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Mathematics Teachers' Beliefs and Curriculum Reform

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This paper discusses the role of mathematics teachers' beliefs and their impact on curriculum reform. It is argued that teachers' beliefs about the teaching and learning mathematics are critical in determining the pace of curriculum reform. Educational change is a complex process in which teachers hold strong beliefs about the quality and the process of innovation. Curriculum implementation may only occur through sufferance as many teachers are suspicious of reform in mathematics education given its equivocal success over the past decades. It is not surprising then that many teachers, when they come to enact the curriculum in their classes, rely more on their own beliefs than on current trends in pedagogy. These beliefs, conservative as they might be, have their own rationality in the practical and daily nature of the teaching profession, and in the compelling influence of educational systems from which these teachers are paradoxically the social product. The literature indicates that many of these teachers hold behaviourist beliefs, a fact that has strong implications for the success of constructivist-oriented curriculum reform. In general, studies of teachers' pedagogical beliefs reveal the extreme complexity of bringing about educational change, and largely explains the failure of many past reform endeavours.

Mathematics Teachers' Beliefs and Practices

Teachers' belief systems reflect personal theories about the nature of knowledge and knowing that, in turn, influence teachers' curriculum decision-making and teaching approaches (Hofer & Pintrich, 1997; Lovat & Smith, 1995; Pajares, 1992). According to Thompson (1984) teachers' beliefs "seemed to be manifestations of unconsciously held views of expressions of verbal commitments to abstract ideas that may be thought of as part of a general ideology of teaching" (p. 112). They represent implicit assumptions about curriculum, schooling, students, teaching and learning, and knowledge and act as cognitive and affective filters through which new knowledge and experience is interpreted and enacted (Artzt & Armour-Thomas, 1996; Lovat & Smith, 1995).

Mathematics teachers' beliefs can be thought of as an individual's perspective on how one engages in mathematical tasks (Schoenfeld, 1985) and pedagogical practices. A growing body of literature shows that mathematics teachers' beliefs affect their classroom practices although the nature of the relationship is highly complex and dialectical (Pajares, 1992; Thompson, 1985). Although many studies on teachers' beliefs suggest that there is a relationship, causality is difficult to explain. Some studies strongly suggest teachers' beliefs influence instructional behaviour, while in other cases it appears that instructional practice influences teachers' beliefs (Buzeika, 1996; McGalliard, 1983).

The research also indicates that many other factors mediate and influence the direction and magnitude of the relationship between beliefs and practices such as teachers' own school experiences (Brown & Rose, 1995; Foss & Kleinsasser, 1996; Raymond, 1993, 1997; Thompson, 1984, 1985). It is apparent that there is a

range of obstacles that teachers face when trying to implement either their own beliefs or the mathematical ideas underpinning a particular curriculum innovation.

Curriculum Change in Mathematics Education

In education, there is frequently a mismatch between the intended, the implemented and the attained curriculum (Cuban, 1993). The intended curriculum is the one prescribed by policy makers, the implemented curriculum is the one that is actually carried out by teachers in their classrooms, and the attained curriculum is the one learnt by students (Howson & Wilson, 1986). Part of the mismatch is due to the fact that teachers and students work on more limited goals than those proposed by curriculum developers, teacher educators, writers of syllabuses, and textbook authors (Handal, 2001). Mathematics teachers, for example, are concerned only with students acquiring facts and performing skills prescribed by the syllabus rather than being concerned about broader educational goals.

Other factors affecting curriculum alignment and change in mathematics education have been extensively discussed by Anderson and Piazza (1996), Clarke (1997), Memon (1997), and Mumme and Weissglass (1991). In the context of a school based curriculum development project, Clarke (1997) identified 12 factors that appeared to influence the change process: (a) the reform movement in general; (b) the principal and school community; (c) internal support personnel; (d) the spirit of collegiality, collaboration, and experimentation; (e) the grade-level team of teachers; (f) innovative curriculum materials; (g) the in-service program; (h) external support personnel; (i) the researcher acting as a participant observant and critical friend; (j) outcomes valued by the teacher; (k) day-to-day conditions under which teachers work; and (l) teacher knowledge.

