# FaSMEd

Raising Achievement through
Formative Assessment
in Science and Mathematics
Education

# Areas and perimeters

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| **Subject:** | Mathematics |
| **Age of students:** | 9 - 10 years |
| **Hardware:** | iPads and IWB |
| **Software:** | ‘Nearpod’ |
| **Functionalities:** | Sending and displaying |
| **Time:** | 1 hour |
| **FaSMEd partner:** | University of Nottingham |

**Short Abstract:** The lesson focussed on clarifying the concepts of area and perimeter before students carried out an investigation to explore connections between area and perimeter for simple and compound shapes.

# 1. Content

The lesson was designed with the dual purpose of developing students' conceptual understanding of area and perimeter and also their investigative skills. This meant that the context was different to other lessons in which conceptual development was often the sole focus. A combination of structured and unstructured approaches was used, with students first attempting a series of calculations about the areas and perimeters of given rectangular or composite shapes. This was followed by a less structured investigation of connections between the area and perimeter of different shapes.

These students had some prior knowledge of how to work out the area and perimeter of rectangles and squares. In the lesson they were expected use methods such as counting squares or using the dimensions to find the area and perimeter of rectangles, squares and composite shapes made up of rectangles and squares. They also used this knowledge to explore the relationship between area and perimeter for a range of two-dimensional shapes. Students had little prior experience of investigative work in mathematics so this activity was intended to help them identify patterns, test out 'theories' and develop strategies for solving mathematical problems.

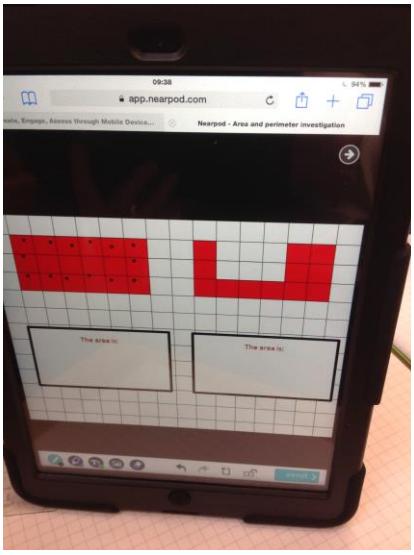
The lesson described was taught to students aged 9-10 years but was also adapted for younger (8-9 years) and older (10-11 years) students.

## 1.1 Aims

The lesson aims were to:

- Develop students' understanding of the concepts of area and perimeter;
- Develop students' ability to employ appropriate strategies when solving problems;
- Enable students to identify and explain numerical patterns and mathematical relationships;
- Develop students' skills in assessing and critiquing different solutions to mathematical problems.

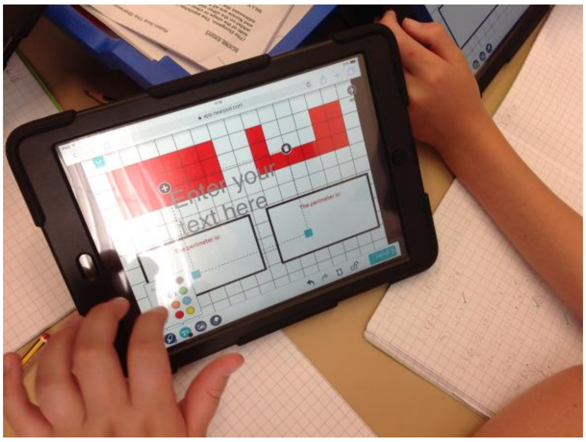
## 1.2 Structure / Methodology




At the beginning of the lesson students were provided with individual iPads and had to log on to *Nearpod*[1]. The teacher introduced the first task, which was to work out the area of a rectangle and of a composite shape. The question was sent to students, using *NearPod*, for them to complete on their iPads. They then returned their answers to the teacher in the same way. Since the shapes were shown on a grid, students could count squares on their screens to calculate the area.

[1] 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.

