# Pre-service teachers' understandings of learning to use digital technologies in secondary mathematics teaching

Rosalyn Hyde and Julie-Ann Edwards

*University of Southampton*

One of the biggest challenges facing pre-service mathematics teachers is that of learning how to make effective use of digital technologies in the classroom in order to enhance the learning of their students. For initial teacher educators the challenge is to enable the development of teachers who have the capability to respond flexibly to new technologies and who are able to evaluate and reflect on the impact of such technologies on learning. We report on data collected as part of a research project investigating ways in which pre-service mathematics teachers can develop more effective skills in using digital technologies to enhance teaching and learning in the classroom. We examine this evidence using Mishra and Koehler's (2006) model of Technological Pedagogical Content Knowledge (TPCK). The emerging understandings of pre-service teachers' learning are considered in the context of their learning experiences during their initial teacher training course and in terms of charting the learning journeys they undertake on the course. The project outcomes point towards ways forward in enabling more effective learning by pre-service teachers in the use of technologies for mathematics teaching

**Keywords: ICT, digital technologies, Technological Pedagogical Content Knowledge, pre-service teachers.**

## Introduction

The current Standards for Qualified Teachers Status (QTS) in England require pre-service teachers to demonstrate that they can use Information and Communications Technologies (ICT) in their classroom teaching. In doing this, pre-service teachers also need to demonstrate that they can use ICT to teach mathematics in accordance with the expectations of the National Curriculum for England (Qualifications and Curriculum Authority 2007). The pre-service teachers on our one-year Post Graduate Certificate in Education (PGCE) course are given a range of opportunities to work towards these QTS Standards through: university-based taught input, tasks and activities on the course, peer support, modelling by university tutors, through the provision of support materials and, crucially, through their experiences whilst teaching in their placement schools. The richness of this provision is made more complex by our awareness of the range of provision in our Partner school secondary mathematics departments in developing the use of digital technologies in teaching and learning, and that pre-service teachers also differ in the extent to which they are able to make best use of the opportunities offered.

We know that almost all of our pre-service teachers start their PGCE course with good personal ICT skills with a limited range of common generic software packages. However, Cuckle, Clarke and Jenkins' (2000) findings suggest that some pre-service teachers who start a PGCE course with good personal ICT skills find it difficult to transfer these skills to their classroom practice and tend to use their ICT skills for tasks such as planning and recording assessment, rather than for teaching. The reasons suggested for this include poor access to facilities, limited encouragement in some subject specialisms (not including mathematics) and the pedagogical beliefs of existing teachers regarding the use of ICT in teaching. The first of these reasons seems no longer to be a major issue given Enochsonn and Rizza's (2009) research review of ICT in teacher training, which concludes that there is generally not a problem with access to technology in schools in the 11 countries surveyed. Even so, they report that pre-service teachers do not integrate technology into their teaching.

## Literature

Many researchers (see, for example, Miller and Glover 2010 and Mishra and Koehler 2006) argue that the availability of digital technologies in learning environments requires teachers to respond by changing their pedagogy. It therefore becomes important to consider how changes might come about.

There are two main approaches discussed in the literature (see, for example, Miller and Glover 2010) to developing the use of digital technologies in the classroom with practising teachers. In the first, teachers become proficient in using the technology and then incorporate it into their classroom pedagogy. In the alternative, pedagogical realisations made by teachers in situ stimulate them to pursue new ways of working with ICT. Mercer, Hennessy and Warwick contend that, with the first of these two approaches, "…policy and training initiatives have often tended to ignore the vital need to relate the use of new forms of technology to what is known about effective pedagogy" (2010, 196). They, along with Minaidi and Hplanas (2005), suggest that the latter of these two approaches is more effective. Mercer, Hennessy and Warwick go on to say that the effective use of digital technology (in their case the interactive whiteboard) is not a function of the technology itself, but dependent on the teacher's understanding of how to engage school students and help them learn.

