



Teaching and learning Mathematics using an enquiry-based approach

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Aims of the project

The aims of the project were to answer the questions:

- What is an effective way to prepare to teach Mathematics using an enquiry-based approach?
- What would be the impact on pupil learning and attitudes of introducing an enquiry-based approach to Mathematics teaching in Year 7?

Dimensions of the study

The study took place at Lancaster Girls' Grammar School, a selective 11-18 state school with 877 on roll. Initially, four Year 7 classes and their respective teachers were involved, with the assistance of other members of the department and consultant Mike Ollerton.

Summary of main findings

- Pupils who experienced the new curriculum:
- became more enthusiastic about Mathematics; and
- were more prepared to engage in open-ended tasks and less likely to be discouraged by being stuck, e.g. they were less likely to declare: 'I can't do Maths'.

Background and context

Lancaster Girls' Grammar School is a successful school which has been recently rated as Outstanding by Ofsted. It is fair to say that generally we had taught Maths in a traditional fashion chiefly based on exposition and practice. Although the introduction of interactive whiteboards had a substantial impact on our teaching, it had not significantly altered the basic structure of lessons.

We were concerned that our Year 7 curriculum did not provide sufficient challenge for a significant number of pupils. Although we had developed a wealth of extension activities, we felt that at least some pupils, for at least some of the time, were undertaking tasks which did not provide an opportunity for progression. We

also felt that, since our syllabus was largely based around a textbook, we were tending to compartmentalise Maths and not encouraging pupils to make connections across topics.

The suggestion, found in the QCA publication *Developing reasoning through algebra and geometry*, that opportunities to generalise and to use algebra should pervade Maths lessons and not just crop up in algebra lessons or lessons on proof seemed to suggest a way forward.

After discussion within the department and with Mike Ollerton, who was temporarily a member of the department, we decided to completely rewrite our Year 7 scheme of work with a view to using enquiry-based approaches wherever possible.

As we planned to write and introduce the new scheme, the department had mixed feelings about moving away from a familiar *modus operandi*. Whilst there was excitement and enthusiasm, there was also trepidation and some concern about the effectiveness of this approach and about our own ability to make the transition to working in an unfamiliar way.

Teaching processes and strategies

Mike Ollerton worked with us whilst we prepared for the new curriculum. A number of extended departmental meetings with Mike were arranged at the planning stage and during the course of the year. We discussed possible approaches to mathematical topics and how they might be used in the classroom.

Mike came in on a number of occasions to teach our classes so that we could watch him model the kind of approach that we were intending to adopt. Some of the department opted to team teach with Mike. Usually his lesson would throw up a number of lines of enquiry that we could pursue with our classes in subsequent lessons.

We also trialled some of the new approaches, prior to the introduction of the new scheme, with our Year 7 or Year 8 classes. In some cases the activities seemed appropriate or adaptable for other year groups so we tried them there too. Mike encouraged us to discuss the outcome of these lessons and where possible to share reflective write-ups of the lessons so that the sharing happened in a more formal way and was more inclusive than *ad hoc* staffroom discussions.

We adopted a collaborative planning approach. Mike suggested that we work in pairs. Two of us planned and delivered a unit of work over a number of weeks. We then swapped with the other pair (there are 4 classes in our Year 7) and taught their unit after sharing planning and receiving their advice about how to teach the module. This meant that at the end of a module it was necessary to sit down and review the activities that we had used before deciding what to pass on to the other pair. Obviously, this halved the workload in terms of planning. It also meant that reviewing and amending our curriculum was inherent in the process. In practice, the discussions about particular modules often included all of the team as we shared ideas, and debated the merits of particular

approaches. In our meetings with Mike we reviewed what we had done and looked forward to upcoming modules. Finally, at the end of the year, the Year 7 team met to run through the entire scheme of work; discussing which approaches had been effective and amending the written scheme of work for future use.

In moving from a textbook-based exposition and practice model to an enquiry-based approach we looked for appropriate open-ended tasks which would provide pupils with opportunities to consolidate previous knowledge whilst also offering a potential challenge for more confident pupils. For example when working on long multiplication we set the problem:

Use the digits 1,2,3 and 4 once each to make two numbers, for example 14 and 23. Multiply your numbers together. Which numbers give you the largest and smallest possible products?

The advantage of this task is that it enables the teacher to identify any pupils who have a difficulty with the basic skill required i.e. long multiplication, but on the other hand the problem can easily be extended and pupils then have opportunities to make generalisations and to justify their reasoning. We found that finding a suitable starting point made assessment for learning an inherent part of the process.

Typically, we would allow some time for pupils to work individually on the initial problem, but would then ask them to discuss either in groups or as a class their work to date on the problem, to justify their solutions and to compare the efficacy of the methods they have used.

The starting point might not necessarily be a problem as such. It might be a simple prompt such as 'Tell me everything you know about squares'. Again pupils would be expected to initially work alone before sharing and agreeing their answers in a group and then as a class. With one Year 7 class this starting point led to discussions on the bilateral and rotational symmetries of squares, the meaning of the word perpendicular and whether or not any two-dimensional objects exist, with one pupil sagely pronouncing: "the only two dimensional object you can see is a shadow".

