Planning the effective use of ICT in teaching and learning mathematics

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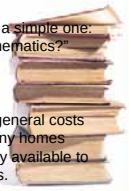
✓ ICT is just another, albeit very powerful, resource which we, as a mathematics teachers, will need to consider when planning work for our students inside and outside mathematics lessons.

✓ Parents, students and teachers have a right to expect that teaching of all subjects in the curriculum should make the best possible use of ICT resources, and that means that the selection and deployment of ICT resources should be made to fit the needs of the subject – and not the reverse.

✓ The test of whether it makes sense to deploy ICT is a simple one: "Does it benefit the students' effective learning of mathematics?"

✓ Of course finance for resources is finite.

✓ Developments in ICT have been very rapid, and in general costs have fallen considerably, so it is now the case that many homes contain more powerful ICT resources than are currently available to many teachers of mathematics in schools and colleges.



✓ Many common ICT tools have been developed for personal use, and their deployment in a teaching environment requires careful consideration.

✓Unfortunately a culture has arisen in education in which the provision of resources to support the acquisition of appropriate curriculum software lags far behind that of hardware, which often comes with a range of so-called `generic' software bundled-in.

✓ Inspection evidence consistently shows very little use of appropriate ICT tools in mathematics teaching at all levels.

✓ Reasons for this may include:

1) lack of support and/or training,
2) lack of funding devolved to mathematics departments,
3) scepticism about benefits of using ICT and
4) lack of knowledge of what is available.

Models of ICT deployment in schools and colleges

✓ Whole class work with ICT

✓ Individual, or paired, use of ICT

✓ Group work with ICT

✓ Mixed models

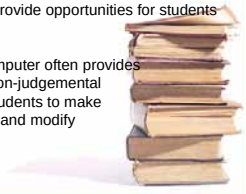
Changes in teaching approaches

✓ It is quite possible to use ICT in mathematics lessons in a way which does not throw into question your own teaching approaches.

✓ However the power of the medium is such that to restrict its use in this way is to deprive the students of access to a resource which could revolutionize their learning.

✓ Six major ways in which ICT can provide opportunities for students learning mathematics are:

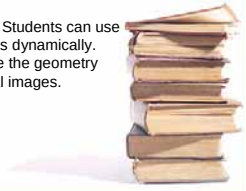
1.Learning from feedback: The computer often provides fast and reliable feedback which is non-judgemental and impartial. This can encourage students to make their own conjectures and to test out and modify their ideas.



2. ***Observing patterns:*** The speed of computers and calculators enables students to produce many examples when exploring mathematical problems. This supports their observation of patterns and the making and justifying of generalisations.

3. ***Seeing connections:*** The computer enables formulae, tables of numbers and graphs to be linked readily. Changing one representation and seeing changes in the others helps students to understand connections between them.

4. ***Working with dynamic images:*** Students can use computers to manipulate diagrams dynamically. This encourages them to visualise the geometry as they generate their own mental images.



5. ***Exploring data:*** Computers enable students to work with real data which can be represented in a variety of ways. This supports interpretation and analysis.

6. ***Teaching' the computer:*** When students design an algorithm (a set of instructions) to make a computer achieve a particular result, they are compelled to express their commands unambiguously and in the correct order; they make their thinking explicit as they refine their ideas.

Impact on the curriculum

✓ As we know, the mathematics curriculum can take a very long time to respond to technological changes, such as the development of the electronic calculator.

✓ Yet now ICT is so well established in all branches of industry, commerce and research as a mathematical and statistical modeling and problem-solving tool there are few people who still use pencil-and-paper techniques.

✓ So while the impact may be slow, we should at least be prepared to re-examine our own ideas of what are the fundamentally important elements of the curriculum.

✓ As the technology progresses and becomes more prevalent, teachers will also need to be continually reconsidering the mathematical content of their teaching.

✓ Having software which can, for example, solve systems of equations at the touch of a button has strong implications for the way particular topics are approached.

✓ One important aspect of the widespread availability of mathematical ICT tools, and easy access to sources of mathematical information via the Internet, is that they can enable you to keep in touch with developments in your own subject.

✓ While it is the norm for teachers of many subjects to keep themselves up-to-date with their subject, this does not appear always to be the case in mathematics.

✓ So maybe teachers could help lead the way by creating a mathematics learning community and ethos in your own school – and hopefully inspire more students to want to study, and perhaps teach, the subject?

Using ICT to provide enrichment activities to support differentiation

✓ There are three terms that are closely associated with enrichment and, whilst they are not entirely mutually exclusive, they do represent different agendas.