Memon (1997) suggested a more comprehensive list of factors affecting curriculum change that are grouped as curricular, instructional, and organisational factors and reproduced in Table 1. It is clear that curriculum change is a complex process and while there are many resource and support factors that appear to influence change, it is apparent that any successful reform will need to take into account mathematics teachers' beliefs about the intended, the implemented, and the attained curriculum.

Curriculum Change and Mathematics Teachers' Beliefs

If an implemented curriculum is a set of beliefs put into action, as Short and Burke (1996) have argued, then curriculum policy-makers may do well to look in depth at mathematics teachers' beliefs. If the mathematics teachers' beliefs are not congruent with the beliefs underpinning an educational reform, then the aftermath of such a mismatch can affect the degree of success of the innovation as well as the teachers' morale and willingness to implement further innovation.

Table 1
Factors Affecting Educational Reform in Mathematics Education

Curriculum factors	Instructional factors	Organisational factors
Externally imposed innovation	Importance attached by teachers to old practice	Lack of supportive mechanism
Lack of curriculum users' participation	Inadequate knowledge of subject matter, method and student assessment	Lack of coordination
Non-clarity of curriculum changes	Examination dominated teaching	Lack of communication
Mismatch between official curriculum and actual curriculum	Mismatch between teachers, belief system and curriculum goals	Lack of classroom materials
Change is not responsive to curriculum users' needs	Lack of detailed planning	Lack of physical facilities
Imported innovation	Lack of motivation, incentives and rewards	Lack of resources
Unplanned change	Lack of professional development	Lack of INSET
	Lack of classroom interaction	Lack of community participation
	Lack of students' interest	Influences of political leaders
		Influence of bureaucracy

Mathematics teachers' beliefs can play either a facilitating or an inhibiting role in translating curriculum guidelines into the complex and daily reality of classroom teaching (Haynes, 1996; Jackson, 1968, 1986; Koehler & Grouws, 1992; Sosniak, Ethington, & Varelas, 1991). If teachers hold beliefs compatible with the innovation then acceptance will be more likely to occur. However, if teachers hold opposing beliefs or perceive barriers in enacting the curriculum, then low-take up, dilution and corruption of the reform will likely follow (Burkhardt, Fraser, & Ridgway, 1990). Prawat (1990) has affirmed that teachers can be either conveyances of, or obstacles to, change. No matter how much is expected of them to support reform, it is always possible that their views do not coincide with those underpinning the reform and therefore become a major impediment in that effort. Hart (1992) adds that when teachers consider new tasks to be trivial and superficial they tend to mistrust other innovations.

Unfortunately, innovations can create disunity because groups of 'resisters' are formed (Fullan, 1993). Hall (1997) explained that any innovation represents an encounter of two cultures in which conflict of values and goals needs to be minimised and hopefully blended. Aborted reforms affect teachers' morale causing stress, cynicism, burnout syndromes, anxiety and scepticism (Fullan, 1993; Sinclair & McKinnon, 1987).

The high rate of failure of educational innovations (Fullan, 1993) has drawn

researchers to look more closely at teachers' beliefs as a significant mediator in curriculum implementation. Fullan and Stegelbauer (1991) have stated that it is very unlikely that teachers can modify their teaching practices without changing their values and beliefs. Change can also be cosmetic, that is, a teacher can be using new resources, or modify teaching practices, without accepting internally the beliefs and principles underlying the reform (Fullan, 1983). Burkhardt, Fraser, and Ridgway (1990) warn that even innovative programs that boast of having attained changes on a large scale, have accomplished these changes with a 'travesty' of the explicit and original principles underlying the innovation.

