FaSMEd

Raising Achievement through Formative Assessment in Science and Mathematics Education

Magic V investigation

Subject:	Mathematics
Age of students:	13 - 14 years
Hardware:	iPads and IWB
Software:	Nearpod
Functionalities:	Sending and Displaying
Time:	1 hour
FaSMEd partner:	University of Nottingham
Short Abstract:	The lesson focused on an investigation, using positive integers only but requiring students to develop strategies, recognise patterns and make generalisations.

1. Content

The lesson was in the form of an investigation based on selected questions from a problem referred to as the 'Magic V' on the NRICH website[1]. This was carried out using iPads. The questions related to the ways in which a sequence of numbers could be arranged within a (V-shaped) template to satisfy certain conditions, such as making the numbers in different sections add up to the same total (See examples in Appendix). The investigation required little mathematical conceptual knowledge, since students were only required to add positive integers but focused on the development of problem-solving skills.

The purpose of the lesson was to develop students' investigative skills. Students were expected to build on their prior experiences of investigative work to employ appropriate strategies, identify patterns, make generalisations and find solutions to a series of related number problems. The activities were semi-structured and involved some open-ended questions so students had to make decisions about how they interpreted and approached the problems.

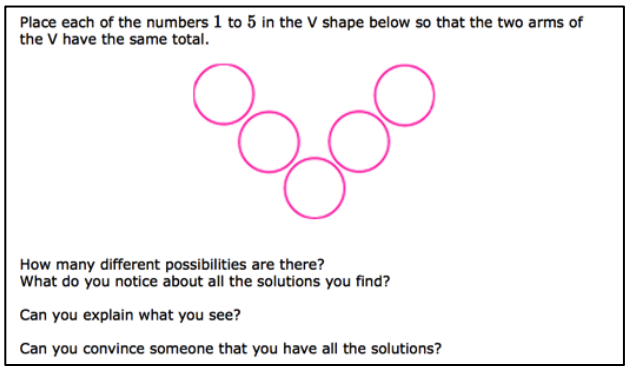
1.1 Aims

The lesson aims were to:

- Develop student's understanding of strategies to use when solving problems;
- Enable students to identify and use appropriate methods to find solutions to numerical problems;
- Enable students to identify and explain number patterns and mathematical relationships and make appropriate generalisations;
- Develop students' understanding of ways to record their investigative work in writing;
- Develop students' skills in assessing and critiquing solutions to mathematical problems.

1.2 Structure / Methodology

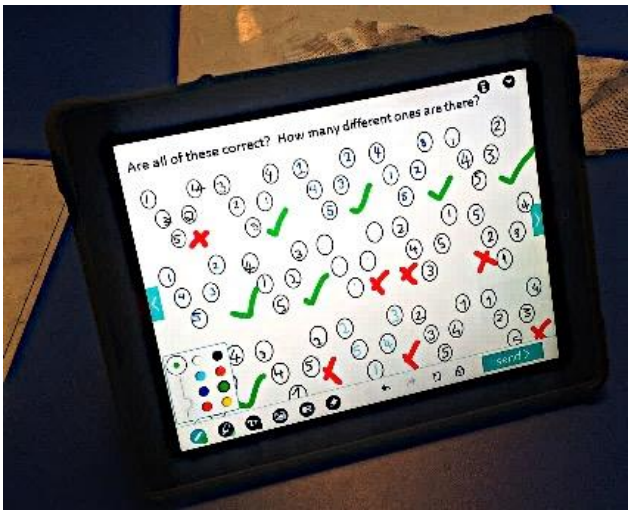
The first of the problems is given below.



Students were asked to attempt this problem for homework, prior to the lesson and send their solutions to the teacher using *NearPod* in homework mode. At the start of the lesson

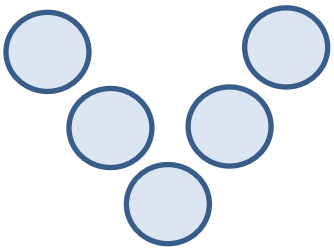
[1] http://nrich.maths.org/6274

the teacher asked students to suggest solutions and displayed some of the students' answers to the question using the interactive whiteboard (IWB). The students were also sent selected solutions suggested by their peers using *NearPod* (in normal class mode) and were asked to decide whether or not all of the solutions shown on their iPad screens were correct. Some students indicated their responses with ticks and crosses:



The teacher spent some time explaining to their classes that they were undertaking an investigation and questioned students about their prior knowledge of problem-solving strategies. During the lesson they worked collaboratively in pairs to explore further questions that were related to this initial problem and extensions to the original problem, with some class discussion at times to share ideas on emerging patterns and generalisations. The lesson was therefore lossley structured around a cycle of investigative work in pairs, the sharing of solutions and the use of whole class discussion to move students forward.