We believe that it is self-evident that pre-service teachers have some need for experiences that develop their technical skills with generic mathematics software they may be less familiar with, such as graphing packages, LOGO and dynamic geometry software. Our PGCE course also focuses on matters relating to teaching and learning mathematics, and pedagogy in particular. However, because the PGCE course is short and intensive, we are in a situation in which we need to work with pre-service teachers in developing their skills in teaching effectively with ICT often before they have sufficient depth of understanding of effective pedagogical approaches for mathematics learning to do so. It is therefore necessary to consider the relationships between pedagogy, technology and mathematics in order to develop these ideas further.

## Theoretical Framework

In Shulman's (1986) well-known model, Content Knowledge (C) and Pedagogical Knowledge (P) are depicted as overlapping circles, where the intersection is a new type of knowledge specific to subject teaching called Pedagogical Content Knowledge. Mishra and Koehler (2006) develop this model further by including a third circle labelled Technology Knowledge (T) and, overlapping this with Shulman's circles to form new categories of knowledge called Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK) and, where all three circles overlap, Technological Pedagogical Content Knowledge (TPCK). These are illustrated visually in Figure 1:

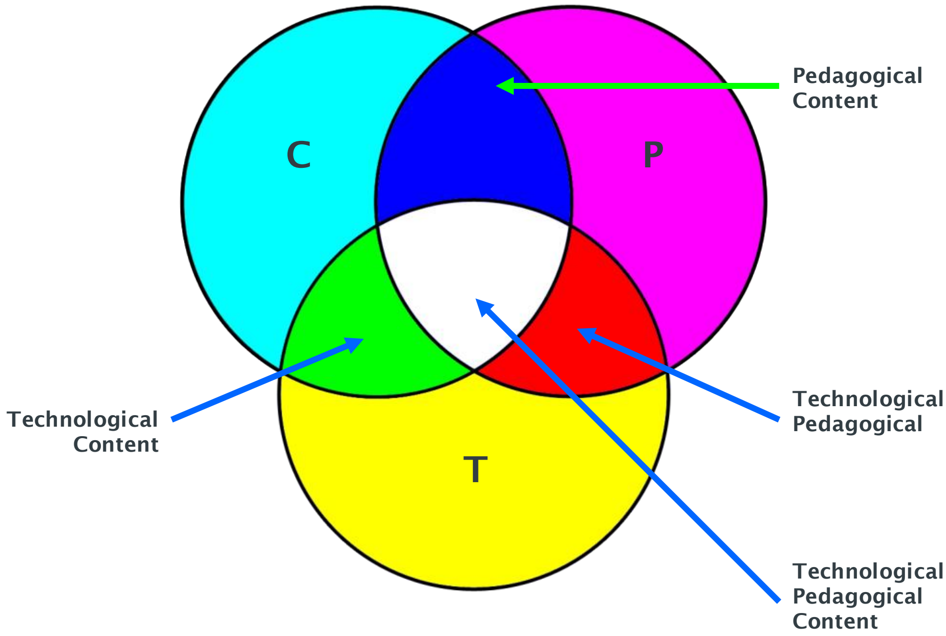


Figure 1: Mishra and Koehler's (2006) framework for Technological Pedagogical Content Knowledge

The need to add Technology Knowledge to Shulman's model is justified by Mishra and Koehler on the grounds of both the current rate of change of technology and the impact it has on both content and pedagogy. Technology Knowledge is seen by them as encompassing generic technology skills, TCK is about the manner in which subject knowledge is changed by the application of technology and TPK refers to knowledge about generic pedagogy for technology. Mishra and Koehler (2006, 1039) describe TPCK as "…the basis of all good teaching with technology" and that "…developing good content requires a thoughtful interweaving of all three key sources of knowledge: technology, pedagogy and content" (ibid).

## Research methods

Our research study was designed to analyse and develop our pre-service teachers' access to pedagogical practice supporting effective use of ICT for teaching and learning mathematics, and to address possible inequities in provision in practical use of ICT whilst on school placement during the PGCE course.

Data were collected in a number of ways from one cohort of 43 secondary mathematics PGCE students. These students undertook the usual course practice of an ICT audit at the beginning, middle and end of their PGCE year. A random sample of these students were selected to take part in focus groups at the end of their course and data were also collected through focus groups drawn from the previous year's cohort and from a team of 'expert' teachers involved in the project. Analysis is presented here of data drawn from the audits pre-service teachers undertook of their personal competence and classroom competence with a range of content-free mathematics software as well as analyses of responses to the free-writing question on the audit "Describe how you think ICT improves the teaching and learning of mathematics".

