

MATHEMATICS TEACHERS' LEARNING ABOUT AND INCORPORATION OF ICT INTO CLASSROOM PRACTICES

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In this paper I report on a study of secondary school mathematics teachers' use of ICT. The study adds new dimensions to understanding teachers' use of ICT by treating the teaching of mathematics and ICT use as interwoven aspects of a teacher's practice. The analysis of the data collected using a case study research strategy yielded a number of salient factors, of both contextual and personal nature, which were identified as key to the integration of ICT into mathematics teaching. A framework which conceptualises teachers' learning about the potential and limitations of ICT and teachers' incorporation of ICT in their teaching of mathematics will be advanced with the aim of contributing to a better understanding of the pedagogy of teaching mathematics with ICT.

INTRODUCTION

This study is grounded in my own experience of getting acquainted with the new technology and attempting to design computer based mathematics activities (reported in Crisan, 1999). As a result of reflecting on the implications the use of ICT could have on my own teaching of mathematics and on pupils' learning of mathematics, I became interested in how secondary school mathematics teachers incorporate ICT into their practices.

A critical review of studies carried out in the area of teachers' use of ICT revealed that most studies were mainly carried out in the USA (e.g., Becker, 1994), in technology-rich classrooms (e.g., Fisher, Dwyer & Yocam, 1996), while in the UK they were mainly carried out at primary school level (e.g., Cox, Rhodes & Hall, 1988). Also, the studies reviewed either tended to focus more on individuals or were nationwide surveys of the technical skills of a large number of teachers (e.g., Marcinkiewicz, 1994; Dupagne & Krendl, 1992). As a result, I set out to conduct a study which would complement the existing research by investigating how a number of mathematics teachers teaching in secondary schools in the UK learn about the potential and limitations of ICT and how they plan to use it as a result. I thus aimed to contribute to what Shulman called a 'case literature' (Shulman, 1987, p.12) by unravelling teachers practices with ICT and by making explicit some of the interaction between different components of their 'knowledge base for teaching' (Shulman, 1987, p.4).

CONCEPTUAL ORIENTATION

Some of the existing insights which surfaced from the review of the literature, were empirically tested by carrying out a Pilot Study (reported in Crisan, 2001). The Pilot Study suggested that teachers' learning experiences with ICT, i.e., their learning

about the capabilities of ICT as well as learning about and doing mathematics with ICT, influenced the way they used the new technology in their teaching.

At the same time, the teachers' components of the professional knowledge base for teaching paradigm, as initially advanced by Shulman (1987), offered a way forward with the analysis of the data collected during the Pilot Study, pointing to a new and interesting direction of research, namely the importance of exploring how these components are modified and shaped during the process of learning and thinking about using and using ICT in teaching the subject.

Based on a critical review of the literature concerning teachers' use of ICT, the components of teachers' knowledge base for teaching and the evidence in the data collected during the Pilot Study, a conceptual framework was advanced. The framework posited in a broad way the different sets of variables which were thought to influence how teachers incorporate ICT into their practices and thus relevant to investigate within the Main Study: teachers' background characteristics and the contextual conditions of teachers' implementation of ICT, together with teachers' conceptions of mathematics, their pedagogical content conceptions and conceptions of ICT, all looked at in the context of teachers' learning about and using ICT in their teaching.

THE MAIN STUDY

The Teachers

Seven mathematics teachers (four females and three males), teaching in three secondary schools in City Z expressed an interest and willingness to participate in the study. These teachers were at different stages in their teaching career, as well as at different stages of incorporating ICT in their practices, with some more skilled in the use of ICT and more knowledgeable of different mathematics packages than others, but with all willing to explore the potential of ICT (especially of the content free applications such as Omnigraph, Autograph, Excel, The Geometer's Sketchpad) into their classroom practices.

Methods of Data Collection and Analysis

The teachers were interviewed twice over a period of time and observed while teaching at least one mathematics lesson where ICT was being used. Where available, written documents (such as lesson plans, pupils' work and handouts) were collected. The interviews were recorded and transcribed, while detailed notes were taken during and after lesson observations and informal conversations with the teachers.

The collection of data was guided by the conceptual framework which structured what I noticed and paid attention to and took as important in teachers' practices. In consequence, the data were organised and categorised initially under the five main categories as suggested by the orienting conceptual framework.

The analysis of the data yielded more categories and sub-categories, and in an effort to give voice to the teachers involved, teacher profiles were written. The interpretive

nature of these accounts allowed me to consider the teachers' practices in the light of the conceptual framework considered and thus to explain the teachers' perspective from my perspective (Simon & Tsur, 1999, p.254).

