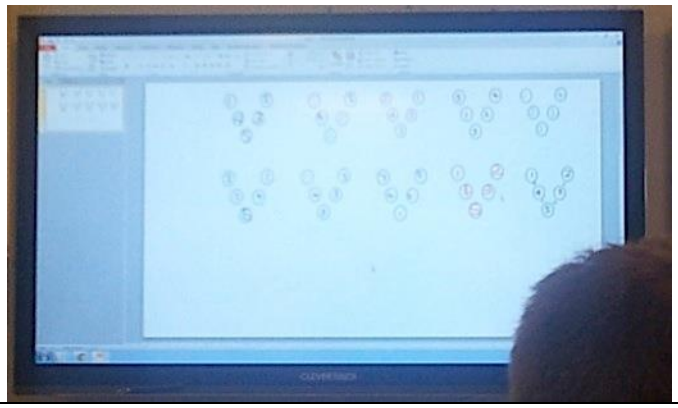
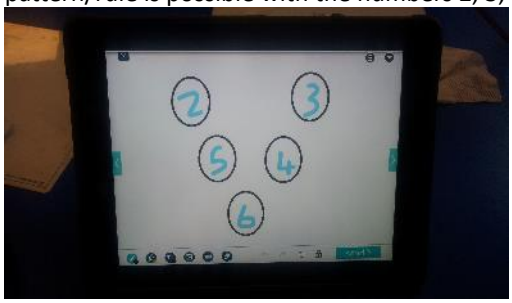
USES OF TECHNOLOGY

Code	iPad/laptop/IWB	Software	Activity	Link to formative assessment
T1	Each student is working on an iPad. There are 2 iPad's recording the lesson (positioned at the front and back of the classroom). There is an IWB at the front of the classroom (displaying the teacher's Nearpod screen loaded on the classroom computer). Each student is also given a whiteboard to write on.	Nearpod	Teacher has pre-loaded questions on Nearpod. The students work through these questions and from time to time the teacher displays some work to discuss with the class. The activity involves arranging numbers 1 to 5 in upside down triangle such that the numbers on both sides of triangle add up to same total. Some of the questions in the activity extend this idea to the use of different numbers and to triangular patterns that include adjacent triangles.	The teacher displays student responses that they have recorded on their i-Pad's on the IWB for reflection and discussion. She selects particular solutions for discussion and elaboration. She also uses Nearpod to check on the progress of the students and to measure the pace of their working.

LESSON STRUCTURE

Time	Activity	T	FA
13:40	Teacher gives instructions on how to access Nearpod to access on the iPads.		
13:45	Teacher displays PP slide on IWB. The slide shows some of the answers to a problem that the students worked on for homework. Previous activity: *arrange the numbers 1 to 5 in an upside down triangle such that the numbers on both sides of triangle add to same total*. Students are then give a task to complete on Nearpod where they have to decide if all of the solutions shown on their tablet screens are correct (according to the rule/challenge stated above). Some students check which are correct and which are incorrect and indicate these with ticks and crosses:  Other students use coding systems (e.g. shading) to match which combinations of numbers give the same answers: 	T1	TSW

Time	Activity	T	FA
13:55	Students are presented with a series of different problems to complete – the problems become progressively more complex. e.g. First problem involves a series of blank circles (in triangle shape) that the students have to fill numbers into.  The second problem involves two adjoined triangle patterns.  While students work on the problems the teacher walks around observing working and offering advice / guidance.		SPG TMG
	Some students experience technological issues with Nearpod crashing - this occurs intermittently throughout the whole lesson.		
14:00	The teacher displays a students' work on the IWB and has a discussion with the class about the solution. The solution shows: 1. Correct and incorrect patterns 2. Which patterns use the same ordering of numbers (e.g. number 5 always at the bottom and 1, 2, 3 and 4 always along the sides). 		TSW TWC
	While the teacher is working through this solution on the whiteboard several students are distracted by the iPads and don't seem to be paying attention to the discussion.		