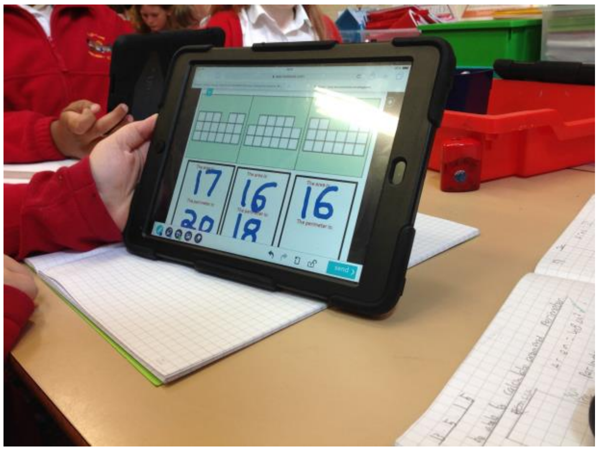
Question 1: Find the area of each shape.




The teacher selected and displayed some samples of student work on the interactive whiteboard (IWB) and used these as a basis for whole class discussion. Individual students were asked how they arrived at their answers and the teacher used students' responses to clarify the meaning of area and how this could be worked out from the diagrams. For the composite shape the teacher questioned several students so that more than one method was discussed with the class, e.g. dividing the shape into two rectangles, or considering the shape as a large rectangle with a smaller rectangle removed.

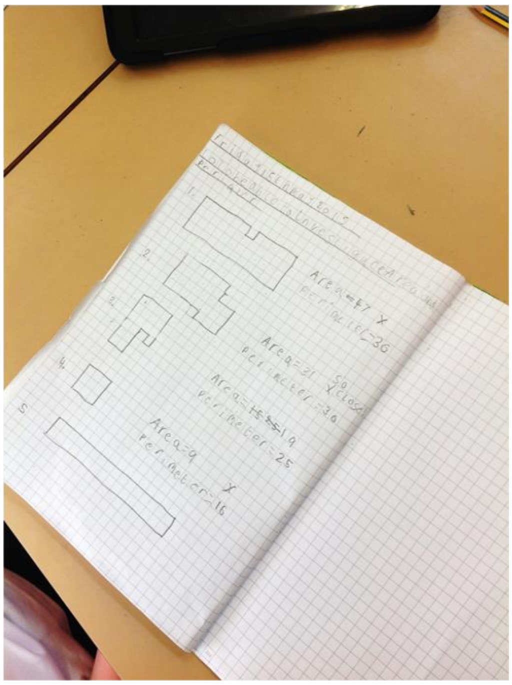
Further questions about area and perimeter were sent to students, one at a time, and their responses discussed in a similar way. The second question required them to calculate the perimeter of the same shape but for the third question they were asked to work out the area and perimeter of three different composite shapes. Individual students were asked to explain their methods and the teacher asked why the perimeter was the same for diagram 1 and 3 when the shape was different? Some students provided explanations and these led into the main investigative activity.

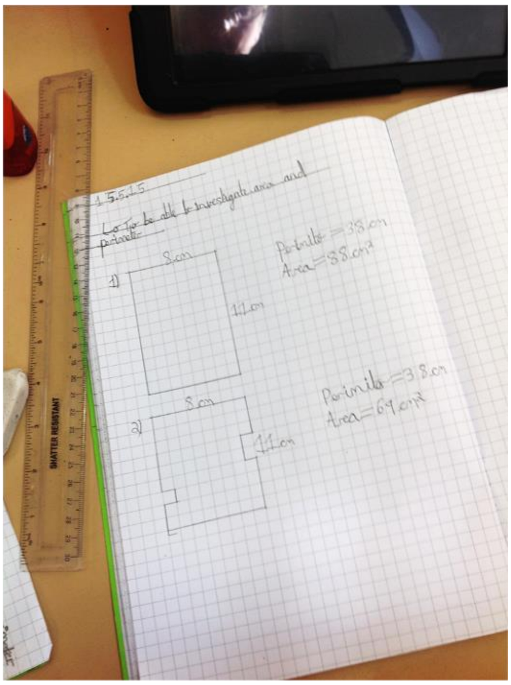
Question 2: Find the perimeter of each shape (the same two shapes as before).



