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THE ROLE OF PROFESSIONAL DEVELOPMENT IN TEACHER RENEWAL IN MATHEMATICS

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Professional development plays a significant role in teacher renewal in mathematics. In this study, 20 primary and 10 lower secondary teachers in 15 South Australian schools undertook a professional development program over five months, to foster the use of technology in the teaching and learning of mathematics. Significant positive changes were found in the teachers' attitudes and beliefs about the role and value of technology in mathematics, access and use of technology in mathematics, and confidence in using technology. This study contributes to knowledge of effective professional development strategies that foster teacher renewal in mathematics teaching and learning.

Teacher renewal is a precondition for school renewal (Ingvarson, 1997), with the classroom recognized as the epicenter of educational change (Buchanan & Khamis, 1999). In order to enact change in their classrooms, teachers must not only take ownership of change (Hargreaves, 1994; Joyce & Showers, 1988) but also challenge their prevailing attitudes, beliefs and practices (Sirotnik, 1999; Soder, 1999). It is widely recognized that the teachers' personal beliefs and theories play a central role in their teaching practices (Bullough, 1997; Clark & Peterson, 1986; Ethell, 1997; Handal & Herrington, 2003; Kagan, 1992a; Pajares, 1992; Richardson, 1996; Trumbull, 1990) and implementation of curriculum reform (Handal & Herrington, 2003). It is less clear whether their beliefs influence instructional behaviour or whether instructional practice influences teacher beliefs (Buzeika, 1996; McGalliard, 1983). What is clear however is that teacher beliefs are robust, resistant to change (Block & Hazelip, 1995; Clark, 1998; Kagan, 1992b; Richardson, 1996), serve as filters for new knowledge (Nespor, 1987; Pajares, 1992; Weinstein, 1990) and act as barriers to changes in teaching practices (Fullan & Stegelbauer, 1991; Handal & Herrington, 2003). Educational change takes place slowly over time (Louden & Wallace, 1996; Boston, 1997; Eltis & Mowbray, 1997) and must be supported by appropriate Professional Development (PD) which has a significant role in teacher renewal.

Mathematics education is replete with examples of failed innovation and curriculum reform (Handal & Herrington, 2003), caused mainly by a failure to take teacher beliefs and pedagogical knowledge into account (Knapp & Peterson, 1995). These same factors seem to be partially responsible for the current underutilisation of Information Communication Technology (ICT) in mathematics teaching and learning (Clarkson, Dunbar & Toomey, 1999; Cuban, 2001; DEST, 2002; Forgasz & Prince, 2001; Moersch, 1995; National Center for Educational Statistics, 2000; O'Neil, 1995; Smith, 2000), although lack of teacher confidence, technological knowledge and skill development in ICT are also significant factors (Schofield, 1995). Lack of computer knowledge and skill is particularly evident in female teachers at the primary school level (Meredyth, Russell, Blackwood, Thomas & Wise, 1999). Teacher beliefs about teaching and learning mathematics are intertwined with their beliefs about the efficacy and usefulness of computers in mathematics classrooms (Banturo, McRobbie, Cooper & Kidman, 1999; Forgasz & Prince, 2001; McInerney, McInernery & Sinclair, 1994; Norton, 1999; Russell & Bradley, 1997). For many teachers the use of ICT in mathematics involves shifting from traditional transmission views of mathematics pedagogy (National Research Council, 1989; Howard, Perry & Lindsay, 1997; Perry, Howard & Conroy, 1996; Perry, Howard & Tracy, 1999) to more child-centred views (Anderson, 1996; Perry *et al.,* 1999). PD for ICT in mathematics thus has a dual role of providing opportunities for teachers to become familiar with ICT (Goos, Galbraith, Renshaw & Geiger, 2000; Penglase & Arnold, 1996), and helping them to adapt and infuse ICT into the curriculum (Wetzel, 2001; Wetzel, Zambo, Buss & Padgett, 2001). As part of this process, teachers must be given time to reflect on their attitudes and beliefs towards ICT in mathematics and to clarify their preferred instructional strategies (Zhao, Pugh, Sheldon & Byers, 2001).

