Changes in Teachers' Perceptions of Technology in Mathematics

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Teachers' perceptions of technology in mathematics were measured with a questionnaire administered immediately before, and after, a programme of professional development targeted at encouraging the use of technology in mathematics. Thirty teachers commenced the programme in July, 2002. Over a five month period, significant positive changes were found in teachers' (a) access and use of technology in mathematics teaching and learning; (b) confidence in using technology, and (c) attitudes and beliefs about the role and value of technology in mathematics.

Technology has had a significant impact on teaching and learning in schools (Cuttance, 2001), with its importance in facilitating the teaching and learning of mathematics recognised by the mathematics education community (Chinnappan & Thomas, 2000), curriculum authorities and professional bodies (Australian Association of Mathematics Teachers, 1996; Australian Education Council, 1991; National Council for Teachers of Mathematics, 1989; 1991). Two decades of research on the effects of Information Communication Technologies (ICT) have produced equivocal results for general student learning outcomes (Cuttance, 2001) as well as for mathematics (Lesmeister, 1997; Maldonado, 1998; Penglase & Arnold, 1996), although Yelland (2001) questions the latter conclusion. Technology has been shown to be effective in teaching basic mathematics skills (Parr, 2000), with the strongest evidence to date supporting the use of computer-based technology in mathematics for upper primary and high school students (Goos, Galbraith, Renshaw & Geige, 2000; Penglase & Arnold, 1996; Portafoglio, 1998; Roschelle, Pea, Hoadley, Gordin & Means, 2000; Weber, 1999). Technology, particularly graphic calculators, is changing the face of high stakes examinations at senior secondary levels (Jones & McCrae, 1996).

Reviews of several research projects have substantiated the potential of educational technology to enhance learning environments (Sivin-Kachala & Bialo, 1994) and improve student learning outcomes (Hativa & Becker, 1994) through active student engagement, collaborative learning, frequent and immediate feedback and real-world contexts for learning (Roschelle, Pea, Hoadley, Gordin & Means, 2000). In addition, ICT enhances higher order thinking (Educational Testing Service, 1989), and impacts on student attitudes, motivation, self esteem, social competencies and enjoyment of learning (Joiner, 1996: Rowe, 1993: Tiernay, 1996; Wellburn, 1996). However, the extent to which ICT facilitates higher order thinking in mathematics is dependent in part on upon the adequacy of teachers' skills and knowledge (Wenglinsky, 1998). The task confronting mathematics educators now is not only:

> how technology can enhance (or impede) mathematics learning, and how technology changes priorities for mathematics content, bur also how technology changes the way mathematics is expected to be performed" (Steen, 2000, p 2).

The potential of ICT to transform education can only be realised when teachers have the knowledge they need to incorporate technology into the curriculum (Schofield, 1995).

This cannot be achieved by short inservice programmes (Zhao, Pugh, Sheldon & Byers, 2002). Teachers need long-term professional development to adapt and infuse curricula with technology (Wetzel, 2001a, 2001b; Wetzel, Zambo, Buss & Pagett, 2001). They also need opportunities to reflect upon their attitudes towards computer technologies and to clarify their preferred instructional strategies (Zhao, Pugh, Sheldon & Byers, 2002). Changes in attitudes or beliefs over intervention periods as short as one semester are difficult to detect (Schuck, 1996; Roberts, Cretchley & Harman, 1998). Teacher transition to a positive view of computers in mathematics education takes time (Thomas, Tyrrell, & Bullock, 1996). Surveys consistently show that while teachers express interest in technology, they lack opportunities to develop their capacities (Cradler, Freeman, Cradler & NcNabb, 2002). The National Education Performance Monitoring Taskforce (MCEETYA, 2000) found teacher skills and knowledge of ICT to be low, prompting the development of an ICT competency framework for all teachers (DEST, 2002).