This mismatch between curriculum goals and teachers' belief systems is a factor that affects current curriculum change in mathematics education. Anderson and Piazza (1996, p. 54) argued that "teachers, who must be the agents of change, are products of the system they are trying to change" and proposed that teachers' feelings, beliefs, and values that are opposite to constructivism are a barrier to reform in mathematics education. Sosniak, Ethington, and Varelas (1991) have described the complexity of this mismatch in the context of changing beliefs, teaching approaches and resources in the United States in the 1950s and 1960s. These authors argued that the success of innovative mathematics programs was constrained by inconsistencies between the content of new materials and the working requirements of that content by teachers. The degree of change was limited, due to the fact that the beliefs about mathematics underlying the innovation did not match teachers' beliefs. In addition, these programs required new roles and teachers' responsibilities that were too demanding. Not only did teachers feel unfamiliar with the content change, they had to align to a new way of teaching.

According to Martin (1993a, 1993b) curriculum implementation approaches that do not consider teachers' beliefs have a temporary life. Unfortunately, many educational reforms in mathematics have had a top-down approach (Kyeleve & Williams, 1996; Martin, 1993a, 1993b; Moon, 1986) that did not take into account mathematics teachers' beliefs and belittle the fact that "the ultimate fate of an innovation would seem to depend upon user decisions" (Doyle & Ponder, 1977, p. 3). These reforms were often disseminated using a traditional approach in which teachers were presented with a prepared product and a rigid set of procedures to follow. The major cause of failure of these programs was their negligence in failing to take into account teachers' pedagogical knowledge and beliefs as well as the contexts in which these teaching behaviours occurred (Knapp & Peterson, 1995). In other words, curriculum change in the last several decades relied on the simplistic assumption that teachers will, machine-like, alter their behaviours because they were simply told what was good for them and for their students (Grant, Hiebert, & Wearne, 1994).

Current approaches to curriculum implementation need to rely on more realistic assumptions about teachers' beliefs, recognising that it is difficult to change teaching styles because changing practices demands a process of unlearning and learning again (Mousley, 1990). It also needs to be recognised that change will cause feelings of discomfort that can be unpleasant and intimidating (Martin, 1993b).

Ball (1997) argues that oftentimes teachers are afraid of what parents and administrators will think in regard to a curriculum innovation and therefore must defend things they are trying even before they themselves feel convinced or self-confident. It is therefore risky and burdensome to be a reformer because the system itself does not encourage innovation and change but rather a "stable and harmonious classroom" (Sullivan, 1989, p. 15). In the reality of today's school climate, students resist unfamiliar approaches, administrators do not provide adequate support either in professional training or in resource materials and they dislike less-orderly classrooms. As well, curriculum guidelines suggest content coverage and pacing rather than teaching for understanding (Ball, 1997).

In the past several decades, mathematics was the subject with the highest number of fleeting innovation attempts. It is this reality, hanging on teachers' minds, that causes many teachers to frown (Blane, 1990). To add to this scepticism, many reform documents are presented as "panaceas," "chimeras," and "cures" (Dengate, 1999; Fleener, Westbrook, & Rogers, 1995; Wilson, 1990). Clements (1995) and Clements and Ellerton (1996) complain that in the last three decades teachers have been swamped with magical instructional recipes such as Cuisenaire rods, the New Math, mastery learning, problem solving, applicable mathematics, metacognition, and more recently outcomes-based education. Many of these innovations represent large-scale changes that were poorly defined in operational terms and without positive gains in student learning (Hall & Loucks, 1978). Hence, it is important that teachers believe that any new innovation is workable and likely to enhance student learning (Martin, 1993b).

Traditional mathematics teaching is easier than attempting more progressive approaches (Skemp, 1978) as innovations bring additional burdens to teachers, despite the merits and advances that each innovation might potentially bring. Teachers' difficulties in adopting innovations in mathematics education have been reported in the use of Cuisenaire rods (Hassall, 1986), the New Math(s) (Clements & Ellerton, 1996), mastery learning (Herrington & Wolf, 1985), teaching in themes (Clements, 1987; Henderson & Landesman, 1995), teaching for problem solving (Hembree & Marsh, 1993; Schroeder & Lester, 1989), teaching metacognitive skills (Schoenfeld, 1992) and outcomes-based education (Clements & Thomas, 1996).