Characteristics of good PD for teacher renewal are recognised widely (Lovett & Gilmore, 2003). Table 1 presents several recommendations for effective PD promulgated by the Center for Educational Research and Innovation (CERI, 1998), which parallels research findings of effective PD strategies for the development of teacher knowledge, skill and confidence in classroom ICT use.

Table 1 Recommendations and research findings of effective PD

Effective PD: (CERI, 1998)	Research findings of effective PD for use of ICT in classrooms
Sustained, intensive and ongoing (Darling-Hammond, 1998).	Intensive, ongoing PD (Roschelle, Pea, Hoadley, Gordin & Means, 2000; Toomey, 2001; Wetzel, 2001; Wetzel *et al.*, 2001). Considerable time for collaborative learning and practise for teachers to be confident ICT users (Cradler & Cradler, 1995; Coley, Cradler & Engel, 1997; OTA, 1995).
Experiential, engaging teachers in concrete tasks	Teachers need ready access to ICT when planning and flexible timetabling for learning to use ICT at school (Honey & McMillan, 1996).
Participant driven. Grounded in inquiry, reflection, experimentation.	Teachers need time and opportunities to (1) reflect on attitudes towards ICT (Thomas, Tyrrell & Bullock, 1996) (2) clarify preferred instructional strategies (Zhao *et al.*, 2002).
Collaborative, interactional, involve sharing knowledge inside & outside the setting (Hawley & Valli, 1999)	Frequency, breadth and depth of colleague collaboration influences instructional context and quality of technology use (Becker & Riel, 2000). Collaboration and professional association participation beneficial (Becker & Riel, 2000).
Supported by modelling, coaching, collective problem solving around specific problems of practice.	PD needs to provide opportunities for modelling, practice and reinforcement of ICT use (Roschelle *et al.*, 2000). Use of mentors to help teachers adapt ICT applications to classroom (Zhao *et al.*, 2002).
Connected to and derived from teachers' work with students (Hawley & Valli, 1999).	ICT PD must be linked to curriculum goals and objectives from the outset (Roschelle *et al.*, 2000). Opportunities for teachers to develop computer skills correlated with enhanced student achievement (Mann, Shakeshaft, Becker & Kortkamp, 1999).

PD can also provide direct personal benefits to teachers including increased confidence (Dewar & Bennie, 1996; Hollingsworth, 1996; Renyi, 1998; Zeegers, 1994), opportunities to reflect, plan, organise, experiment and practice new skills (Stanley, 1995; Zeegers, 1994), improved pedagogy (Hollingsworth, 1996; Renyi, 1998; Zeegers, 1994), greater awareness of available resources (Dewar & Bennie, 1996; Renyi, 1998), enhanced awareness of how students learn best and how to cater for them (Dewar & Bennie, 1996; Renyi, 1998; Zeegers, 1994), and an in-depth understanding of the use of ICT in teaching and learning (Stanley, 1995). Such benefits are crucial if teachers are to transform their mathematics teaching and learning environments (Yelland, 2001).

While the need for teacher renewal in mathematics through PD remains a critical issue (Cuban, 2001; Wetzel, 2001, Wetzel *et al.*, 2001) there is very little formal research on the differential effects of specific PD strategies on changes in teaching and learning (Cradler, Freeman, Cradler, & McNabb, 2002). In particular, research on "leading practice PD activities involving the use of ICT that impact best on teachers and schools" (Toomey, 2001 p.4) is needed.