FINDINGS

A variety of factors which affected teachers' implementation of ICT into their classroom practices were borne out by this research. They are divided into two broad categories: the contextual factors and the personal factors.

Although the research was not designed to examine in depth the impact of the contextual factors on individual teachers, these factors are briefly summarised in the following as they emerged as influential: the school context, the availability of and access to ICT facilities and resources, teachers' ICT skills, teachers' ICT professional development, departmental ethos and key persons in promoting the use of ICT and the departmental policy with regard to integrating ICT into the mathematics scheme of work.

Conceptualising mathematics teachers' learning about and incorporation of ICT into their classroom practices

The Main Study was carried out with a limited number of teachers, giving me the opportunity to do a thorough analysis, thereby providing a solid base for inference, although not providing, however, a good basis for applying these inferences to a wider population (Yin, 1994). By focusing the analysis across cases, the present study facilitated the building of a framework aimed at conceptualising teachers' learning about and incorporation of ICT.

There was ample evidence when analysing the data to suggest that, when learning about ICT, teachers developed **a conception base for teaching mathematics with ICT**, encompassing knowledge, beliefs, understandings, preferences, and views about teaching and learning of mathematics with ICT. In this paper, I will present the components of the conception base (see Figure 1). A detailed discussion of the development of the framework and of the dynamic interaction of its components will follow in a future extended version of this paper.

As initially suggested by the conceptual framework, the evidence in the data indicates that teachers' conceptions of ICT affected their incorporation of ICT. In particular, two aspects of teachers' conceptions of ICT emerged as important and are thus put forward as categories of teachers' conception base for teaching with ICT. First, the category *ICT content conceptions* which comprises conceptions that a teacher might hold about the content of a variety of ICT based mathematics resources (especially the content free applications), such as familiarity with the features of the applications, how to access and use them, as well as an awareness of the potential and limitations of such applications for the learning and teaching of specific mathematics topics and skills. Second, the category *ICT curricular conceptions* which consists of conceptions about the National Curriculum recommendations regarding the use of ICT in the school mathematics curriculum, knowledge and understanding of the existing hints in

the scheme of work of when and how to use ICT, together with teachers' knowledge and preferences of the ICT based ready-to-use resources available in their departments.

There was also evidence in the data to suggest that, when teachers thought about incorporating ICT in their teaching, their *conceptions of mathematics* and *pedagogical content conceptions* affected their thinking about and use of ICT in their teaching. For example, the availability of appropriate ICT environments enabling multiple representations of the same concept was appreciated by all the participating teachers, but the data collected suggested that the teachers made use of such environments in different ways, according to their own conceptions of what mathematics was.

Moreover, the analysis of the data indicated that the development of teachers' pedagogical 'expertise' with ICT was characterised by personalisation. The participating teachers perceived and used the potential of ICT applications in the teaching and learning of mathematics in different ways according to their personal view of what an application is capable of and of how it could be incorporated into the classroom practices. For example, there is evidence in the data that supports the view that some of the teachers perceived the benefits of ICT use in their mathematics lessons in terms of enhancing pupils' enjoyment of mathematics lessons and rewarding them at the end of lessons for working hard or obtaining good results in tests, others used ICT in order to address difficulties pupils had with the understanding and learning of transformation of graphs, geometry proofs and transformation of shapes, while others used ICT because it enabled them to teach more effectively mathematics topics that they would be apprehensive to teach in the past.

Thus the dynamic interaction of the categories mentioned above contributed to the construction of teachers' **personal ICT pedagogical construct**. It was their personal constructs that teachers used when thinking about and incorporating the ICT tools and resources at their disposal for what they thought benefited their teaching of mathematics and their pupils' understanding and learning of mathematics.

An important source for teachers' conception base with ICT were their *own learning experiences with ICT*, which were found to be of paramount importance in their uptake and incorporation of ICT. Other source were teachers' generalized wisdom of practice, of having taught without ICT for a number of years, their ICT professional development and their wisdom of practice with ICT, which developed as a result of using ICT in their lessons and which fed from and into their personal ICT pedagogical construct. Ideas on how to use ICT in mathematics lessons came mainly from the existing ready-to-use resources, feeding from trainers or colleagues' ideas, sharing teaching experiences of what worked and what did not work with ICT, peer observation of lessons where ICT was being used and discussions about strategies of implementing ICT during departmental meetings. However, there is no evidence in the data collected indicating that the teachers themselves came up with new

representations of mathematics concepts/topics enabled by ICT. The teachers believed that professional characteristics such as imagination, creativity and contrivance with a piece of software would enable them to think of or envisage new situations where and how ICT could be used to enrich their representational repertoire and thus their teaching of mathematics.

