Cross-curricular work involving mathematics using hand-held technology

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> Aim

To improve standards and achieve greater curriculum coherence in mathematics, science and related subjects by exploiting the opportunities that exist for collaborative approaches to teaching and learning using low cost, portable and easily accessible technology.

> Dimensions of this Case Study

THE MOUNTBATTEN SCHOOL, ROMSEY
Year 10, 2 sets of mathematics classes; 3 sets of science classes.
THE HENRY BEAUFORT SCHOOL, WINCHESTER
Year 9, 1 class for mathematics and science.
HOUNSDOWN SCHOOL, HOUNSDOWN
Year 9 and Year 10, 2 classes for mathematics and science.
RINGWOOD JUNIOR SCHOOL, RINGWOOD
Year 6, 1 class for mathematics and science.

> Summary of Findings for this Case Study

- Mathematics teachers saw how they could exploit real data from other subjects to enrich different areas of the mathematics curriculum.
- Working collaboratively allowed teachers to expand their knowledge of their own and other subjects.
- The use of real data and instantaneous feedback gave pupils a greater understanding of the diagrams and formulas involved in mathematics and science.
- The use of graphing calculators allowed the pupils to work with greater independence.
- Planning cross-curricular groups between mathematics and other subjects allowed the interchange of ideas.
- Students became more interested in learning mathematics and science.

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Introduction

When was the last time you saw two teachers in the same classroom working together? Perhaps that is not too unusual, but were they from different subject areas? This research investigated how mathematics and science teachers in three secondary schools worked together to explore rich and productive links between these two subjects using low cost portable technology. The technology we used was the Texas Instruments (TI) graphing calculator TI-83 and associated products.

We looked at the following questions:

- How can productive links be established between mathematics and science using this technology?
- How can pupils develop greater understanding and connections in mathematics and science between different forms of representation (diagrams, formulas and modelling etc.)?
- How can we draw upon the relevant and natural opportunities in science lessons involving data handling to carry out mathematical analysis and modelling?
- How do information and communication technology (ICT) tools allow pupils to work independently?

How can productive links be established between mathematics and science using this technology?

This was where a lot of innovative work took place, and is now being developed further. One aspect of the work done in this project was to see how the two subjects could support each other, so time was not wasted in either subject by repetition. The schools involved looked at how team teaching and/or pair observation could help their understanding of what was happening in each subject.

Evidence, in the form of teacher logs, was kept to inform the final report of this research. We are now far better informed about each other's subjects and can see how we can work co-operatively to plan pupils' work more efficiently.

One school had previously had problems when comparing the efficiency of washing powders. The mathematics and science teachers collaborated to design an experiment that capitalised on the tools available to measure the amount of light that passed through the dirty and cleaned fabrics. Pupils could at last measure the changes quantitatively rather than qualitatively. Mathematical links were established at a basic level. The mathematics teacher was there to capitalise upon the opportunities that arose naturally to discuss the mathematics involved. This was a real benefit of team teaching. The pupils were able to apply mathematics outside the mathematics classroom. This led to increased independence in the pupils' work and opportunities for the development of effective strategies for teaching high attainers.

How can pupils develop greater understanding and connections in mathematics and science between different forms of representation (diagrams, formulas and modelling etc.)?

Pupils have trouble interpreting distance/time graphs, and speed/time graphs. By working in groups with a motion sensor linked to a calculator they were able to see how their motion produced graphs on the screen. There was a real air of excitement and enjoyment as pupils directed others to copy a given graph, or one they had produced themselves. This improved their learning and knowledge because they could physically see a graphical and mathematical interpretation of their motion.

The use of this technology enhanced opportunities for differentiation since high attainers were modelling the situation by finding an equation that fitted the motion, while low attainers were obtaining a greater knowledge of graph interpretation. Trouble-shooting worksheets were developed to support pupils, coping with common problems.

Extending this work really motivated the high attainers by giving them a means by which they could measure the value of the acceleration due to gravity (g) and extended their knowledge to gradient as representing the velocity of the moving object. It also extended the teachers' knowledge.

