The "Back to Basics" Dilemma for Middle School Mathematics Teachers

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There is a common belief amongst teachers, particularly in the middle school grades, that students must have a firm foundation in basic skills before they can benefit from more challenging instruction Views about mathematics pedagogy were explored through interviews with fifteen experienced middle school teachers. They were passionate about mathematics but were caught in a "back to basics" dilemma, fuelled by their perceptions of declines in student knowledge and strong beliefs that basic skills can only be mastered through direct instruction, rote learning and repetition and must precede more complex learning. These findings have implications for middle school mathematics pedagogy.

Over the last twenty-five years cognitive psychologists have established a clear relationship between the development of basic computational automaticity and the development of complex mathematical problem solving skills (Tronsky & Royer, 2002). A multiplicity of studies have found that being able to accurately and rapidly produce answers to basic number facts reduces the load on the working memory and "it is this saving that is a key factor in being able to develop more complex problem solving abilities" (Tronsky & Royer, 2002, p. 118). Over the same time frame, mathematics education has emphasised the development of student understanding through exploration and discovery (Elkins, 2002; van Kraayenoord & Elkins, 2004). Unfortunately, a bogus dichotomy of basic skills or conceptual understanding has arisen "from the common misconception that the demand for precision and fluency in the execution of basic skills in school mathematics runs counter to the acquisition of conceptual understanding. The truth is that in mathematics, skills and understandings are completely intertwined" (Wu, 1999, p1). The basic skills versus conceptual understanding debate is most intense at the primary school level (Wu, 1999). Some mathematics educators assert the teaching of standard algorithms are unhelpful and hinder children's development of numerical reasoning (Carpenter, Franke, Jacobs, Fennema & Empson, 1998; Kamii & Dominick, 1998; Mack, 1990) while others take the stance that learning standard algorithms is only harmful if they are not taught properly (Ma, 1999; Wu, 1999). As "the importance of automaticity (in basic computational skills) becomes apparent when it is absent" (Wong & Evans, 2007, p. 91) it is timely to explore experienced teachers' beliefs about in the place and value of basic skills in the teaching and learning of mathematics in the middle school grades.

Understanding the place and value of basic skills is important as practice allows students to achieve automaticity of basic skills in all mathematics content areas (National Mathematics Advisory Panel, 2008). The neglect of such skill acquisition in favour of a conceptual approach results in conceptual understandings which are often superficial (Wu, 1999) but "an exclusive focus on the basics leaves students without the understandings that" enable them to use mathematics effectively (Schoenfeld, 2004, p. 280). Students need to be presented with a balanced curriculum experience (Vincent & Stacey, 2008) but there is a commonly held belief amongst teachers, particularly in the middle school grades, that students must have a firm foundation in basic skills before they can benefit from more challenging instruction (Stein & Lane, 1996). This belief leads teachers to focus on procedural skills in mathematics during the middle school years, particularly when they are

In R. Hunter, B. Bicknell, & T. Burgess (Eds.), *Crossing divides: Proceedings of the 32nd annual conference of the Mathematics Education Research Group of Australasia* (Vol. 2). Palmerston North, NZ: MERGA.

faced with time constraints, to engage in "path smoothing" (Walshaw & Anthony, 2008) and to perform the most demanding parts of tasks for students (Stein & Lane, 1996; Hiebert et al., 2003). However, this "shallow teaching approach" (Stacey, 2003) is not associated with improvements in student performance in basic skills (Schoenfeld, 2004) and does not promote deep student learning (Vincent & Stacey, 2008).

What teachers do in their classrooms has a significant effect on student achievement. A best evidence synthesis of effective programmes in elementary mathematics has found "impressive effects (median effect size = +0.33) for programs that target teachers' instructional behaviors rather than the mathematical content alone" (Slavin & Lake, 2008, p. 481). Further, the review suggests that choice of textbook and curriculum differences are less consequential for achievement outcomes than instructional differences between teachers (Slavin & Lake, 2008). Classroom research at the secondary level has shown that much of teacher behaviour does not support students to think mathematically (Ruthven, 2002). Rather, it has been found that teachers tend to simplify the mathematics "until it becomes a sequence of small smooth steps which can be easily traversed" (Watson, 2002, p. 462). This "path smoothing" by teachers requires students to merely fill in the gaps with the arithmetical answer or low level recall of facts and does not lead to sustained learning as it gives students minimal opportunity for cognitive processing (Walshaw & Anthony, 2008).