Time	Activity	T	FA
14:05	The teacher uses the ordinary whiteboard to draw diagrams for students to think about how many possible combinations of patterns are possible with the number 5 at the bottom (and 1, 2, 3 and 4 along the sides). She does not provide the students with a definitive answer/approach or with a more general formula. Instead, she leaves the issue unresolved for the students to think throuhg 		TWC
	Students continue working on the problems posed on Nearpod. One of the more difficult problem involves students having to decide if this pattern/rule is possible with the numbers 2, 3, 4, 5 and 6. 		SPG
14:17	Some of the students have not progressed far with the tasks. They do not seem to understand that the purpose is for them to start to think in more general / generalisable terms about the pattern / rule and the conditions when the rule will work.		
14:25	The teacher displays a student's solution on the IWB and hosts a whole class discussion about the solution. She draws attention to the fact that an odd number is needed at the bottom because the other numbers add up to an odd number.		TSW TWC
14:28	The teacher instructs the students to move to problems that have algebraic notation on the circles instead of only numbers. This is too close to the end of the lesson and the students do not engage sufficiently with these problems. The teacher instructs the students to pack up and the lesson comes to an end.		

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

REFLECTION

The main use of technology included students working on iPad's through pre-posed / programmed problems. From time to time the teacher also uses the technology (specifically the Nearpod software) to formatively to assess individual students' understanding and progress, and to compare different solutions and methods. When the teacher display a solution on the IWB it is mainly to initiate a whole class discussion about the need to think in more general terms about the conditions under which the rule/pattern will work.

A fair number of students were not actively engaged in the lesson. They attempted the initial activity but did not progress on to the more complex activities. These students did not seem to realise the need to think in more general and algebraic terms about the pattern. The teacher did not respond directly to this issue with these students during this lesson.

Appendix C: Interview with teacher

DIANE: So, at least you've already given me some information on paper here, but could I just first ask you all about your past experience of using formative assessments within lessons? Could you just explain that a bit?

CAROL: So, I would reasonably often, I suppose, use white boards. Each pupil has a white board and I would give out open answer questions such as show me a quadrilateral or something, and then show me another one, that way it's fairly people directed. People can decide how many they'll end up doing. Or sometimes closed questions, it works as well, although less well. Questioning with the hands on board (?) directed at pupils, marking exercise books, either having them in to mark and where I can get an overview of what they've done, or go around the classroom, marking those.

DIANE: And what about using the technology, particularly the IPads that we've used? But any technology that you've used. How much of that has been a part of your lessons before this project?

CAROL: Not a huge amount. I suppose, partly because it was an extra thing to learn. But I have used an IPad a bit. Generally in a sort of technological white board type way, but useful for getting lots of answers all at once from a group and comparing them.

DIANE: So you've used it to get students responses to an answer, have you?

CAROL: Yeah.

DIANE: And then do you just play those? Use them in any way?

CAROL: Yeah, yeah. I suppose. Yes we could have. Yes, discussed a certain response and therefore would try to develop their thoughts, ready for the next question.

DIANE: So, some use. And you've been involved in a research project before? Could you explain what sort of a project that was and what you did in it?

CAROL: Yes. That was where, it was called "Lesson study" based on the idea in China, I believe, and presumably other places as well, that there is a lot of collaboration done between teachers, and a large proportion of their time is actually spent preparing their lessons and teaching lessons, and then re-planning, then re-teaching again, then re-planning again. There were three or four schools put together, and about three teachers from each school, and it was a problem-solving lesson that we did for the first round. We did spend a lot of time planning it. One teacher taught it, the rest of us observed. And then we got together again after that and talked about it, and owned it and decided how we were going to do that differently next time. And the process went on like that.

DIANE: So how did you first become involved with the FaSMEd project and were you attracted to it or were you asked to become involved? How did that happen?

CAROL: That's this one that we've been doing? I think I probably was asked about it by Andy, probably because he knew that I had been involved with this one previously and I might be interested. I have, ever since getting into teaching really, wanted to do something in research, because I find it interesting rather than just doing teaching, and had been thinking about it, finding out about it.

DIANE: So you were asked, but you had been interested, if that's what you're saying? There was some attraction.

CAROL: Yes.

DIANE: So what did you hope to get out of it?