However, teacher knowledge and experience with computers does not of itself guarantee teachers will make use of them in the mathematics classroom (Thomas, Tyrrell, & Bullock, 1996). While computers are available in most schools and most have internet connections, they are under-utilised (Cuban, 2001; DEST, 2002; Moersch, 1995; O'Neil 1995; Smith, 2000). Thomas, Tyrrell, & Bullock (1996) found that merely placing a computer in the classroom did not result in changes to the teaching and learning of mathematics. Teachers need to be given the opportunity and provided with support to transform their mathematics teaching and learning environments (Yelland, 2001). Even when teachers have access to computers in school, the need for professional development of teachers is critical to their successful implementation (Yelland, 2001). It is essential for teachers to be confident and competent to use software that is available to them in an integrated way and they should be supported in doing so (Yelland, 2001).

Increased confidence can be gained through appropriate programmes of professional development (Dewar & Bennie, 1996; Hollingsworth, 1996; Renyi, 1998; Zeegers, 1994). In addition, PD programmes have been shown to provide many other direct personal benefits to teachers including improved teaching practices (Hollingsworth, 1996; Renyi, 1998; Zeegers, 1994), increased awareness of how children learn best and how to cater for this (Dewar & Bennie, 1996; Renyi, 1998; Zeegers, 1994), increased awareness of available resources (Dewar & Bennie, 1996; Renyi, 1998), opportunities to reflect, plan, organise, experiment and practise new skills (Stanley, 1995; Zeegers, 1994) and an in-depth understanding of the use of technology in teaching and learning (Stanley, 1995).

In the editorial of the Special Issue of the *Mathematic Education Research Journal, 12,* (3) focussing on Technology in Mathematics Learning and Teaching, Chinnappan & Thomas (2000) highlighted concerns by mathematics educators and teachers about issues and problems associated with employing technology in mathematics classrooms. These concerns have been echoed more generally by the Commonwealth Department of Education, Science and Training (DEST) who commissioned a study of the role of professional development programmes in developing teacher skill and knowledge of ICT. The resultant report, published in 2001, identified the need for continuing professional development (PD) for teachers, based on known principles of effective teacher development. These principles, promulgated by the Centre for Educational Research and

Innovation (CERI, 1998) include experiential, inquiry and reflection based methodologies that engage teachers in concrete tasks and research connected to and derived from their work with students (Hawley & Valli, 1999). PD should also be collaborative, interactional, involve a sharing of knowledge and connected to a comprehensive change process (Hawley & Valli, 1999). Moreover, PD needs to be sustained, intensive and ongoing (Darling-Hammond, 1998), supported by modelling, coaching and collective problem solving around specific problems of practice.

The Present Study

Context of the study

In Term 1, 2002, a programme of professional development targeted specifically at encouraging and enhancing the use of technology in mathematics teaching and learning, was offered to teachers in South Australia. This program arose in part from a strategic plan for mathematics educators to develop shared understanding of mathematics and the role of technologies in mathematics teaching and learning practice for all school students. Technology was considered to embrace Information Communication Technologies and was defined as the use of calculators, computers and the internet in mathematics. The programme of professional development was designed to incorporate the CERI (1998) principles, but also included an evaluative process, to measure changes in teachers' perceptions of technology in mathematics. From July to November, 2002, fifteen pairs of teachers in fifteen schools undertook a wide variety of action research projects within their schools, each of which had a common focus of using some aspect of technology within their mathematics teaching. Evaluation of teachers' perceptions about technology in mathematics, measured by a questionnaire, took place immediately prior to (Time 1) (T1) and following the conduct of the projects (Time 2) (T2).

Purpose of the study

The study was designed to evaluate changes in teachers' perceptions of technology in mathematics following a programme of professional development.

The specific aims of the study were to evaluate changes in:

1. teacher and student access to and use of technology in mathematics classrooms;
2. teachers' beliefs and attitudes about technology in mathematics; and
3. teachers' confidence about using technology in general.

Method

Participants

Fifteen pairs of teachers in 5 Junior Primary, 5 Primary and 5 Lower Secondary schools in South Australia participated in the evaluation at T1, with 23 of these present at T2. Table 1 presents participants by gender, decade of birth and teaching experience at T1 and T2.