Since the 1990s in Australia new mathematics curriculum and standards frameworks have been developed and implemented in the primary and middle school years and state-based testing programmes have been introduced progressively to monitor achievement. Despite these innovations teaching has changed very little and student mathematics performance levels have not improved. The 1999 TIMSS video study of Year 8 classrooms in Australia show a heavy reliance on textbooks or worksheets (Hiebert et al., 2003) and a cluster of features referred to as the "shallow teaching syndrome" (Stacey, 2003). This syndrome is characterised by low procedural complexity of problems, a high proportion of repetition and absence of mathematical reasoning in the classroom discourse. Australian student mathematics achievement in Grades 4 and 8 has remained largely static in the *Trends in Mathematics and Science Studies* (TIMSS) since 1995 while many other countries have increased. Relative to other countries, Australian Grade 4 students performed less well in mathematics in 2003 than they did a decade earlier (Thomson & Fleming, 2004) although the score was significantly higher in TIMSS 2007 (Thomson, Wernert, Underwood & Nicholas, 2008). Year 8 Australia students showed a statistically significant decrease in TIMSS 2007 from that of TIMSS 1995 but there was no significant change from TIMSS 2003 (Thomson et al., 2008). Similarly, the mathematical literacy performance of 15 year old Australian students in the Programme for International Student Assessment (PISA) has remained statistically the same between 2000, 2003 and 2006 but in PISA 2006 eight countries outperformed Australia compared with only one in PISA 2000. Australian mean mathematical literacy scores declined between PISA 2003 and PISA 2006, with these declines statistically significant for Western Australia and South Australia (Thomson & De Bortoli, 2008).

In light of the TIMSS 2007 results the Australian Council for Educational Research (2008) has recommended that the teaching of mathematics in the junior secondary deserves attention, particularly in the areas of algebra and geometry where Australian students performed quite poorly. Slavin and Lake (2008) suggest that educators and researchers should focus on how mathematics is taught rather than on the curriculum or technology alone. Studies of teachers' instructional practices must also consider their beliefs about the

teaching and learning of mathematics as there is considerable evidence to suggest that most teachers are deeply reluctant to change their instruction and when presented with curriculum innovations either fail to take them up (Fullan, 1993) adopt the new practices in a piecemeal fashion or adapt reformers' ideas such that they differ very little from conventional practices (Cohen & Hill, 2001).

The Study

This paper is focussed on teachers views expressed during individual interviews with 15 middle school teachers conducted as part of a larger study involving 127 primary teachers (29 males and 98 females) and 154 middle school teachers (84 males and 32 females). The 281 teacher participants were employed in 54 Department of Education and Children's Services (DECS) schools in South Australia and had 10 or more years of experience in teaching mathematics. Since 1995 DECS has introduced two major curriculum reforms in mathematics into South Australian schools, with the most recent reform the *South Australian Curriculum Standards and Accountability Framework* (SACSA) initiated in 2001 across all curriculum areas including mathematics. 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). All 281 participants were surveyed about their beliefs about mathematics, the teaching and learning of mathematics, their current pedagogical practices in mathematics and their experiences with curriculum reforms in mathematics (see Yates, 2008; 2006b).

Aim

The aim of this study was to explore experienced teachers' views about the teaching and learning of mathematics in the middle school grades.

Method

Participants

Ten male and five female middle school teachers volunteered to be interviewed after completing the written survey. They ranged in age from 34 to 64 years (average age 52.8 years) and came from 12 government schools which differed considerably in size, student cohort, organisational features and degree of disadvantage. The majority had undertaken their teacher training in the 1960s and 1970s, with half of the teachers having taught mathematics for more than 30 years. One teacher had a teaching diploma, six a teaching degree, seven a degree and postgraduate teaching qualification and one did not provide information about qualifications. All teachers had some tertiary level specialisation in mathematics but only one had undertaken tertiary studies in pure mathematics.

Structured Interview

Ten questions were posed to all participants in the interview, with the following three questions designed to elicit the teachers' views about the teaching and learning of mathematics:

1. *Which methods do you think are most successful in helping students to gain a good grounding in mathematics?*
2. *What do you think causes students the most difficulty in learning mathematics?*
3. *Do you feel you have enough time to teach your mathematics programme?*

The interview concluded with an open-ended invitation for any additional comments.

Procedure

Interviews were conducted with each teacher in his/her school in 2007. All interviews were audio recorded and field notes made throughout the interview.