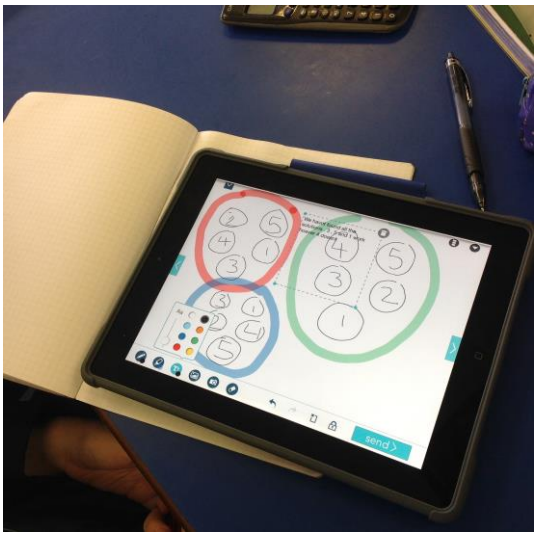
The questions posed for students to investigate were as follows:

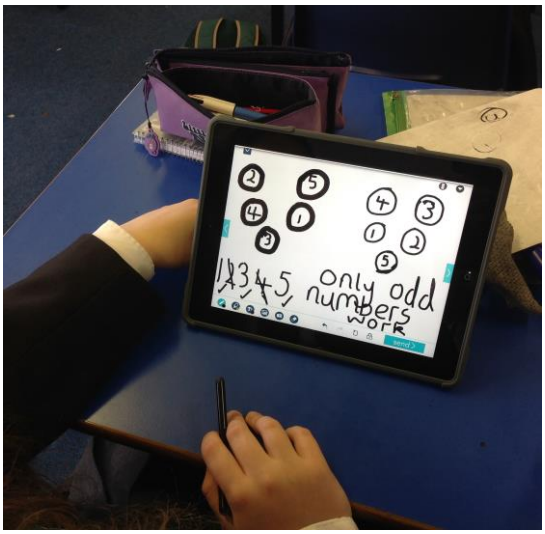


1. Can you place the numbers 1,2,3,4,5 in the V shape so that the numbers in each arm add up to the same number?
2. Is there a solution to this problem when 2 is placed in the bottom of the V? Give reasons for your answer
3. Have we found all the possibilities? How can we be sure?
4. What are the solutions 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? What would be a general algebraic solution using n,n+1,n+2,n+3,n+4 ?

These were introduced one at a time at appropriate points in the lesson.

Here are two samples of student work in progress using the iPads.





1.3 Technology

The main use of technology involved students working on iPads to explore the problems and record their work. From time to time the teacher also used the *NearPod* app to assess individual students' understanding and progress, or select sample students work for class discussion of different solutions and methods. When the teacher displayed a solution on the interactive whiteboard (IWB) it was often to facilitate a whole class discussion in which formative assessment strategies could be implemented. The technology therefore performed a 'send and share' function within the lesson that facilitated formative assessment processes, as described earlier.

NearPod was used in two different modes for the work, prior to and during the lesson. Prior to the lesson a task was sent using *NearPod* in homework mode, whilst during the lesson the normal class mode was sometimes used. Both uses provided a mode of communication between teacher and student, so that written questions and responses could be exchanged. In addition to this exchange of information, teachers had ready access to student work that they could share more widely through electronic circulation or by display on the IWB. This availability of sample student work for sharing helped facilitate class discussion, through which students engaged in peer assessment and self-reflection. In this lesson the teachers sometimes asked students to submit their work in progress using *NearPod* so they could gain information about their current thinking. This contrasted with the use of NearPod in other lessons where students only sent completed solutions to the teacher.

1.4 Aspects of Formative Assessment

In this lesson a combination of different formative assessment strategies was used to ascertain where students were, clarify what they needed to achieve and indicate how they might progress towards appropriate solutions. Due to the emphasis on developing students' investigative skills rather than conceptual understanding and the students' lack of familiarity with problem-solving tasks, there was a strong focus on making the criteria for success clear for this type of activity and on ways of ensuring students were taking useful steps towards finding solutions.