The Present Study

The study was designed to foster teacher renewal through a PD program focused on the use of ICT in mathematics and incorporating the CERI (1998) principles and PD for ICT research findings (see

Table 1). For the purposes of the study, ICT was defined as the use of calculators, computers and the Internet in mathematics teaching and learning. Pairs of teachers in 15 South Australian schools, selected on the basis of a written proposal from their respective school, undertook a variety of action research projects during 2002, each of which had a common focus of using ICT within the teaching and learning of mathematics. Funding was provided to each project for the procurement of ICT equipment, software and/or expertise, such that each teacher pair was provided with PD that was meaningful, timely, relevant and delivered onsite. Teachers' attitudes, beliefs, confidence and use of ICT in mathematics were evaluated with the *Using Technology in Mathematics* questionnaire (UTIM) (Yates & Harris, 2002*)* immediately before (Time 1) (T1) and after the PD (Time 2) (T2).

Aims

The aims of the study were to:

1 foster teacher renewal in mathematics teaching and learning through effective PD; and

2 investigate changes in teachers' attitudes, beliefs, confidence and use of ICT in mathematics brought about by the PD program.

Method

Fifteen pairs of teachers in 5 Junior Primary, 5 Primary and 5 Lower Secondary schools in South Australia participated. Ten teachers were male, 20 were female. Twenty-five of the teachers had been teaching for more than 10 years.

The PD commenced with a one-day conference at which the 30 teachers were administered the UTIM (Yates & Harris, 2002*)* and introduced to a seven-stage action research cycle presented in Table 2 (adapted from Burns, 1990). Teachers worked in pairs to plan an action research project to be carried out in their school. Six weeks after the one-day conference each teacher pair submitted a detailed *Site Action Plan* which specified the focus of their action research and incorporated considerations of Stages 1 - 5 of the action research cycle. Practical considerations of strategies, timelines and outcomes in relation to the focus areas of collaboration and communication, personal learning, professional development, materials development and student learning were addressed.

Table 2: Undertaking Action Research

Stage	**Action Research Cycle Procedures** (adapted from Burns, 1990)
Stage 1	Identify, evaluate and formulate problem
Stage 2	Fact finding to describe fully situation or problem under inquiry
Stage 3	Review relevant research literature
Stage 4	Collect additional preliminary information
Stage 5	Determine actual research procedures - resources, materials, people involved, data recording, time
Stage 6	Implement action research plan. Record data systematically
Stage 7	Interpret data and prepare report

Stage 6 commenced once the project coordinators approved each *Site Action Plan*. At this stage, each teacher pair purchased equipment and/or engaged ICT expert mentors, chosen primarily from a list complied by the project coordinators, to assist them in the enactment of their research project.

During Stages 6 and 7 teachers were visited onsite by the project coordinators who provided practical advice, encouragement and assistance. In some instances project coordinators facilitated informal contact between teacher pairs working on similar action research projects. Projects concluded five months later with a second one-day conference at which all participants completed the UTIM (Yates & Harris, 2002; 2003) and each teacher pair shared their findings with the total group. Written project reports were published on a CD, distributed to the 15 participating schools.

Results

Significant positive change was found with repeated measures ANOVA (see Table 3) between the teacher beliefs and attitudes about ICT in mathematics, access and use of technology in maths and teacher confidence in using ICT variables (Yates, 2003) measured by the UTIM (Yates & Harris, 2002*)* at T1 and T2. Means in Table 3 refers to raw scores scored in the positive direction.

Table 3 Changes in dependent variables between Time 1 and Time 2

Variable	Time 1	Time 2	*F* (1,23)	*p*
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
Access and use of ICT in maths	33.3 (4.7)	36.7 (4.8)	14.5	0.001

The extent of change was also indexed by noting the percentage of teachers who responded at a level of 80% or higher on each variable (see Figure 1). The 80% level was used as an arbitrary 'cut-off' point to classify teachers responding at a high level of agreement. Thus, at T1 only 38% of teachers held positive attitudes towards ICT in mathematics at T1, which increased to 67% at T2. Similarly, 5% of teachers reported high levels of access and use of ICT in their mathematics teaching, but by T2 this had increased to 32%. While 52% of teachers reported being confident about using ICT prior to their PD program at T1, this increased to 78% at T2.