Analyses

Preliminary analyses of the survey data indicated no statistically significant differences between the 15 middle school teachers who volunteered to be interviewed and the remaining 139 who did not in relation to their age, years of teaching mathematics, constructivist beliefs about the teaching and learning of mathematics and beliefs about the beauty and meaningfulness of mathematics (see Yates 2006a, 2006b). The total sample of 154 middle school teachers were grouped in relation to their espoused constructivist beliefs about the teaching and learning of mathematics by means of a quartile split, with 34 teachers scoring in the upper quartile (Mean = 26 out of a possible 32) and 31 teachers scoring in the lower quartile. Scores of four of the teachers interviewed (CISY, HELE, BELL and ZEIS) place them in the upper quartile of teachers indicating they hold strong, positive views about constructivism while the scores of two of the teachers interviewed (JOLL and WOOD) were in the lower quartile indicating they did not espouse strong constructivist views.

Teachers' responses to the interview questions were transcribed from the audio recordings and matched with their written responses to three open-ended items in the survey which tapped their views of the most effective way to teach mathematics and their reactions to the curriculum reforms in mathematics they had experienced. Field notes taken during the interviews were used to clarify the recordings of teachers' comments, particularly when they were indistinct, unclear or barely audible. The transcripts were analysed initially for each teacher by combining their written responses to the open-ended items with their oral responses to the interview questions and then by the combined oral responses of the teachers to each of the three questions posed in the interview. Major themes, trends and issues that cut across the individual teacher and the interview questions were identified. Typical comments made by teachers during the interviews have been selected to highlight the major themes, trends and issues identified and are reproduced in italics in the results followed by the teacher's unique code.

Results

In their responses to the interview questions teachers commonly asserted that students entering high school at Year 8 lacked the foundational skills and knowledge to be successful. Comments from five of the teachers are typical of the views expressed:

> Poor foundation of basic skills in previous years. There are big gaps in basic knowledge. (JOLL)
>
> I would love children to have table knowledge because this is critical. (WOOD)
>
> Lack of tables knowledge. Lack of fundamental past knowledge. (HELE)
>
> Basic knowledge often missed (ZIES).
>
> Lack of drilling in primary schools leads them into high school with a very poor foundation. Students enter Year 8 without the necessary computational tools which need to be established throughout the primary and strengthened in Years 6 and 7. Once students lack this skill, it is too late to rectify it in Years 8 and 9. Without a confident, rapid recall of times tables many other tasks are impossible – with fractions, for example, they can't cancel, convert from mixed numbers to

> improper fractions, find common denominators, or add, subtract, multiply or divide fractions. (FOGW)

Some teachers felt that progressive pedagogies, such as group work, undermined the acquisition of mathematical knowledge. Comments included:

> Group work in primary schools has a bad effect. Children can't always work individually or sit quietly and think (FOBG).

> Many students come to high school unable and unwilling to quietly reflect on a problem, when the answer isn't immediately obvious. They need time and space to think, and explore solutions ON THEIR OWN, rather than look to someone else to supply the answer. Too much group work can lead to a rather haphazard approach and an "intellectual laziness" with thinking at a very superficial level, with social interactions being a dominating factor. (FOBW).

Much of the blame for student's lack of knowledge and skills was attributed to the primary schools, as evident in the comments from three of the teachers:

> Primary schools need to prepare students better and more uniformly for high school maths. There are too many variations in standards. I would like to see more teachers who can teach maths! (KAML).

> Some primary teachers are afraid of maths and so avoid it (DOWL).

> We have an overloaded curriculum in primary schools and some primary teachers do not have maths backgrounds so avoid it. There is no rigor (SHER).

However, two teachers did suggest there should be more sharing of practices within and across schools, with one teacher stating:

> Secondary teachers (specialists) need to be in touch with primary teachers in a very direct way to influence what kids are doing in primary school (FOGB).

The vexatious issue of streaming versus mixed ability grouping in mathematics classes was a recurring theme in the teacher interviews:

> Non-streaming has resulted in the better kids being held back by the lack of skills and abilities of the poorer students (FOGB). Class structures and content and ability grouping all affect outcomes. Pressure from SACSA prohibited ability grouping – therefore children enter maths ill-prepared (IREL).

Further, teachers felt that reforms in the middle grades did little to improve this situation. Although teachers reported mathematics is generally allocated 200 minutes per week in the middle years of schooling, ten of the fifteen teachers were firmly of the opinion that they did not have enough time to teach their program

> There is not enough time to teach everything in the curriculum (HELE).