1. Acceleration: takes pupils into areas of the curriculum normally covered by older children often resulting in early entry to public examinations. This is sometimes achieved by moving pupils into higher year groups for all subjects or just the subject in which they excel. Alternatively, children can be accelerated within their own class working independently, often with some additional support.

2. Extension: involves moving outside the syllabus and looking at aspects of mathematics not normally covered within the `normal' curriculum. The mathematics can give opportunities for problem solving which requires pupils to use their mathematical skills in non-standard contexts.

3. Enrichment: is about extending pupils' understanding of the mathematical ideas they have already met by applying them to other situations and problems, often requiring decisions on what area or areas of mathematics to employ. The aim is to develop higher level problem solving and communication skills. It extends the notion of using and applying. The aim is to produce a thinking mathematician who can look beyond the standard `test' type questions. Enrichment also implies a teaching approach which encourages mathematical discussion and communication.

✓ More able pupils need to be stretched and motivated but this is often very difficult in a classroom with 30 or more pupils all needing individual attention.

✓One of the most powerful resources available to you is the computer.

✓ More able pupils will no more benefit from the computer than other students but in the same way as ICT can support basic literacy or numeracy skills through targeted, skills focussed, software or the use of generic software (such as word processors and spreadsheets) or access to resources via the Internet, it can support the needs of the more able mathematicians.

✓ Effective use of ICT will enable you to:

• Find appropriate online resources that can be used off-line or converted to a paper based resource – an example of this are the resources to be found on the NRICH website(offering enrichment materials for mathematics to pupils of all ages)

• Use generic software and open ended tasks that will engage pupils who are struggling but offer real opportunities for stretching the most able. Software such as *Logo, dynamic geometry software and spreadsheets all have this potential but closed, skills based, software does not give the flexibility to encourage enrichment.*

✓ This can be achieved by:

• Planning tasks for the whole group that will involve all pupils but stretch the most able (differentiation by outcome). So, for example the whole group might be using Logo to find their way through a maze – working on right and left and estimating distance. At the same time in the same room more able pupils may be creating a maze of their own. What are the properties of mazes? How can you ensure that the width of passages remain constant? This will involve using the same mathematical ideas but extending them to more demanding contexts. What they are not doing is `more of the same'.

• Sending individual or small groups of pupils to work at a computer on tasks particular to their ability but related to the activities being undertaken by the rest of the class. So if the group are working on angle properties of 2D shapes a small group might be investigating the angle properties by creating tiling patterns in Logo.

• Using the Internet to locate resources to provide enrichment material that supports the lesson objectives and the more able pupils.

Implications for management

✓ Inevitably teachers will become involved with management – not only of deploying ICT in their own teaching. Teachers may be responsible for managing others, and they may need to persuade their own managers to support them with their own, or the department's, development plans.

✓ The role of school management at any level is to develop, support, and direct the learning community.

✓ Two general features of ICT applications that enhance the learning experience are software that is **responsive** and techniques that provide **leverage,** making easy something that was otherwise a considerable effort.

1. Responsive software – examples include where a change to one value on a spreadsheet automatically changes all calculations that depend on that as a source value, and where movement of one point on a dynamic geometry display causes movement in all constructions that depend upon that point.
   It is useful to make explicit the value of `interactivity', i.e. responsiveness, in software.
   - Interactive software encourages learning by experiment and discovery – the "try it and see what it does" and "why did that happen?" approach.
   - A facility to make changes, with instant effect, invites generalisation.

2. Leverage - making easy something that was otherwise a considerable effort. Examples of leverage include moving text around within a word processor document, replication of formulae on a spreadsheet and the automatic production of graphs on a graphical calculator. Any of these would have been tedious, or even worthless, without ICT.

✓ There is a proposed ICT Development Cycle with phases which managers need to support.

✓ The familiarisation phase applies both to students and teachers – this is a period of orientation and uncertainty. During the familiarisation period an important initial perspective forms about what the new object is, and what it might be worth, together with an assessment about what is being threatened. The familiarisation phase is important and needs to be handled by managers with awareness, imagination, and clear purpose. The familiarisation phase is passed through many times as a teacher or pupil moves on to encounter each major new environment. The teacher who, for example, has used graphical calculators in the classroom for some time, but is coming to a dynamic geometry package for the first time, will experience again the excitement, uncertainty, and perhaps frustration, of the familiarisation phase.

