# ELEMENTARY TEACHERS' MATHEMATICS BELIEFS AND TEACHING PRACTICES AFTER A CURRICULUM REFORM

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*Beliefs about mathematics, mathematics teaching and learning, teaching practices and curriculum reform experiences were surveyed in 127 experienced elementary classroom teachers in 21 schools in Term 4, 2005. All teachers had been required to enact a constructivist approach to mathematics teaching since 2001, with classroom use of Information and Communication Technologies promoted. Teachers' espoused beliefs about mathematics were unrelated to their beliefs about mathematics teaching and learning. Furthermore, teachers' beliefs differed, with those with stronger beliefs making greater use some constructivist teaching practices. Teachers experiencing a high number of reforms utilised computers and the internet more often in lessons and sought constructive information about student mathematics learning more frequently.*

It is widely recognised that teachers' personal beliefs and theories about mathematics and the teaching and learning of mathematics play a central role in their teaching practices (Handal & Herrington, 2003; Kagan, 1992; Pajares, 1992) and implementation of curriculum reform (Handal & Herrington, 2003). It is unclear whether teachers' beliefs influence instructional behaviour or whether their practices influence their beliefs (Buzeika, 1996). What is clear however is that teacher beliefs are robust (Pajares, 1992), resistant to change (Block & Hazelip, 1995; Kagan, 1992), serve as filters for new knowledge (Nespor, 1987; Pajares, 1992) and act as barriers to changes in teaching practices (Fullan & Stegelbauer, 1991). Furthermore, teachers' beliefs can either facilitate or inhibit curriculum reform (Burkhardt, Fraser & Ridgway, 1990; Koehler & Grouws, 1992; Sosniak, Ethington & Varelas, 1991).

Failure in curriculum reform in mathematics is a significant problem worldwide. Teachers hold the key to reform in mathematics education (Battista, 1994), with a lack of congruence between curriculum innovation intent and teachers' pedagogical knowledge, beliefs and practises the most cited reason for the poor history of reform in mathematics. Cuban (1993) describes this as a mismatch between the official curriculum prescribed by policy makers and the actual curriculum taught by teachers in classrooms, a phenomenon demonstrated in mathematics through case studies in several countries (Brew, Rowley & Leder, 1996; Buzeika, 1996; Konting, 1998; Sowell & Zambo, 1997). Most mathematics education reforms have been introduced by education authorities through a top-down approach (Kyeleve & Williams, 1996; Moon, 1986) which ignores teachers' beliefs and pedagogical practices and the changes which would be necessary for them to be able to embrace the innovation (Norton, McRobbie & Cooper, 2002; Perry, Howard & Tracey, 1999).

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In elementary schools all teachers are required to teach mathematics, but most are ill-prepared for the task (Battista, 1994). Most experienced elementary teachers have not acquired a deep understanding of mathematics (Gregg, 1995), as they are products of the traditional mathematics-as-computation view of teaching in which mathematics was regarded as a transmitted set of facts and procedures. For curriculum reform to be successful teachers must challenge their prevailing attitudes and beliefs about the nature of mathematics (Sirotnik, 1999; Soder, 1999) rather than simply making cosmetic changes to their practices (Fullan, 1993). More recent reforms however, also require teachers to broaden their mathematical knowledge and competencies (Battista, 1994). This is particularly evident for the incorporation of Information and Communication Technologies (ICT) into the teaching and learning of mathematics which requires teachers to shift from traditional transmission views of mathematics pedagogy (National Research Council, 1989; Perry, Howard & Conroy, 1996;) to more child-centred constructivist views (Perry *et al.*, 1999).

## THE PRESENT STUDY

This study took place in elementary schools operated by the Department of Education and Children's Services (DECS) which introduced a *South Australian Curriculum Standards and Accountability Framework* (SACSA) across all curriculum areas in 2001 and promoted the use of ICT as a strategic direction for mathematics education. SACSA is based on constructivism which *views learning as an active process in which learners construct new ideas or concepts based on their current and past understandings* (DECS, 2001). Teachers selected to participate in this study had 10 or more years of teaching mathematics so had taught mathematics prior to and after the introduction of SACSA. The survey administered to the teachers incorporated a rating scale research instrument developed by Perry *et al.* (1996) to investigate teachers' beliefs about mathematics and the teaching and learning of mathematics, but it also measured their current pedagogical practices in mathematics and their experiences with curriculum reforms in mathematics.

### Aims of the study

This study had four aims:

1 To examine experienced teachers espoused beliefs about mathematics and the teaching and learning of mathematics after the introduction of the SACSA curriculum reform;

2 To investigate experienced teachers current classroom teaching practices in mathematics;

3 To identify the number of curriculum reforms in mathematics that teachers have experienced; and

4 To explore relationships between teachers' espoused beliefs about mathematics and the teaching and learning of mathematics, current classroom practices and reform experiences.