Table 1

Participants by Gender, Decade of Birth and Teaching Experience at T1 and T2

Gender	N at T1/T2	Birth Decade	N at T1/T2	Tch. Experience	N at T1/T2
Male	9/7	1940s	3/1	1 to 10 years	5/3
Female	20/16	1950s	16/14	11 to 20 years	9/5
Unknown	1/0	1960s	6/5	21 to 30 years	12/12
Total	30/23	1970s	5/3	30 years +	4/3

The Using Technology in Mathematics Questionnaire

The *Using Technology in Mathematics* (UTIM) (Yates & Harris, 2002) questionnaire comprised 48 items. A five point Likert scale was used from: 1 *Strongly Disagree*, 2 *Disagree*, 3 *Neither agree or disagree*, 4 *Agree,* to 5 *Strongly Agree*. Two additional items were open ended. Thirty-five of the items were adapted for this study from the *Attitudes to Technology in Mathematics Learning Questionnaire* (Fogarty, Cretchley, Harman, Ellerton & Konki, 2001). However, the UTIM is a new scale as the items were devised for the purposes of evaluating changes in teachers' perceptions. Ten items addressed teacher and student access to and use of computers for mathematics in their respective schools. Eleven of the items measured teachers' beliefs and attitudes about the role and value of technology in mathematics. Fourteen items tapped their confidence about using technology in general.

Ten additional items were included in the UTIM to gauge the climate of the school in which each teacher pair was working, in terms of participatory decision-making and innovation about technology. Teacher knowledge about South Australian curriculum frameworks was addressed briefly in three items. Finally, the two open-ended items gave teachers opportunities to express their personal views on the role of technology in student mathematics teaching and learning and the implications of the rapid changes in technology for the teaching of mathematics. These latter items measuring school climate and curriculum frameworks and the open-ended questions are not considered in this paper.

Procedure

All participant teachers completed the UTIM on 1 July, 2002, prior to the commencement of their projects (T1) and again on 18 November, 2002 at their conclusion (T2). Data from the 48 rating items were entered into SPSS, with teachers matched on both occasions through their unique ID.

Results

The questionnaire had been designed with three factors in mind, and these were confirmed using Principal components factor analysis followed by Oblimin rotation. Of the 10 possible items, 9 were used to define access and use of technology in maths teaching (yielding an alpha coefficient of 0.83). Ten of the 11 envisaged items were used to define the second factor, belief and attitudes about technology in maths (alpha 0.76). Teachers' confidence in using technology was measured by using all 14 of the available items (alpha 0.91). Thus, analyses were able to proceed on the basis of deriving scores for each of these three aspects. Differences between these three variables from T1 to T2 were investigated with repeated measures ANOVA (see Table 2).

Table 2
Changes in Dependent Variables Between Time 1 and Time 2 Expressed as Means and Standard Deviations

Variable	Time 1	Time 2	*F* (1,23)	*p*
Access and use of ICT in maths	33.3 (4.7)	36.7 (4.8)	14.5	0.001
Belief about ICT in mathematics	35.6 (3.7)	37.9 (2.8)	11.8	0.003
Confidence in using ICT	57.0 (8.2)	60.0 (6.4)	9.0	0.007

The means, as reported in Table 2, refer to the raw scores on the scales scored in the positive direction. Thus, significant positive change on each of the three dependent variables was found. The extent of change was also indexed by noting the percentage of teachers who responded at a level of 80% or higher on the scales (see Figure 1). In this Figure the level of 80% was used simply as an arbitrary 'cut-off' point in order to classify teachers responding at this high level of agreement. Thus, in June, 2002 only 5% of teachers reported high levels of professional use and access to IT in their mathematics teaching, but by November, the corresponding figure had increased to 32%. Similarly, 38% of teachers held positive attitudes towards technology in mathematics at Time1 but this had increased to 67% at T2. While 52% of teachers reported being confident about using technology prior to the commencement of their programme of professional development, this had increased to 78% after the completion of their action research projects at Time 2.