## Findings

In Mishra and Koehler's (2006) terms, the audit section recording personal confidence with ICT tools can be considered a measure of part of a pre-service teacher's Technology Knowledge. In analysing the pre-service teachers' self-reported level of personal competence with ICT, values from 0 to 5 were allocated to responses given by participants on a scale from never having used the software to very confident in its use for spreadsheets, data handling packages, graph plotting packages and dynamic geometry software. Totalling the reported confidence scores gave a personal score with a maximum of 20 for each pre-service teacher. In Figure 2, the scores reported at the start of the course in September are compared with the scores reported as the course ended the following June.

It is notable that the initial total scores show a confidence range of 17 and that the end-of-course total scores record a confidence range of 7, with the majority of pre-service teachers reporting very high levels of personal confidence with ICT at the end of the course. One might, therefore, suggest that there has been a gain in the Technology Knowledge of our pre-service teachers whilst on the course.

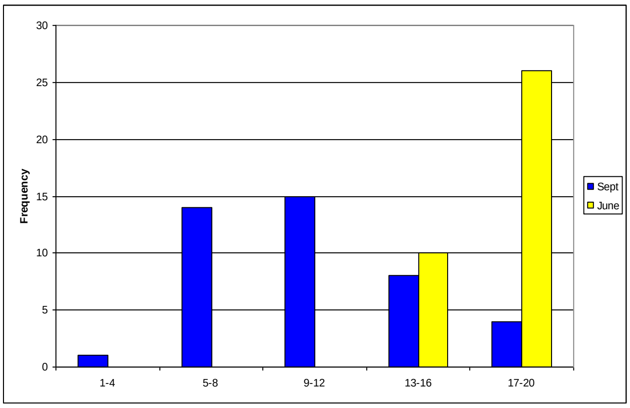


Figure 2: Personal confidence score.

Technical competence and some level of confidence are clearly only part of the necessary knowledge pre-service teachers require in order to make effective use of digital technologies in their teaching. Another part of the audit asked pre-service teachers to record their level of classroom confidence with ICT at the mid-point and end of the PGCE course. The data for classroom confidence (defined on the audit as actual classroom practice with ICT) were totalled in the same way as for the personal confidence scores. Figure 3 shows this data.

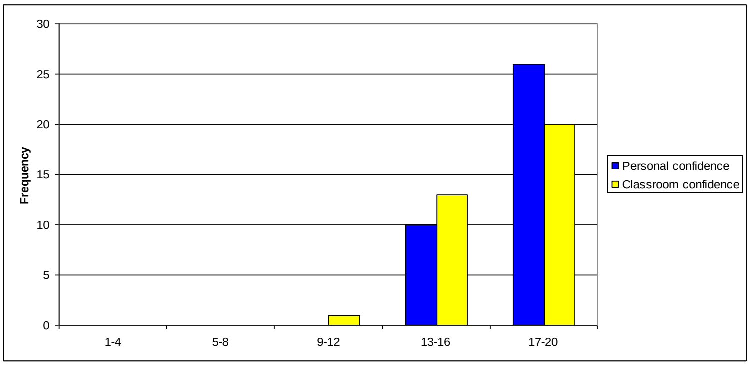


Figure 3: Personal confidence and classroom confidence scores at the end of the PGCE course.

Our analysis shows a very strong positive correlation between pre-service teachers' level of personal confidence with ICT and their confidence in the classroom with ICT. It is interesting to note that classroom confidence scores were almost always the same, or slightly lower, than personal confidence scores. These findings contradict Cuckle, Clarke and Jenkins' (2000) findings that personal competence with computers at the start of their PGCE course was not strongly related to pre-service teachers' use of ICT in classroom teaching. This might be explained, at least in part, by increased access to ICT facilities, particularly the availability of interactive whiteboards, since the Cuckle, Clarke and Jenkins study as well as the focus here on pre-service mathematics teachers rather than pre-service teachers in a range of curriculum subjects.