All of the teachers attached a lot of emphasis to mastery of mathematics through direct instruction in the basic computational skills, rote learning and constant practice, with the comment of two teachers *Unfortunately, there is not substitute for practice* (DICK) and *Practice is necessary* (HELE) typical of the others. However, they did acknowledge the importance of linking learning to students' lives with one teacher commenting:

> Whilst some practice is needed to master some techniques, the overarching principle is the enabling of a student to make sense of the world and thence to be able to manipulate and describe it (CISY). Another teacher commented:

> Students should be taught the basic fundamental concepts and be given the opportunity to practise and acquire the skills needed and how to apply them to real life problem solving situations (YOUS).

Middle school teachers considered the curriculum changes they had experienced were detrimental to the long-term viability of mathematics in the upper secondary years. Teachers also felt the decline in enrolments in senior mathematics courses was a direct outcome of the problems experienced at the middle school level:

> Numbers doing high level mathematics in senior school have declined. They lack the confidence and skills that they need (FOGB).

Indeed, there was general despondency about the future of mathematics in the school curriculum, with several respondents lamenting falling standards

> Many students cannot cope with basic skills, so you tend to fall back to teaching these again. Students are getting weaker. The knowledge base 30 years ago was much, much better than today. Tables and fraction knowledge is lacking (SHER).

Discussion

Participants in this study are representative of diverse school settings and of the total sample of middle school teachers who participated in the survey. They offer a range of perspectives and ideas that inform educators and policy makers about significant issues related to the teaching and learning of mathematics in the middle school years. Their strongly held beliefs that students must have a firm foundation in basic skills before they can undertake more challenging instruction and that this foundation can only be attained through a focus on procedural skills in mathematics are deeply rooted, resistant to change and affected adversely by the cumulative effects of multiple reform experiences. These middle school teachers appear to be locked in a learning cycle that will at best bring only small gains in student achievement (Stein & Lane, 1996). Furthermore, the teachers are caught in a unresolvable dilemma as they are expected to engage students in rigorous learning that will ensure mastery of mathematical ideas and maintain pathways for senior school mathematics but know that motivating and engaging students in mathematics demands that they move beyond teacher-directed approaches focused on the acquisition of basic skills to encourage investigative learning and hands-on activities. This conundrum was expressed by the constructivist and non constructivist oriented teachers alike.

It is clear from a synthesis of several studies that students should be actively engaged with mathematical ideas (Walshaw & Anthony, 2008) but that a certain level of repetition is desirable *so that procedures may be practiced and become a secure part of a student's mathematical toolbox* (Vincent & Stacey, 2008. p 102). However, teachers in this study are clearly caught up by their concerns about students' lack of basic skills and knowlege in the middle school years and their focus on remedying these deficits appears to be diverting them from teaching the intended SACSA curriculum. Their preoccupation with basic skills may also provide an alternative explanation for student achievement in TIMSS and PISA other than misplaced confidence in their ability to teach mathematics subject matter suggested in the TIMSS 2007 report (Thomson et al., 2008).

There is much at stake in the teaching and learning of mathematics for any nation. In the USA the National Mathematics Advisory Panel (NMAP) (2008, p. xvi) has recommended *a focussed, coherent progression of mathematics learning with an emphasis on proficiency in key topics … in elementary and middle school mathematics curricula.* The vision of the

Australian Association of Mathematics Teachers is for students in the middle school years to *experience mathematics as a coherent, meaningful and purposeful aspect of their schooling that is connected to their lives as learners and as adolescents developing into adults*. However, for many students mathematics falls short of this ideal and *is a series of hurdles and challenges – a task met with continued failure and irrelevance* (Walshaw & Anthony, 2008, p 517). The views expressed by the experienced teachers in this study provide powerful insights into their views about students and the pedagogical processes in their mathematics classrooms. The strong and pervasive feelings of pessimism, despondency and cynicism reported by the teachers about the future of mathematics suggests the road to pedagogical change in the middle grades will be long and arduous but it is also clear that these changes can only occur when middle school teachers are able to resolve their current "back to basics" conundrum. While a combination of curriculum reforms and professional development targeted at teachers' instructional behaviours in middle school mathematics classrooms is required for change to occur (Slavin & Lake, 2008), automaticity of basic skills in all mathematics content areas can only be achieved by resolving the skills versus understanding dilemma at the primary school level.

Acknowledgments

1. Assistance from Marilyn Rogers Dianne Harris and Dr Peter McInerney is gratefully acknowledged.
2. The research was supported by a Flinders University Research Grant.

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