CAROL: I suppose initially I signed up thinking it would be a way of making sure I got more involved in use of technology and therefore learned more, because I think often when we just have it available but one doesn't have to use it, you don't always. You find other things that fill up your time. So it did do that to an extent. I think it wasn't perhaps a huge extent, because, again, life takes over, teaching takes over and the rest of the lessons take things as well. But it was interesting as well to do the discussion part. Just generally to talk about teaching as such.

DIANE: Could you tell me about the professional development side of things? What have you experienced and what you might have gained in terms of professional development in being involved?

CAROL: As I say a certain amount of knowledge about IPad use in teaching and thought assessment. Yes certainly I really knew so little before that just the few lessons that I've used it for has certainly taught me a lot about how to use it. I think it's also taught me a certain amount about how useful or not IPads are in lessons. Obviously it's a quite limited, the vastness that IPads and apps offer. My experience is very limited. But within that, it has shown me, or given me a feeling about how useful they are or not.

DIANE: Do you want to say more about that?

CAROL: So I, so far, I suppose, discovered that they are useful for the showing/shining (?) up and whole-class discussion of somebody's ideas, but other than that, I'm not hugely convinced that they're not a sort of a new-fangled version of a white board. So far.

DIANE: Could you now just describe to me your experience of the FaSMEd project, the things you've done, any resources that you've used? How has it worked for you in terms of the process and what have you done?

CAROL: So we've tended to plan together, the three of us within this school, we have used resources that are, we've used ideas from resources that are available online such as enrich the previous map lessons, and just tweaked them to fit, to turn them into, with input and ideas from yourself or from the meetings.

DIANE: So you've met quite regularly with your two colleagues that were involved in the project here?

CAROL: Yes.

DIANE: So do you think that'd be an important part of it?

CAROL: Yes, definitely. Mostly because Andy was the one who already knew the most about apps and IPads, so he was able to teach us other two about how to get something set up, and useful just to be able to bounce ideas about what will work and what won't.

DIANE: I just wondered how you worked with the FaSMEd tools and outside resources you mentioned Enrich website and you mentioned the Map assessment which is actually there in the toolkit. Are those the main that you've used or have you used other sources or other tools?

CAROL: I think they are probably the main things. I'm just trying to think about what the lessons are that we've done. We did the negative numbers one, that was mainly taken from the map. The first one was the areas of rectangles.

DIANE: Yeah you used the IPad on that one?

CAROL: Yeah. I think that one came from a map.

DIANE: Yes I think it did.

CAROL: And the recent one was the magic bee which was enrich. I think I just used resources that were already tried and tested rather than trying to re-invent the wheel ourselves too much.

DIANE: Or even adapt them to use with the IPad?

CAROL: Yes.

DIANE: You've already mentioned you worked with two other colleagues from the School. Have you interacted with any teachers outside your school about the project?

CAROL: I don't think so other than the meetings we've had through the university.

DIANE: And any support from outside of your school? What kind of support did you have? Obviously you've had some from the University you've already mentioned it. Any other support?

CAROL: No I don't think so.

DIANE: My question then would be, would any other support have been useful from the University or elsewhere?

CAROL: Yes, I suppose actually some formal or proper training on the use of apps would have been good.

DIANE: Right, that's really helpful, thank you. So the next area is just to think about your teaching practice. In what ways has the project impacted on your teaching practice? You've hinted, mentioned a few things already, but could you explain a little bit more about how it impacted your teaching practice and whether you think that's short term or whether there's long term?

CAROL: Well I suppose initially it would give me some ideas for using the technology I previously used in a similar way a little bit more. Because when it's useful only for variety, apart from anything else.

DIANE: Do you think it's short-term or longer-term impact?

CAROL: I'm just trying to think back to my reflection that I had to write up. Because I found those quite useful to get me to think about how things went in a way that I wouldn't have done otherwise except as a passing thought.

DIANE: That's fine. If you think about anything a bit later, we can add it.

CAROL: It might have been a question that perhaps I would have thought about more if I had more time.

DIANE: The sort of tools from the toolkit, the support that you've had from external sources, is that something you'd recommend to other teachers or that you can envision using in your future practice, obviously they would be more available in the future?