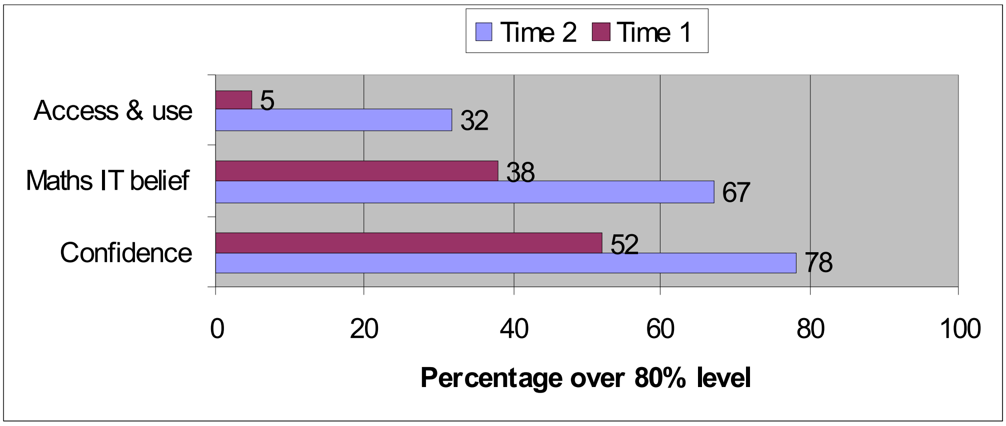

Figure 1. Percentage of teachers indicating highly positive scores of 80% or over

Discussion

Significant positive changes in teachers' attitudes, confidence and use of ICT, measured from T1 to T2 by the UTIM (Yates & Harris, 2002), indicate the success of the PD program in fostering teacher renewal in mathematics teaching and learning. These findings support the essential role of PD (Cuban, 2001; Wetzel, 2001; Wetzel *et al.*, 2001) in encouraging teachers to incorporate ICT in mathematics (National Council of Teachers of Mathematics, 1989) as well as demonstrating benefits that accrue to teachers personally. Previous evidence relating to teacher confidence with ICT (Cradler & Cradler, 1995; Coley *et al.*, 1997; OTA, 1995), greater awareness and use of resources (Dewar & Bennie, 1996; Renyi, 1998) and positive attitudes towards the role and value of ICT in mathematics (Stanley, 1995) was also supported by this study.

Appropriate and timely PD can not only provide the impetus and imperative for teacher renewal and change, but can also provide teachers with opportunities to explore, experiment, develop and practise new skills (Stanley, 1995: Zeegers, 1994). The PD program reinforced several of the principles of effective PD (CERI, 1998) and associated ICT research findings presented in Table 1. The PD took place over an extended period of time (Coley *et al.*, 1997; Cradler & Cradler, 1995; Darling-Hammond, 1998; OTA, 1995; Roschelle *et al.*, 2000; Toomey, 2001; Wetzel, 2001; Wetzel *et al.*, 2001), giving teachers opportunities to reflect on their beliefs and methodologies, try out new ideas and become confident (Thomas, Tyrrell, & Bullock, 1996; Zhao *et al.*, 2002). Collegiality and collaboration (CERI, 1998) were features from the outset, with teachers working in pairs, with project coordinators (Hawley & Valli, 1999; Becker & Riel, 2000) and mentors (Zhao *et al.*, 2002).

Coordinators and mentors provided timely modelling, guided practice (Roschelle *et al.*, 2000), and practical support (CERI, 1998) in teachers' own schools and classrooms. The PD was participant driven and experientially based (CERI, 1998; Honey & McMillan, 1996), with teachers' action research focused on their specific problems and related directly to their work with students (Hawley & Valli, 1999). Project findings were shared (Hawley & Valli, 1999; Becker & Riel, 2000).

The PD program also had some additional notable features. The research problem to be addressed was specified, there was a written plan of action which addressed the seven stages outlined in Table 2, funding was associated with completion of the requisite stages and teachers' work was legitimised through conference presentations, written reports and published CD. These effective strategies contribute to current knowledge about leading PD practices for teacher renewal in mathematics (Cradler *et al.*, 2002; Toomey, 2001).

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