✓ In managing the familiarisation phase, the context within which the initial encounter occurs matters greatly. The initiation experience needs not only to reveal just what the tool does, and give enough practice to sow the seeds of confident use, but also to convince the new user that the tool has value. For example, the first use of a spreadsheet should be based on something mathematically interesting, such as a number puzzle like the magic square.

✓ This is followed by a phase known as `Routine Specific Activity', which is needed before a general culture of creative use establishes itself. In this period of routine but specific use, particular lessons will involve particular activities which make use of particular techniques.

✓ One examples of good practice is to identify key modules in schemes of work which will require all mathematics teachers to use ICT in an aspect, say, of the geometry curriculum.

✓Planning this, and finding department time for training, means that teachers who need support can get it, but at the same time they are challenged to deliver lessons with ICT.

✓Another successful strategy has been to hold mathematics enrichment days for a particular year group which involve the use of ICT.

Evaluating the impact of the use of ICT

✓ Evaluation occurs at many levels – e.g. of the use of some ICT as part of a lesson, or of the lesson as a whole, or maybe of teacher own, or the department's, facility with ICT.

✓ Teachers will also need to be able to evaluate particular ICT tools in considering their usefulness for mathematics teaching.

Evaluating a lesson using ICT

✓ In order to set the context we will need to know:
- What are you trying to do?
- How are you trying to do it?
- Who are you going to work with?

✓ Then we will need to pose appropriate questions such as:
- Did you meet the learning objectives?
- Were the students actively engaged and were all abilities catered for?
- Were the students confident?
- Did the plenary work – could they transfer knowledge to other scenarios?
- What mathematics did they use?
- What progress did they make?
- Can it be extended further?

Evaluating the ICT use of the mathematics department

✓ A form of "*Review of IT in Mathematics"* is necessary with aim to help departments with the process of review, and can be divided into 7 sections:

1.ICT in learning mathematics
This section establishes the extent to which ICT is built into the teaching of mathematics in all classes. In which years are there modules of work including ICT use, support materials and teaching notes? How do we use the technology as a teaching and learning resource?

2.Current ICT skills of mathematics teaching staff
This section establishes the types of software, and devices, with which teachers are familiar and how widespread ICT skills are across the department.

3. **Curriculum resources**
This section establishes whether there are appropriate mathematical activities and other support materials (published, or produced within school) for the different categories of ICT.

4. **ICT resources**
This section is about the hardware available in the school.
How many machines (desktop PCs, laptops, palmtops, graphical calculators etc.) are available in mathematics classrooms? Comment on suitability, sufficiency, accessibility and reliability.

5. **Entitlement opportunities**
Mathematics and IT – a Pupil's Entitlement' highlights six major opportunities for exploiting the power of the computer. This section establishes which opportunities are offered in school.
Indicate on a scale from 1 (minimal) to 5 (extensive) the extent to which pupils in school have access to the 6 major opportunities.

6. **ICT development**
This section establishes how you arrived at your current stage of development.
Can schools identify helpful factors? Have schools had contact with other schools through an corporation, subject association, project etc.? Are ICT resources available for teachers to take home? Can schools identify helpful sources of ICT support and advice inside the department, school or elsewhere?.

7. **Action plan**
Completing the previous sections may have suggested directions for development. Teacher's action plan could be written under the following headings, giving some indication of time scales.
Embedding ICT (entitlement opportunities and curriculum objectives):
- Staff development, both within and outside school;
- Updating and improving ICT resources.

Evaluating resources such as software and web-sites

✓ Information about ICT resources, which can be searched by subject, age-range, or both, are very useful.

✓ It gives details about, and links to, suppliers including costs of licences etc.

✓ When evaluating software or web-sites it is recommend that you consider the philosophy behind their design as well as any implicit or explicit teaching and learning styles when you use them.

Achievements

- At the beginning of the school year, in September and October 2006, Complex numbers contents were used online
  - 123 students of the second grade attended to this classes
  - 91 students of the first year at the Faculty of Civil Engineering, University of Mostar, attended to this classes
- Promotion of digital literacy among teachers and students
  - Seminar “Development of Mathematics Learning Contents with ICT” at University of Sarajevo
  - Seminar “Development of Mathematics Learning Contents with ICT” at University of Mostar
  - Seminar “Development of Mathematics Learning Contents with ICT” at University of Banja Luka

Content development

- New content for subject regarding complex numbers were developed
  - Complex numbers and complex plane
  - Standard form of complex number
  - Equality of complex numbers
- These contents (lessons) are developed only on Croatian language, I will translate them on English language after completing whole subject - complex numbers.
- Exercise for all above mentioned lessons
- Use developed materials offline

Thank you for your attention!