CAROL: Yes, yes. Very much so. I think having lessons that have been worked through are certainly useful starting points. I think that seems to make it only useful in schools with perhaps teachers who aren't even math trained, these sorts of things, where they have a scheme of work with "teach this" on it, and if they had a way of teaching that that works, and they can develop their own from that.

DIANE: So lessons in particular that have been tried would be useful?

CAROL: Yes.

DIANE: What about the students then? How do you think the students have responded to the sort of things you've done, the way you've made them do the peer assessment using the IPads and they've actually done some self-assessment, the sort of discussions, presentations that you've made them do on the technology? How have they responded? Any thoughts on that?

CAROL: I think they've responded well to the technology, again, whether it's a novelty factor in this school because we don't tend to use them that often, mostly from the fact of the logistics of it, getting them into the classroom, is something I need to mention to people about getting a

technician on this, it would make a huge difference. So yeah there's that. That group is a group which I think responded well to most things that you seem to give them. They're quite a keen group and quite good at discussing things and talking about each other's work.

DIANE: Have you noticed any difference in the higher and lower students in the group and how they responded?

CAROL: To be honest, it seemed to put them on a more even key actually, that I suppose, when they're seeing each other's ideas, that perhaps, I think it is a good way of inspiring, not inspiring the lower students, but learning from each other can be so much more powerful than learning from a teacher, perhaps even more so for the lower students because of the fact that they feel less of a difference.

DIANE: I just have a few questions, generally, to finish with. What do you think has worked well within the project and what has been difficult within the project, and what would you do differently if you were to repeat the process, or if we were to repeat the process?

CAROL: I suppose what I found useful and helpful has been meeting with other, well meeting with other teachers, but also meeting with other schools is what I found quite useful. I think a difficulty has been just the time factor, fitting it in and obviously with your timescale frame (?) that we need to work with as well, it has been a little bit tricky at times. So I suppose in terms of doing differently, what might be useful for something like that, I suppose, could be a timetable issued right at the beginning with deadline, this needs to be finished by then, which I think you did verbally, but I don't know quite how we really got things kind of through Andy but perhaps if the university were able to contact the school a little earlier on and say, "look there's this project going on, would you like to be involved and here's the timetable", just so that everyone's got an initial and then perhaps you can try to factor into your weekends and all. I don't know if it would make much of a difference but perhaps it might.

DIANE: That's a good suggestion. Do you intend to work with colleagues and use these FaSMEd, these project tools, any so which ways in your school elsewhere?

CAROL: Well, yes, I think they would be a useful thing for directing people to. I suppose either if there are new or newish teachers saying "can you give us some advice on how to teach such and such", perhaps could direct them to those. And that is probably something worth sharing with a department meeting or something. I guess I hadn't been sure what their purpose was, whether that is what they're for or whether they're for research, to sort of direct them how the researchers want, rather than having them nationally shared or… I supposed I didn't feel they were my property to share, without checking or having the permissions from the people who made them in the first place.

DIANE: We can clarify that then. You can share things. Is there anything you'd like to add that you'd thought of that would be related to these questions?

CAROL: I'm just trying to think on that how it will affect my practice, because I'm sure there are things, but I'm just having difficulties thinking on the spot.

DIANE: Well that's fine because you can always send me an email if something occurs to you, if you think, Oh I should have said that, you can always add it in. No that's great, thank you very much.

END OF INTERVIEW

Appendix D: Focus group discussion

DIANE: This is recording at Trinity School with Focus Group and first of all, then, I want you to tell me about the lessons. We talked about the two particular lessons that you've had. Could you just tell me about your experience of those lessons? What were they like if you can take your mind back to those?

STUDENT: Is that the one that we had with an airport thing?

DIANE: Yes.

STUDENT 1: I enjoyed using it.

STUDENT 2: Yes.

STUDENT 3: It was different from what we do normally in lessons.

STUDENT 1: Yes but it's connected.

STUDENT 4: I think it was frustrating because mine didn't work.

STUDENT 2: Yeah.

STUDENT 3: (???) don't work so people have to (indistinct overlap)

STUDENT 1: But they have to set them up.

STUDENT 4: Yeah but then you have to start all over again.