Firstly, the pre-lesson task was used to ascertain whether students understood the basic task, on which further problems would be based. This provided the teachers with evidence of students' understanding of the task description but also allowed them to share selected student solutions for their peers to assess. In this way the activity was used both prior to the lesson and within the first stage of the session to establish the learning intentions and indicate some of the criteria for success.

This was planned as a teacher-led formative assessment process but, nested within this, were opportunities for student-centred formative processes as they considered samples of work from their peers. Students engaged in peer assessment and self-reflection as they discussed these samples of work and made decisions about the validity of the solutions. For the initial task this was a fairly successful activity, since the problem was not complex and students were generally able to identify any errors made. The simplicity did, however, mean that most students just 'marked' the work and agreed about the correct solutions, with little substantial discussion of ideas beyond this.

During the rest of the lesson, students were provided with a series of further problems 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 possible answers, or showing that there were no solutions. Some of these problems were more challenging, which encouraged richer discussion, particularly when students disagreed. There was some evidence of students taking greater ownership of their own learning during this time due to the less structured approach. Students were able to make their own decisions about the strategies and methods they would utilise to find solutions, whilst working at their own pace.

Interspersed with the students' collaborative work were interventions from the teacher, either to small groups or individuals, or in the form of whole class discussions. The teachers often allowed the students to work for some time before selecting a sample of student work for class discussion and displaying this on the interactive white board (IWB). In this way 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 intended to help students develop particular investigative skills, clarify the criteria for success and move thinking forward. In practice, however, students were slow to respond to these interventions. Many struggled to identify patterns and most continued to search for solutions without developing any productive strategies. Furthermore, when students who had identified some patterns were asked to explain their observations to the class they found it difficult to provide coherent verbal accounts. Students' struggles in explaining their work convincingly limited the benefits that could be gained from using peers as instructional resources in these class discussions.

The class discussions also presented additional difficulties for the teachers. With a more flexible structure to the lesson, students were working at their own pace to find solutions to the problems and were at different stages in their investigations at any one point in time. Whole class discussions were therefore difficult to place within the lesson so that the varying needs of students were all met effectively. In addition, some students were reluctant to stop their investigative work to engage in a class discussion whilst others lost concentration during long periods of individual work and were hard to re-engage. Planning for lessons involving investigations and effective formative assessment strategies presents different challenges for teachers. Even though the basic formative processes in this case were similar to those used in other lessons, it seemed that making productive use of whole class discussion in a less structured learning context proved more difficult. There was, however,

the same need for teachers to anticipate students' responses and difficulties in advance in order to plan effectively. In this lesson the context was different but teachers still needed to consider carefully how students would respond so they could plan appropriate interventions and specific questions in advance that would move students' thinking forward.

Within the formative assessment strategies described above, feedback to students from the teacher and from their peers was an important part of the processes involved. The use of collaborative approaches to investigative work was fundamental to this lesson and this involved frequent discussions between students in which they provided feedback to each other. This was carried out more formally in the first activity, in which students were asked to assess samples of pre-lesson work from their peers and less formally in the following activities as students worked together, discussing different approaches and possible solutions to the problems. Feedback from peers was often formative, since it was part of a process that led to self-reflection and adjustments to thinking that could potentially move students forward.

Whole class discussions also provided a forum in which some students received direct feedback from their peers and/or the teacher because their work was chosen for display and discussion. In this situation students benefitted from being both the providers and recipients of feedback since this involved them in formative assessment processes, although the quality of the feedback from their peers was a crucial factor in whether these processes were effective.

During students' work in class, teachers also provided feedback to individuals or small groups as they circulated around the class and observed work in progress. This was given through one-to-one or shared conversations involving correction, instruction or questioning from teachers to ascertain where students were and how they might move forward.

2. Further Information

Some teachers expressed reservations about the use of *Nearpod* in 'homework mode'. Although it was useful because students could work at their own pace, it was less easy to view and select student work to share. Walking around the class to identify work worth displaying for discussion seemed an easier way of achieving the same ends in this case. For displaying student work, this teacher concluded that using iPads with *NearPod* in this mode was no more useful than a visualizer since this could perform a very similar function.

The students however could see how being able to display answers from all the class simultaneously on the IWB helped them to compare answers and methods. Overall the students identified more benefits than disadvantages in using the 'send and display' function of the technology and these were clearly linked to an enhanced use of formative assessment in the lesson.

Since the lesson was entirely focused on the investigation, the lesson plan was flexible and teachers adapted their plans to suit the responses and rate of progress of the students.

3. References

Information on Nearpod available at https://www.NearPod.com.

Magic V investigation available from NRICH website at http://nrich.maths.org/6274

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

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

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