Question 3: Find the area and perimeter of each of these three shapes.

The students were then asked to explore the question: Can you draw a shape that numerically has the same area and perimeter? The students were asked to work together in pairs using squared paper in their books to draw their shapes. The teacher provided additional guidance, suggesting they could be creative with the shapes they chose as long as they were still based on rectangles. Most students started by using a trial and error approach but some then started to think about modifying their existing shapes that were getting close to a solution rather than randomly choosing measurements. Here are two examples of approaches taken by students. In the first example the student has tried removing small squares from the edge of a shape to increase the perimeter. In the second example the student tried a more random selection of shapes, although one of them, the 4 by 4 square did work.





After some time the teacher initiated a class whole discussion around the problem of getting close to the answer and how to modify the shape rather than starting again. The students provided some useful ideas that the teacher expanded on by drawing diagrams on the whiteboard to show what happens to the perimeter when a square is added in different places. The students then returned to the investigation to try this approach and find another shape that worked.

The students were asked to draw one of their solutions, if they had one, on their iPads, using a squared grid and send this to the teacher. (These diagrams were drawn with their fingers and, although most shapes were recognisable, drawing accurately was a problem. Some students were unhappy with their wobbly lines and tried using rulers on the iPad to make the lines straight.)

The teacher displayed a student solution on the IWB and asked the other students to check if this was alright. There was agreement that it worked. A more complex shape was displayed for other students to check and then the student responsible was asked to explain what they did. They explained how they were close to a solution so they took a square away and added this somewhere else. The teacher explained this idea a bit further and asked whether it mattered where you added or subtracted squares? The students offered some suggestions in response before the lesson was concluded.

## 1.3 Technology

The main use of technology involved students working on iPads and using the *NearPod* app to receive questions from their teacher and send their answers. The teachers then had access to all the students' responses and could select appropriate samples for display and discussion. This process was used to compare different solutions and methods, asking students for explanations of their own work or comments on the work of their peers. The technology, therefore, performed a ‘send and display’ function but this facilitated formative assessment processes whereby both teachers and students gained information regarding student thinking that could be used to establish students’ existing understanding, clarify the criteria for success and help them move forward.

The use of *Nearpod* was particularly helpful when used with the diagnostic questions since it provided an accessible visual overview of student work, from which the teachers could quickly select appropriate samples for class discussion. Similarly, being able to display students’ solutions to the investigation also helped focus class discussion on key learning points, such as the effect of adding or subtracting squares, and also respond to misconceptions that were arising.

Some technical difficulties were experienced with the slowness of the Internet connection and the malfunctioning of several iPads, indicating the importance of having good support mechanisms for the operation and maintenance of digital technology. Other problems arose during the lesson that highlighted some potential issues for the use of iPads in mathematics teaching. In particular, these students had difficulty drawing straight lines with their fingers on the iPads and some of their diagrams were difficult to interpret. This seemed to be more problematic for the younger students than those who were a little older. Also, the dual approach of using iPads for some tasks and exercise books for others did cause some confusion amongst students when moving between activities.

## 1.4 Aspects of Formative Assessment

A combination of different formative assessment strategies was planned into this lesson to ascertain where students were, clarify what they needed to achieve and indicate how they might progress towards appropriate solutions. The modifications of the lesson and differences in questioning techniques did however lead to some teachers using these strategies more effectively than others.

Due to the dual emphasis on developing students’ conceptual understanding and investigative skills, clarifying the criteria for success and the next steps for students was challenging for teachers. The lesson observations suggested that although the teachers had both aspects in mind they tended to focus more on one than the other.