STUDENT 1: It does take quite a long time to work and set them up, but once we're actually doing it, it's straight forward.

STUDENT 3: Yeah.

STUDENT 2: You get all your questions put together then you work out, then you see answers and the teacher can show you how it works out and then you could put it on the screen to compare them.

STUDENT 3: And we can work it out all together.

STUDENT 4: I think it's a load/waste of time (?). It's not (???) fast. Some people it took them ages to do the question and then you just have to wait for everyone to finish (overlap)

STUDENT 1: Besides there is a lot of (???).

STUDENT 2: This is why I got a bit confused.

DIANE: So had you use (???) before?

STUDENT 3: That was the first time we used in that lesson.

STUDENT 4: Yeah I did not use the app before.

STUDENT 1: It's the first on the shield/sheet (?) isn't it?

STUDENT 4: Yeah.

STUDENT 3: I think so.

STUDENT 4: I haven't used it.

STUDENT 1: (incomprehensible)

STUDENT 3: Oh yeah the IPads. Wasn't that (???)?

STUDENT 1: Yeah yeah (???)

DIANE: So, using the IPad was a bit different to your normal math lessons. Was anything else that was different from your normal math lessons or was it much the same otherwise?

STUDENT 1: I think it was usually quite the same.

STUDENT 4: Yeah.

STUDENT 3: It's the same with the technology.

STUDENT 2: Everybody acted the same too. Everyone was responsible.

STUDENT 1: Yeah.

DIANE: Okay. Thinking back particularly about these two lessons, or any other time that you can think of that you've used Nearpod that you can think about, but particularly those two, has anything been useful about those lessons? You said some things were different, the fact that you used Nearpod and that you could obviously see things on the screen, but is anything useful about that, and in sort of what ways, might had it been useful?

STUDENT 2: You could show multiple ways of how to work out an answer, that's not just on a board.

STUDENT 3: Yeah.

STUDENT 1: We can learn from our mistakes as well.

STUDENT 3: Yeah.

STUDENT 4: It's like that one where in the end they've got everyone's screen on the board and then you can see everyone's answer and you can compare, and different answers from different people and how they worked it out. And if you got it wrong, you can see…

STUDENT 2: Didn't they do step by step kinds? Like they showed you step by step, going through it?

STUDENT 4: (incomprehensible)

DIANE: And did you like that idea of being able to see things on the board and show things on the board?

STUDENT 4: Yes, I think. Because then you can see how you've gone wrong and then if you've gone wrong…

STUDENT 3: You can work on it together.

STUDENT 4: You can see how other people got the answer, if it's different to you.

STUDENT 2: You can see the majority.

STUDENT 3: Yeah, what other people think.

STUDENT 4: It makes it so everyone understands it, and then if you don't understand it, you can go over it again (not sure this is what he says).

STUDENT 1: And people aren't hiding it and see that they actually got the answers right just so that they can get the mark.

STUDENT 3: And you can see how different people approached that kind of question.

STUDENT 2: Because you're working it out, don't you?

STUDENT 3: Yeah.

DIANE: So it makes you see different ways of doing it?

ALL: Yeah.

DIANE: You agree with that?

STUDENT 3: Yeah.

DIANE: Do you have anything about that that you want to say? Tell me what was difficult about the lessons? You mentioned a couple of things earlier.

STUDENT 3: If some would stop …

STUDENT 4: Yeah some people, they kept like, they just messed around because obviously like, you can draw on it, they kept drawing.

INDISTINCT: Yeah (multiple)

STUDENT 2: Then the nickname. They'd put fake names, so you wouldn't be able to tell who it was.

DIANE: So you didn't like that bit?

STUDENT 4: I think sometime when you'd start off, like I said, it doesn't work sometime. It's frustrating and then…

STUDENT 1: And you have to put a certain code, and if you mess up with the… (BIP) you get connected with somebody else.

DIANE: Do you think these lessons have helped your learning of math and in what ways?

STUDENT 2: Yes and no.

DIANE: Yes and no, you have to explain. I'll let you explain first, and you can all explain this one. Did it help or not?

STUDENT 2: Yes, yes, because you can see everything as if everyone else is put in their own page. So you can see every answer, where every answer is working out. (BIP)

DIANE: It's alright. There will be more time.