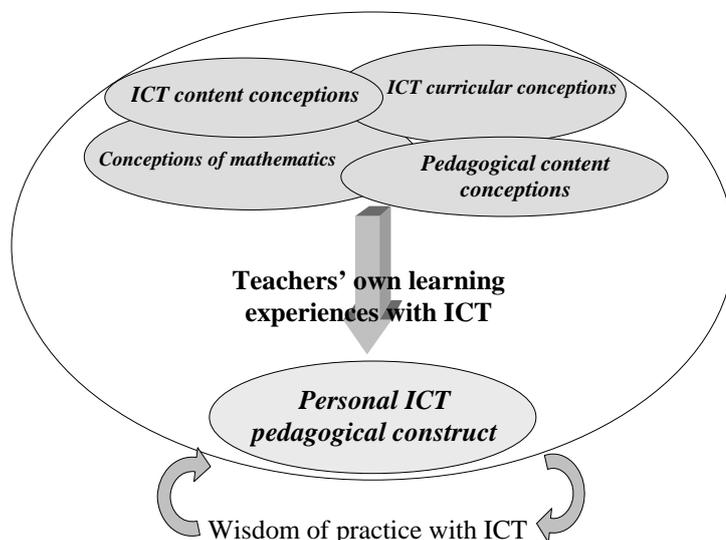


Figure 1: A framework for conceptualising teachers' learning about and incorporation of ICT into their classroom practices

THE FRAMEWORK IN USE

The proposed framework of teachers' learning about and incorporation of ICT in their teaching of mathematics can be seen and used as a tool by teachers for categorising their personal understanding of ICT use. They can use it as a way of articulating what they know about and are able to do with ICT.

The framework could also be seen and used as a useful tool for planning in-service development for teachers. As it could provide a useful starting point for discussing teachers' learning about and incorporation of ICT, the trainers could therefore draw out a training plan customised to each participating teacher's needs.

The teacher education area could also benefit from using this framework in order to facilitate explicit discussions about the components of the professional conception base for teaching mathematics with ICT. The framework could guide educators on how to address student-teachers' conceptions of teaching and learning mathematics with ICT and to focus on what student-teachers ought to know and how they might improve their personal construct of the pedagogical conceptions of using ICT in teaching mathematics.

One of the main findings of this study, namely that teachers' own learning experience with ICT was of paramount importance in their uptake and implementation of ICT. This suggests that mathematics teacher educators need to help increase student-teachers' knowledge about the usefulness of ICT by engaging them in extensive experiences with computers and a variety of educational software. They should also encourage student-teachers to reflect on their own learning about and doing mathematics with ICT. Such experiences might help student-teachers to reflect critically on the potential and limitations of ICT for pupils' learning of mathematics.

REFERENCES

- Becker, J. B.: 1994, 'How exemplary computer-using teachers differ from other teachers: Implication for realizing the potential of computers in schools', *Journal of Research on Computing in Education*, 26 (3), pp.291-321.
- Cox, M., Rhodes, V. & Hall, J.: 1988, 'The use of computer assisted learning in primary schools: some factors affecting the uptake', *Computer Education*, 12 (1), pp.173-178.
- Crisan, C.: 1999, 'Reflecting on my first experience with the new technology', *MicroMath*, 15(2), summer issue, pp.20-23.
- Crisan, C.: 2001, 'The interaction between teachers' Use of ICT and the components of their professional knowledge base for teaching', in C. Morgan and K. Jones (eds.), *Research in Mathematics Education – Papers of the British Society for Research into Learning Mathematics*, vol. 3, Chapter 5, pp.87-100.
- Dupagne, M. & Krendl, K.A.: 1992, 'Teachers' attitudes toward computers: a review of the literature', *Journal of Computer Assisted Learning*, 24 (3), pp.420-430.
- Fisher, C., Dwyer, D.C. & Yocam, K.: 1996, *Education and Technology: Reflections on Computing in Classrooms*, Apple Press, Jossey-Bass Publishers, San Francisco.
- Marcinkiewicz, H.R.: 1994, 'Computers and teachers: factors influencing computers use in the classroom', *Journal of Research on Computing in Education*, 26 (2), pp.220-235.
- Shulman, L. S.: 1987 'Knowledge and teaching: Foundations of the new reform', *Harvard Educational Review*, 57(1), pp.1-22.
- Simon, M.A. & Tsur, R.: 1999, 'Explicating the teachers' perspective from the researchers' perspective: generating accounts of mathematics teachers' practice', *Journal for Research in Mathematics Education*, 30 (3), pp.252-264.
- Yin, R.K.: 1994, *Case study research: Design and Methods*, (2nd ed.), Sage Publications Inc., Thousand Oaks.