## METHOD

### Participants

One hundred and twenty-seven elementary teachers in 21 DECS schools participated. Sixty-four teachers had a basic teaching qualification, 45 held a Bachelor degree and 18 had postgraduate qualifications. The 29 male and 98 female teachers ranged in age from 30 to 62 years with a median age of 51 years and had been teaching mathematics from 10 to 31+ years with a median range of 26 to 30 years. Teachers had experienced between 2 to 15 curriculum reforms, with a median of 9 reforms.

### The Survey

The survey measured teachers' age, qualifications, years of teaching mathematics, beliefs and practices in mathematics and experiences of curriculum reform. Teachers' years of teaching mathematics were categorised in five yearly increments, with the final increment measuring 31 or more years of teaching. Beliefs about mathematics and the teaching and learning of mathematics were measured on 20 items developed by Perry *et al.* (1996) from various mathematics education reform statements (Australian Education Council, 1991; Mumme & Weissglass, 1991; Wood, Cobb & Yackel, 1992). Each item was rated on a four point scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). Teachers also rated 10 statements about their current mathematics teaching practices in relation to assessment, use of manipulatives, worksheets, textbooks and ICT (calculators, computers and the internet) on a four point scale from 1 (*never used*), 2 (*occasionally used*), 3 (*used once or twice a week*) to 4 (*daily use*). Teachers identified the curriculum reforms in mathematics they had experienced from a list of 15 reforms introduced since the 1960s. These included mathematics education innovations such as Cuisenaire and New Math that had been enacted in many countries and specific DECS reforms such as Statements and Profiles and the SACSA framework initiated across all curriculum areas.

### Procedure

Surveys were distributed to the selected teachers in each school by reply-paid post between October and December, 2005 (the fourth and final school term in 2005).

## RESULTS

Survey data for 127 teachers were entered into an SPSS programme. The 20 belief items (Perry *et al.*, 1996) were analysed with Principal Components Analysis, with the factor loadings shown in Table 1 based on an Oblimin two factor resolution. Factor 1 is composed of 8 items reflecting teachers' constructivist beliefs about the teaching and learning of mathematics and Factor 2 teachers' beliefs about the beauty and meaningfulness of mathematics. The factor scores correlation of 0.11 is not significant. Mean scores in Table 1 are expressed on a 4 point scale from 1 (*strongly disagree*) to 4 (*strongly agree*). These two factors were then used to explore relationships between teachers' espoused beliefs, reported pedagogical practices, and curriculum reform experiences.

| No. | Item | Loading | Mean |
|---|---|---|---|
| *Factor 1: Teachers' constructivist beliefs about mathematics teaching and learning* | | | |
| 13 | Mathematics learning is enhanced by activities which build upon and respect students' experiences | 0.60 | 3.46 |
| 14 | Mathematics learning is enhanced by challenge within a supportive environment | 0.60 | 3.64 |
| 17 | The role of the mathematics teacher is to transmit mathematical knowledge and to verify that learners have received this knowledge (R) | -0.57 | 2.33 |
| 2 | Mathematics problems given to students should be solvable quickly in a few steps (R) | -0.56 | 2.15 |
| 1 | Mathematics is computation (R) | -0.53 | 2.49 |
| 19 | Teachers should negotiate social norms with the students in order to develop a cooperative learning environment in which students can construct their knowledge | 0.53 | 3.23 |
| 10 | Periods of uncertainty, conflict, confusion and surprise are a significant part of the mathematics learning process | 0.53 | 3.18 |
| 18 | Teachers should recognise that what seem like errors and confusions from an adult point of view are students' expressions of their current understanding | 0.51 | 3.20 |
| *Factor 2 Teachers' beliefs about the beauty and meaningfulness of mathematics* | | | |
| 7 | Mathematics knowledge is the result of the learner interpreting and organising the information gained from experiences | 0.65 | 3.24 |
| 3 | Mathematics is the dynamic searching for order and pattern in the learner's environment | 0.58 | 3.29 |
| 5 | Mathematics is a beautiful, creative and useful human endeavour that is both a way of knowing and a way of thinking | 0.55 | 3.09 |
| 8 | Students are rational decision makers capable of determining for themselves what is right and wrong | 0.51 | 2.49 |

Table 1: Factor analysis of teachers' espoused beliefs.

Relationships between teachers' constructivist beliefs about the teaching and learning of mathematics and their reported practices were investigated with analysis of variance (ANOVA), with the results presented in Table 2. Teachers were grouped in relation to Factor 1 by means of a quartile split, with 26 teachers scoring in the upper quartile (Mean = 28.6 out of a possible 32) and 29 teachers scoring in the lower quartile (Mean = 20.9). The ANOVA revealed significant differences between these two groups of teachers in three of the 10 teaching practices measured by the survey (see Table 2).