Such results are perhaps a limited measure of parts of TCK and TPK, but give a little insight into pre-service teachers' pedagogical understandings of effective teaching and learning of mathematics using digital technologies. To learn more, the responses to the free writing question on the audit were analysed at the three audit points in the PGCE course. In this report, only the evidence of Technological Pedagogical Knowledge and Technological Pedagogical Content Knowledge is reported. We found that all pre-service teachers demonstrated some understanding of TPK through their writing for at least one of the audit points. However, the evidence about TPCK showed that some (9 out of the 43 pre-service teachers) were not able to express any understanding of TPCK at any of the audit points but also that more (16 out of 43) were able to express at least some understanding of TPCK at the beginning of their PGCE course.

## Discussion

Examining the free-writing responses is a task requiring careful interpretation of pre-service teachers' responses, given that articulating pedagogy is challenging for beginning teachers. Part of the rationale for distinguishing between the two categories of TPK and TPCK is the consideration of whether the pedagogic comment referred to a specific use within mathematics teaching or applied more generally to other subject areas. Table 1 gives some examples of responses and their categorisations.

| **Technological Pedagogical Knowledge** | **Technological Pedagogical Content Knowledge** |
|---|---|
| "set myself reminders of points to cover" | "students can use/manipulate large quantities of data" |
| "punctuate a lesson avoiding the need to reference lesson plan" | "using LOGO to create polygons and Autograph to discover rules about straight line graphs" |
| "good for visual learners" | "illustrate changes in variables" |
| "allows quick feedback" | "collect data" |
| "whole class involvement" | "model mathematical situations large scale" |
| "instant and accurate feedback" | |

Table 1: Examples of Technological Pedagogical Knowledge and Technological Pedagogical Content Knowledge as demonstrated by pre-service teachers.

The finding that a number of pre-service teachers can express at least a limited understanding of TPCK at the beginning of their PGCE course was both surprising and encouraging. It demands that we consider how we can build on this early understanding more effectively at the same time as developing the understanding of those who were still unable to express their learning in this area at the end of the PGCE course. It is also possible that there are other factors that affect the development of TPCK, such as the attitudes and beliefs about both mathematics itself and how it is learnt. Importantly, Mishra and Koehler's TPCK framework provides us with what they describe as a "…language to talk about the connections that are present … in conceptualisations of educational technology" (2006, 1044) and therefore a tool for exploring this aspect of our pre-service teachers' learning.

Tracking the learning journeys of pre-service teachers on their route towards a deeper understanding of the use of digital technologies in teaching and learning mathematics is a new line of enquiry, along with considering the affordances and constraints that act on that development. Of particular interest is exploring the sense that pre-service teachers are able to make of their learning experiences using digital technologies, and how they develop into teachers who are able to make pedagogical use of digital technologies in their teaching.

## *References*

Cuckle, P., S. Clarke, and I. Jenkins. 2000. Students' information and communications technology skills and their use during teacher training. *Journal of Information Technology for Teacher Education* 9 (1): 9–22.

Enochsson, A. and C. Rizza. 2009. *ICT in Initial Teacher Training: Research Review.* OECD Education Working Papers No. 38 OECD Publishing.

Mercer, N., S. Hennessey, and P. Warwick. 2010. Using interactive whiteboards to orchestrate classroom dialogue. *Technology, Pedagogy and Education* 19 (2): 195–209.

Miller, D. and D. Glover. 2010. Presentation or mediation: is there a need for 'interactive whiteboard technology-proficient' teachers in secondary mathematics? *Technology, Pedagogy and Education* 19(2): 253–259.

Minaidi, A. and G. H Hplanas. 2005. Pedagogical obstacles in teacher training in information and communication technology. *Technology, Pedagogy and Education* 14 (2): 241-254.

Mishra, P. and M. Koehler. 2006. Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record* 108 (6): 1017–1054.

Qualifications and Curriculum Authority. 2007. The *National Curriculum: Statutory requirements for key stages 3 and 4.* London: QCA.

Shulman, L. 1986. Those who understand: Knowledge growth in teaching. *Educational Researcher* 15: 4–14.