STUDENT 2: And then, on the… No. Because people mess about with it or they can scribble over it, and sometimes your answer gets skipped so…

STUDENT 3: You got 10 seconds left.

DIANE: It's okay. I'll put it on the other one. That's okay it's still on the other one so… Carry on, tell me the rest.

STUDENT 2: I pass over.

STUDENT 1: I think it helped, because, you know, you got different people's opinions and how they thought they could work out a different question. And you could also see from your mistakes by having that projected on the board. And, yeah, same as Louise said, when she said about how people mess about on it and stuff. And sometimes it takes a while to eventually load up.

STUDENT 2: I think what's good about the app, about using this app is that you can share your different ways to work out the question. You can see how people work their answers out and compare it to yours and learn different ways to work out a question, because of someone else's different way of working it out. It's like a new way of learning.

STUDENT 4: I think it's good, because you don't know what's coming next, so you can't prepare yourself on what the next question is going to be, and then I think there's like a variety of questions, so you can see what's happening and stuff. And I think there's a no, because people can't get it from the start, and if it doesn't work…

DIANE: Okay, and you haven't said something?

STUDENT 3: It's like I said, you can use it for not just algebra but you can think of a lot of different ways you can use it.

DIANE: Okay. Just a question, a couple questions, just to finish. Are these the sort or type of lessons you'd like to do in the future or not?

STUDENT 1, 3, 4: Yes.

STUDENT 2: Yeah. (indistinct)

DIANE: Okay, and have you discussed these lessons with any other teachers or students in the school?

STUDENT 1: Science. The other half of the year.

DIANE: Right. So you've had some discussion about these? And particularly science you said?

STUDENT 4: Yeah.

DIANE: Okay, and have you discussed these lessons with your parents or family members?

STUDENTS: Yeah, yeah.

STUDENT 2: Yeah I did.

DIANE: So, some yes and some no. Okay. I'm just going to ask you then, do you think, overall, using an iPad can help you with maths?

STUDENT 4: Yes.

STUDENT 2: Yes, because it has lots of apps as well.

STUDENT 1: Yes in some ways.

STUDENT 2: What's that one where we do the graphs?

STUDENT 1: And there's like different apps.

STUDENT 4: (unclear – names of apps)

DIANE: So you think the apps can help you?

STUDEN

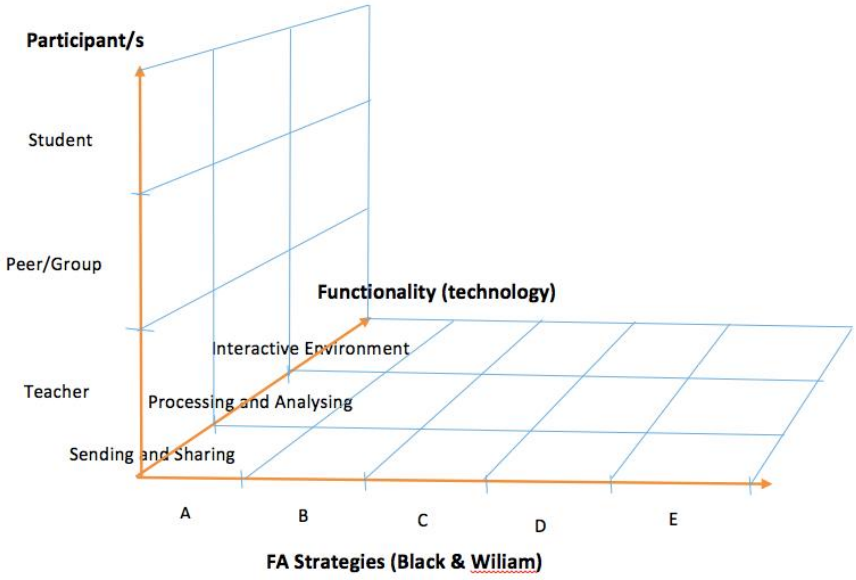
STUDENT 1: Yeah.

DIANE: Actually learn. Okay, well thank you very much. That's all I need to do.

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.

Black and Wiliam framework

	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	