Significant correlations between teachers' beliefs in the beauty and meaningfulness of mathematics were found for two teaching practices (see Table 3). The negative correlation between Factor 2 and worksheet use indicates that teachers with stronger

beliefs in the beauty and meaningfulness of mathematics used worksheets less frequently while the positive correlation indicates more frequent use of manipulatives.

| Reported teaching practices | High v's low constructivist teacher means |
|---|---|
| Students in my class use manipulatives during maths lessons | 3.24 versus 2.69<br>F (1,53) = 7.1, $p$ = 0.01 |
| I give students worksheets in maths lessons | 2.24 versus 2.58<br>F (1,53) = 4.6, $p$ = 0.04 |
| I use tests to assess student knowledge and understanding of maths | 2.00 versus 2.23<br>F(1,53) = 3.01, $p$ = 0.08 |

Table 2: ANOVA of teacher constructivist beliefs and teaching practices.

| Relationships between teachers' beliefs about mathematics and practices | $r$ |
|---|---|
| Students in my class use manipulatives during maths lessons | 0.22* |
| I give students worksheets in maths lessons | - 0.22* |

*$p$ = 0.05 (2-tailed)

Table 3: Correlations between teachers' beliefs about the beauty and meaningfulness of mathematics and their teaching practices.

The number of curriculum reforms teachers reported having experienced was not related significantly to either their Factor 1 constructivist teaching beliefs or Factor 2 beliefs about the beauty of mathematics. Furthermore, teacher age, qualifications and length of experience in teaching mathematics were not related significantly to Factor 1, Factor 2 or any of the 10 teaching practices measured in the survey. However, the number of reforms experienced was related significantly to four teaching practices (see Table 4). Teachers who scored highly on the number of reforms experienced needed to know what students understood in mathematics more often. They also reported using tests, computers, and the internet more frequently with students.

| Relationship between number of curriculum reforms and teaching practices | $r$ |
|---|---|
| I use tests to assess student knowledge and understanding of maths | 0.18* |
| Students in my class use a computer during maths lessons | 0.20* |
| I need to know what student have understood in maths | 0.18* |
| Students in my class use the internet during maths lessons | 0.18* |

*$p$ = 0.05 (2-tailed)

Table 4: Correlations between reforms experienced by teachers and their practices.

## DISCUSSION

This study took place almost five years after the inauguration of a constructivist curriculum reform and focussed on teachers whose average age would place them firmly as receiving their elementary mathematics education during the rule-based transmission view of mathematics-as-procedures (Battista, 1994) era. Battista paints a

somewhat dismal picture of experienced elementary teachers caught in a *pernicious cycle of mathematical mislearning* (1994, p. 468), whereby their traditional beliefs serve to block their enactment of more recent constructivist innovations. However, this study found teachers' beliefs about mathematics and beliefs about the teaching and learning of mathematics were not related to their age, qualifications or length of teaching experience. Furthermore, their beliefs about the nature of mathematics were unrelated to their beliefs about the teaching and learning of mathematics. Teachers did differ in their beliefs and this was related significantly to some child-centred practices. Teachers holding strong views about the beauty of mathematics and those that scored highly on constructivism used manipulatives more often and worksheets less often in mathematics lessons. The latter group also used tests less frequently.

While the finding that teacher age, qualifications and length of mathematics teaching experience were not significantly related to their teaching practices is somewhat unexpected, the significant relationship between that the sheer number of reforms experienced by teachers and their use of ICT and some assessment practices is of particular interest. Teachers in this study had been teaching mathematics on average from 26 to 30 years and had experienced an average of nine curriculum reforms over that time – this means that on average they had experienced one reform every three years. While some were mathematics education reforms enacted in many countries, others were initiated solely by DECS. The cumulative effects of numerous reform experiences on some teaching practices would suggest a reconsideration of the general consensus that mathematics education innovations have failed (Battista, 1994; Handal & Herrington, 2003). Educational change takes place slowly over time (Eltis & Mowbray, 1997). While reasons why some teachers are more likely to take up reform initiatives remains a fruitful area for future research, it appears that repeated exposure to reform initiatives over time caused some teachers to update their practices. This is evidenced by their significantly greater classroom use of ICT and more frequent need for constructive information about student mathematics learning.

The National Council of Teachers of Mathematics (1999) has asserted collaboration between researchers and teachers is critical if mathematics education research is to be responsive to questions regarding pedagogy and student learning. This study identified some significant relationships between teachers' beliefs, practices and curriculum reforms experiences in mathematics at the elementary level. The survey data gathered should be enriched with written accounts, interviews and observations of teachers' practices and the study extended to include middle school teachers.

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