In the first part of the lesson the questions on area and perimeter were used diagnostically to elicit evidence of student understanding and expose misconceptions. The teachers were able to view all the students’ answers simultaneously and use selected responses to prompt class discussion. Some teachers developed these whole class discussions into effective formative assessment activities by questioning individual students about their work and that of their peers. These teachers used the class discussions to seek explanations from students and ask probing questions in order to elicit clear evidence of understanding. In this way students became actively involved in formative assessment processes with the teacher and their peers. Students were encouraged to critically review work from their peers, reflect on their own work and adjust their own thinking during these discussions. In addition, when students were asked to provide explanations of their work, this encouraged greater ownership and sometimes students also became instructional resources for others by giving useful accounts of the thinking that led to their solutions. The questioning techniques used, in conjunction with the sample student work, meant that the class discussions were student-focused and not dominated by teacher explanations.

During the investigative work, students worked collaboratively in pairs but often also discussed their work with others around them. This provided opportunities for further peer assessment and self-reflection. The investigation of a broad question with multiple solutions gave scope for students to make their own decisions on methods, strategies and possible solutions, thereby increasing their ownership of the learning process. At times students also acted as instructional resources for each other as they compared solutions, explained their ideas and talked about their strategies. This helped students and their peers understand the problem and how they might move forward.

One of the difficulties for students during the investigation was, however, being clear about the criteria for success. Finding possible solutions to a problem was a different type of mathematical activity for them and there was evidence that students struggled to understand what they were expected to achieve or how to move forward after their first trial attempts. During the investigation, teachers provided support and guidance for individuals to clarify these points. Their observations of student work in progress prompted teacher-led formative assessment processes with pairs or small groups, in which they assessed where students were from their written work, asked questions to elicit further evidence of understanding and posed more questions to clarify the criteria for success with the task and move thinking forward. Choosing the actual questions to ask was, again, an important part of this process since these were key to exposing students' understanding, challenging their current reasoning and opening up their minds to new possible strategies.

Both whole class and paired or small group discussions were significant within the formative assessment processes for this lesson. The teachers were often able to utilise students effectively as instructional resources and there was a clear student focus in the formative processes. There were, however, some difficulties in utilising students in the formative assessment processes, particularly with the investigation where their lack of understanding of the criteria for success made frequent interventions from teachers necessary to keep students moving purposefully towards solutions.

Within the formative assessment strategies described above, feedback to students from the teacher and from their peers was an important part of the processes. During whole class discussions, students whose work was selected for display were asked questions about their work and usually received direct verbal feedback from their teacher and peers. This feedback often prompted self-reflection and adjustments to thinking. Also, when there were discussions about work from their peers, students were involved in either making comments themselves or listening to feedback from others. This often led to them making comparisons to their own ideas and so the feedback on work from other students became useful in their own self-reflection and review process. Feedback from whole class discussion, both direct and indirect was, therefore, used by students formatively in several ways to prompt adjustments to their thinking.

The collaborative work within the lesson also provided a forum in which feedback was given and received by students as they discussed their ideas. Much of this feedback was between peers but this initiated reflection and rethinking of ideas. In addition, teachers supported the collaborative work by providing specific feedback on work in progress to move students forward in their thinking. The emphasis on collaborative work and paired or small group discussion for much of the lesson meant that there were good opportunities for students to receive feedback from their peers as well as from their teachers.

## 2. Further Information

For the class of older students, the first part of the lesson included some additional verbal questions about what an investigation was and how it was carried out. Also, during the initial questions the teacher drew attention to the way in which adding or removing squares from a shape changed the area to guide students' thinking in this direction before commencing the investigation.

In the younger class, the prior knowledge of students was considerably less and so the actual questions were adapted.

The teachers appreciated the visual summary that *NearPod* supplied and the ease of sending questions, receiving students' answers and being able to select samples to display. The students showed interest in using the iPads (which they had rarely used in mathematics lessons) and generally adapted well to the technology.

## 3. References

Information about *NearPod* is available at [https://www.NearPod.com](https://www.NearPod.com).

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

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