Towards a research agenda: Using ICT in Mathematics Classrooms

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In this paper I argue that computers (ICT) are not used to their full potential in mathematics classrooms, and I suggest that this is due to insufficient and perhaps inappropriate professional development for teachers in this area. I put forward the idea that we need to develop a better conceptualisation of teachers' understanding of the use of computers in mathematics teaching and learning in order to inform the design of professional development.

Computers are seen to have the potential to make a significant contribution to the teaching and learning of mathematics. In particular, when students are working on computers, it is generally recognised they are more able to focus on patterns, connections between multiple representations, interpretations of representations and so on (Ainley & Pratt, 2002, Balacheff & Kaput, 1996, Condie & Munro, 2007, Godwin & Sutherland, 2004, Laborde, 2002, Noss & Hoyles, 1996, Ruthven et al., 2004, Säljö, 1999, Sutherland, 2007, Tall, 1996). This sort of computer use may 'enable a deeper, more direct mathematical experience' (Balacheff & Kaput, 1996 p 470).

In the UK there is a statutory requirement for ICT to be used in mathematics teaching and learning at all levels; the requirements are summarised in statements such as

> Students should be offered the following opportunities … using ICT such as spreadsheets, dynamic geometry or graphing software, calculators (DCSF, 2008)

In other countries, similar encouragement is given to teachers, described by Artigue (1998) as 'incentive action and institutional support' (p 121). However, despite these efforts to embed computers in mathematics teaching and learning, and despite the growing numbers of computers in schools (Condie & Munro, 2007), there are some concerns about the degree to which computers have actually become embedded in mathematics classrooms. These concerns fall into three areas: computers are used only marginally in mathematics classes; integration of computers progresses slowly, (Artigue, 1998, Laborde, 2002, Ruthven & Hennessy, 2002, Sutherland, 2007) and where computers are used, they are often used by the teachers in whole class teaching rather than by the students (Ofsted, 2005b).

In addition to what can be seen as a disappointing uptake of computer use in mathematics classrooms, there is some evidence that the ways in which computers are used is also disappointing. The Department for Education and Skills (DfES) has offered implicit recommendations about the software to use (suggesting that 'appropriate ICT' includes 'spreadsheets, databases, geometry or graphic packages'(DfES))[1]. Ofsted's recommendations are more explicit,

> Pupils' involvement in their learning is the key to their engaging with mathematical ideas; they need to participate in forming and testing hypotheses, trying out models and developing reasoned solutions to problems. The use of software such as dynamic geometry, graphing and data-modelling packages enables pupils to participate in these processes (Ofsted, 2005a).

However, the **actual** use of software in classrooms seems to differ from these recommendations. A recent survey (2000 to 2003) reported by the Fischer Family Trust (2003), reported on the responses of 373 mathematics departments about what ICT they use, and how much they use it (amongst other questions). The findings from the survey suggest that *Microsoft Excel* is by far the most popular package used in classrooms with 238 schools reporting its use (on average as 'high'). (No other spreadsheet packages were reported.) This leaves about a third of the schools not using

[1] Now the Department for Children, Schools and Families (DCSF); the web page has changed but the recommendations are much the same (see http://curriculum.qca.org.uk/key-stages-3-and-4/subjects/mathematics/keystage3/index.aspx?return=http%3A//curriculum.qca.org.uk/key-stages-3-and-4/subjects/mathematics/index.aspx0

spreadsheets, despite the fact that they are specifically recommended in the examples given by the DfES (see beginning of this section).

Other examples mentioned in this same recommendation included databases, geometry software and graphing software. The survey reports that the use of these types of software is low, given the specific statutory guidance.

Interestingly, a relatively high proportion of schools reported high usage of intelligent learning systems (ILS), games ((SMILE Mathematics) and medium usage of programming software (*Logo*), and word processing. These are not mentioned in the guidance and (apart from *Logo*) can be seen to provide only limited opportunity for students to engage in the sorts of mathematical activities for which Ofsted endorses the use of computers (above).

The point is that classroom use of software seems to be somewhat at odds with the implicit recommendations in the official rhetoric. It is also somewhat at odds with the software focus in the research literature, which seems to be primarily interested in dynamic geometry software (DGS) and 'other microworlds', spreadsheets and graphing packages (Lagrange et al., 2003).

Further, it seems that teachers lack sufficient understanding of how to incorporate computers into mathematics tasks (Joubert, 2006, Laborde, 2002, Monaghan, 2004, Ofsted, 2005a). Ofsted (ibid), for example, suggests that the tasks 'incorporating the use of ICT are often overstructured … This is somewhat ironic because ICT can be very effective at motivating pupils to learn and to take this learning forward on their own'.

In summary, despite the claims in the literature that computers have the potential to enhance the teaching and learning of mathematics, two major concerns with the current state of affairs have been identified; first that the levels of uptake of computers is still very low and second that, where computers are used, they do not generally seem to be used as well as they might.

A number of factors may explain these concerns, and the literature identifies the lack of sufficient and appropriate teacher training and professional development as the key factor (Artigue, 1998, Laborde, 2002, Ofsted, 2005b, Sutherland, 2007). This situation has arisen despite major initiatives to 'train' teachers in the use of computers mathematics classrooms (for example, the New Opportunities Fund (NOF) training).

It seems that many teachers do not feel confident about the software they use, some of which is highly complex so that teachers do not know where to start exploring it (Sutherland, 2007). Further, because of the ability of some software to perform mathematical processes (e.g. draw graphs) and to provide feedback, planning for the use of computers in the classroom requires a careful analysis of the potential and the intended role of the computer, together with the likely and actual student activity as they work through the task.

I am suggesting that the research agenda should turn towards developing an understanding of teachers' conceptions about the use of computers in mathematics classrooms by investigating the ways in which teachers and students use computers in authentic classroom situations. I argue that, with a clearer understanding and of how teachers put their knowledge and understanding into practice in the classroom, we will be in a much better position to develop effective professional development which may result in an improvement in the situation I have described above.

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