On occasion, we also used classifying activities. For example, we gave each group in the class a set of cards each showing a fraction and asked them to choose their own criteria in order to group the cards into two or more classes.

We found that some groups were very creative and without prompting used two-way tables or Venn diagrams to sort the fractions. The subsequent discussions focused on equivalent fractions, cancelling down, and proper and improper fractions.

Many of the starting points we used incorporated practical

activities or equipment such as Geoboards, multi-link cubes or paper-folding.

We also adopted some of the approaches exemplified in the Standards Unit publication *Improving Learning In Mathematics*.



The findings – preparing to teach through enquiry

The teachers involved in the project found it to be an inspiring experience that benefited both themselves and their pupils as these comments from the teachers show.

Whilst working with Mike to prepare for the new approach we were surprised by the breadth and the sophistication of the ideas generated by students in response to problems or prompts.

"What was surprising was the richness of the content of the work and how one piece of work could open the doors to many areas of Mathematics".

Watching a practitioner experienced in the techniques we hoped to adopt helped to convince us that the approach could work with our students and in our context.

"I was inspired to try a new way of teaching Year 7 by having Mike Ollerton in my Year 8 lesson last summer term, when he showed how an open-ended approach to a topic can yield results which involve pupils doing higher level Maths than I thought possible".

We also found it helpful to experiment with the approach with classes we were already teaching and whom we knew well, before adopting the approach wholesale with new classes.

"Trying an enquiry approach with some of my classes and seeing how many aspects of Maths could arise from a simple starting point, and how far pupils could progress from a simple starting point, I found that I could very quickly assess what pupils did or didn't already understand, and I have been consistently surprised by the insights pupils have shared when asked to find their own method to solve a problem, or when asked to justify a particular solution".

The findings – the impact on pupil learning and attitudes

We found that pupils who experienced the new curriculum, having regularly faced open-ended tasks and problems were more likely to work at a problem that might initially appear difficult or intractable and less likely to be discouraged by being stuck. They are less inclined to give up and say 'I can't do Maths', as these teacher comments show.

"My class are not fazed when faced with an open-ended question or when asked to brainstorm or explain their solutions".

“They feel that they can ‘do’ Maths as they aren’t limited by one particular method”.

We also believe that our pupils have become more inquisitive and critical in their thinking and have noticed that compared with previous classes they are much more likely to pose their own mathematical questions or to make conjectures based on what they have noticed.

“Pupils sort out problems themselves and pose questions and raise issues themselves”.

For these pupils Mathematics has become a creative subject where different methods and ideas are valued and explored and where they expect to have to justify their thinking to their peers with a logical and clear argument.

“Pupils were able to demonstrate more reasoning and logic than in a more formal, ‘working from a textbook’ situation”.

“They are more confident and are able to discuss their ideas about Mathematics coherently”.

Critically, we feel that on the whole, pupils who have experienced the new curriculum have found Mathematics more enjoyable than previous year groups and are more enthusiastic about their learning in this subject.

“This approach enriches their experience of the subject by means of different activities and ways of tackling work and has made Mathematics more enjoyable for them”.

Research methods

The findings and quotes throughout this report are drawn from questionnaires completed by the staff who taught the classes which were involved.

Conclusions

We were aware of a wider impact on our pedagogical approach:

“The project has helped teachers to explore new ideas of delivery and has made us reflect on our teaching styles”.

“I am looking for more ‘experimental’ ways and open-ended ideas

for other year groups for example: more brainstorming, ‘what if’, ‘what do you notice’, try this with a friend’, ‘make up your own example”.

An enquiry approach worked for us and we’re now rolling it out across the whole school. So far we have overhauled our Year 8 scheme of work in a similar fashion and have now embarked on a complete rewrite of our Year 9 scheme. The plan is to continue this annual revision of one year group through KS3 and KS4 and possibly into KS5.

We found the contributions of an external expert extremely valuable in that it helped us understand how it worked, and through modelling and collaborative working we were able to effectively adopt the enquiry approach.

Our experience of collaborative planning has been very fruitful and we have now begun to use Lesson Study, a Professional Development idea from Japan which involves collaborative planning, observation and review of a lesson or series of lessons. We have run two projects so far, one involving all of the teachers in our department and one in tandem with our Leading Edge partner schools.

Suggestions for further reading

- Ollerton, M. (2005) *‘100 Problems In Mathematics’*. Continuum International Publishing Group Ltd
- Swan, M. (2005) *‘Improving Learning In Mathematics: challenges and strategies’*. DCSF Standards Unit Resource
- Prestige, S. and Perks, P. (2001) *‘Adapting and Extending Secondary Mathematics Activities: New Tasks for Old’*. David Fulton Publishers
- Bills, C., Bills, L., Watson, A. and Mason, J. (2004) *‘Thinkers.’* Derby: Association of Teachers of Mathematics.

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