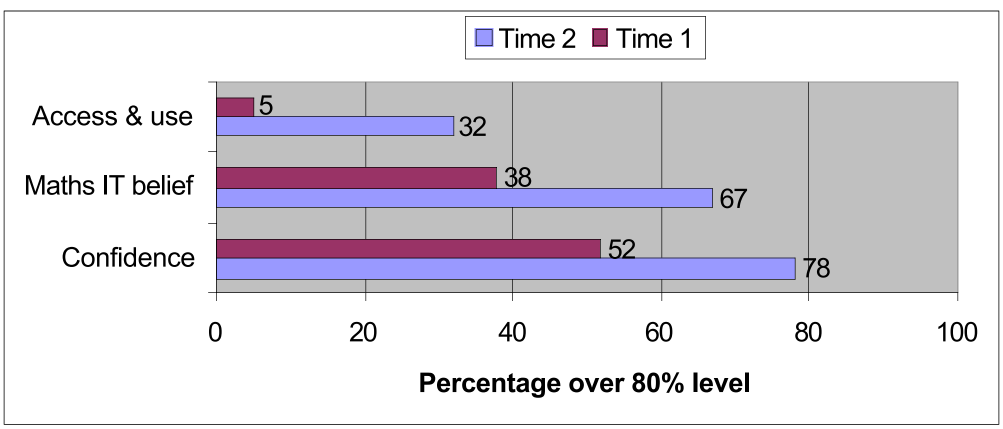

Figure 1. Percentage of teachers indicating highly positive scores of 80% or over on the raw scale measures.

Discussion

The present study focussed on teachers' perceptions of technology and compared differences between their ratings on a questionnaire administered immediately prior to and following a programme of professional development targeted specifically at encouraging and enhancing their use of technology in mathematics. Significant positive changes were found in the access and use of computers for mathematics by the participant teachers and students in their respective schools, the teachers' beliefs and attitudes about the role and value of technology in the teaching and learning of mathematics and teachers' confidence about using technology in general. In particular, the UTIM questionnaire was sensitive to changes in teachers' perceptions of technology in mathematics, and provided a mechanism for the teachers to report on the impact and value of their PD experiences.

These positive findings support previous studies pertaining to the necessity for PD if teachers are to be able to incorporate technology successfully in their mathematics teaching and learning (see Yelland, 2001) as well as the benefits that accrue to them personally. Previous finding relating to teacher confidence about technology (Dewar & Bennie, 1996; Hollingsworth, 1996; Renyi, 1998; Zeegers, 1994), greater awareness and use of technology resources (Dewar & Bennie, 1996; Renyi, 1998) and positive attitudes towards the role and value of technology in the teaching and learning of mathematics (Stanley, 1995) were clearly evident in this study. The profile of the teachers who participated in the study, as presented in Table 2, would suggest that most of them would have been highly unlikely to have received technology training in their initial preservice education. Thus, the manifest changes in their attitudes, confidence, and use of technology suggest the importance of their PD experiences in providing them with opportunities to explore the incorporation of calculators, computers or the internet into their teaching and learning of mathematics. However, the extent to which these positive changes will be maintained over time has yet to be determined as is the question of whether the teachers will be more likely to use technology in mathematics in the future.

Steen (2000) has asserted that proficiency in professional use of technology is an obligation of education. However, teachers need time and support to incorporate technology into their mathematics teaching (Yelland, 2001). Appropriate and timely PD can not only provide the impetus and imperative for change, but can also provide teachers with opportunities to explore, experiment, develop and practise new skills (Stanley, 1995: Zeegers, 1994). Several principles of effective teacher development need to be taken into account into the planning and conduct of any PD (CERI, 1998; Darling-Hammond, 1998; Hawley & Valli, 1999). However, the findings of this study would also suggest the need for careful evaluations of PD programmes, particularly in relation to teacher attitudes and beliefs (Zhao *et al.,* 2001). It can be difficult to detect changes in attitudes and beliefs in the short-term (Schuck, 1996; Roberts *et al.,* 1998), but immediate or transient emotional reactions may become entrenched as attitudes over time. Thus, relevant measures should be taken at both the commencement and completion of PD programmes, with the effects monitored over both the short and long term. The impact of teacher PD on student learning outcomes should also be considered.

Directions for Further Studies

This study took place over a five-month period and involved a relatively small number of teachers. It would be therefore desirable to administer the UMIT in 2003 to determine whether the significant changes in teachers' beliefs, confidence and use of technology in mathematics are maintained over time. Furthermore, it would be advantageous to measure student learning outcomes in the classrooms in which the teachers' action research projects took place, particularly in relation to higher-order thinking in mathematics (Educational Testing Service, 1989).

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