A Japanese researcher, Saeki, described similar experiments. There, initial investigation into pupils' perceptions showed about 45% of them had the misconception that the relationship between the time taken for a pendulum to make one complete swing and the length of the pendulum could be modelled by a straight line graph (linear function). Two weeks after Saeki's experiment only 10% of students thought the relationship was a linear function. We knew from previous evidence that similar work had improved pupils' knowledge (Oldknow & Taylor).

How can we draw upon the relevant and natural opportunities in science lessons involving data handling to carry out mathematical analysis and modelling?

The teachers involved in the research kept logbooks of what they did. The detailed research report contains details of the activities outlined below.

One school investigated the difference between a variety of balls. These were bounced on different surfaces and the heights to which they rose were measured. This resulted in a piece of GCSE coursework that satisfied the criteria for both science and mathematics and enabled pupils to use the same project in both subjects. The project was devised to encourage an investigative approach, using research, planning, collection of data, analysis of results and evaluation. From a teaching point of view the cross-curricular coursework facilitated discussion between departments. Because the activities were easy to engage in with a small group of pupils, the teachers' confidence was increased, particularly in ICT. This led to an increase in competence in the ICT skills of the pupils.

A junior school wanted to find out how the outside temperature varied during the day. They linked up a temperature and light probe to see how the two were linked. The temperature and light intensity were plotted against time. Using the *Viewscreen* one set of data was superimposed on the other. This enabled the pupils to integrate the two sets of data and appreciate the relationship between temperature and light intensity. Interpretation of the scales used added to the pupils' understanding of place value. Key Stage 2 national test results in mathematics and science were higher than expected for the pupils who had been involved with this project.

The research indicated that the co-operation of teachers was to the benefit of pupils and teachers.

Implications

To implement any findings in the future schools should plan to have cross-curricular groups between mathematics and other subjects to allow the interchange of ideas. All the teachers and advisors involved with this research considered the cross-curricular fertilisation of ideas invaluable.

How do ICT tools allow pupils to work with greater independence?

According to the Japanese teacher Saeki it was possible to carry out cross-curricular integrated learning, and help students cultivate a 'zest for living' to discover and solve problems by themselves. We found that pupils were able to pose their own problems that they could then try to answer because they had the tools to help.

One group used the motion sensor as a form of speed control. Not only could they try and log the speed of passing cars, but also they found that if they pointed a strange gadget at a car it automatically slowed down!

The portability and immediacy of this technology gave students ownership of their experiments and allowed them to engage in higher order thinking skills such as making predictions, analysing data and modelling data with equations. Teachers reported in their logbooks that data capture was quick and easy, therefore students had immediate access. This encouraged the students to be critical and allowed them to retake readings if they seemed dubious. The on-screen data happened in real-time, allowing for pupils to account for trends as they took readings, to predict or confirm original predictions. Problems taking readings could be identified and addressed immediately. There were many opportunities for extension work for the high attaining pupils as the equipment was easy to set up and menus were easy to master. Students seemed to have become more interested in learning mathematics and science.

It was interesting to note that in an informal survey, over half the students involved agreed or strongly agreed that they now felt co-operative work was more important than they had previously believed. They felt it gave them the potential to answer further questions. By discussing their work in small groups they supported and helped each other's learning.

Further research in progress

The enthusiasm for this cross-curricular work has spread to geography and Physical Education (PE) departments. To carry out work in the field, there is the means to collect data about the flow rates of water in a stream, and one school is working collaboratively between mathematics and geography in this area. Work between the PE and mathematics departments is underway using heart rate meters, to investigate how physical activity affects the heart rate.

Methods used

Each half term the teachers involved met for a half day with the advisers and consultants to discuss the work in progress. In the time between meetings the teachers collaborated in their own schools.

References

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TTA funded Hampshire Graphing Calculator Project http://www.cisc.soton.ac.uk

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