Case Studies of the Mismatch between Beliefs and Curriculum Innovations

Besides the *New Math*, other major failing reforms in the 1960s included attempts to use "different number bases to help young people understand their own base-ten systems of numeration. Instead of using it to develop such understanding, teachers were demanding proficiency in multiplying and dividing with base six" (Price, 1995, p. 488). The 1960s also saw curricular emphasis on applied mathematics in order to show students the power and usefulness of mathematics, and as a channel to bring mathematics to the masses (Clements, 1987). As Burkhardt, Fraser, and Ridgway (1990, p. 4) noted: "In the outcome, this aspect is barely visible in the classrooms in which the resultant materials were used, where 'practical situations' were entered, if at all, as another sort of

mathematical content." Several recent cases showing a mismatch between teachers' beliefs and the beliefs underlying particular curricular innovations have been documented.

Brew, Rowley, and Leder (1996) interviewed 40 teachers on their perceptions of the implementation of the *Victorian Certificate of Education* (VCE), a curriculum that relied heavily on investigative work. The authors found that a number of teachers held contradictory beliefs to the reform and some teachers were finding difficulties while other teachers were just paying lip service to the curriculum goals but not implementing them. Among the mitigating factors accounting for these behaviours were heavy work loads, lack of training, and the pressure on content coverage. In a related study, Martin (1993a) reported teachers' concerns about the implementation of the VCE indicating the need for greater professional development on course content and assessment.

Buzeika (1996) interviewed three Auckland primary teachers in regard to the *Mathematics in the New Zealand Curriculum*, which emphasised constructivist practices, and found that the participants had personal concerns about the curriculum being implemented. Among these concerns, teachers felt that the curriculum was vague and unstructured. Teachers had difficulties in identifying the mathematical content learned by students within a particular strand. At the same time teachers lacked knowledge about some topics and terminology used in the curriculum. Furthermore, teachers had "difficulties in maintaining control over what was happening if children were left to explore an idea for themselves" (p. 97).

Frykholm (1995) investigated mathematics teachers' beliefs of 44 preservice mathematics teachers throughout a two-year study in order to determine teachers' adherence to the reforms postulated in the *Curriculum and Evaluation Standards for School Mathematics* (National Council of Teachers of Mathematics, 1989). Although most participants agreed with the principles stipulated in the Standards and stated that they were actually implementing them, they were unable to implement them due to their perceived lack of training in the principles underpinning the reform. Participants felt pressurised within their teaching education programs to accomplish those principles. Some participants revealed that the Standards were "not as practical as they were made out to be, especially in dealing with the structure of most schools — short periods, no collaboration, no team teaching" (Frykholm, 1995, p. 14) as well as rigid departmental policies, lack of support from cooperating teachers, and textbooks.

Sowell and Zambo (1997) provided evidence of the lack of alignment between the Standards' reform goals and teachers' strategies. The authors found that the use of official guidelines, competency based examinations, and school textbooks were insufficient in providing the knowledge and incentives for teachers to modify their teaching. In particular, the authors found that teachers who held conceptions of teaching based on transmission were unlikely to align to the goals of the Standards and therefore continued to teach traditionally. Likewise, Konting (1998) reported a substantial mismatch between the principles of good practice prescribed by an innovative mathematics curriculum in Malaysia and the teaching practices of teachers who were previously identified as effective

practitioners.

Watts (1991, cited in Schwartz & Riedesel, 1994), studied 36 inservice teachers' beliefs about the Standards. The researcher found that only four of the respondents held a perspective congruent with the principles of problem solving outlined in the Standards. According to Schwartz and Riedesel (1994):

> The respondents' agreement that mathematics education should focus on problem-solving evidently reflected their explicit belief. However, their underlying meaning for problem solving indicated their implicit beliefs. The difference between explicit and implicit beliefs resulted in apparent agreement with reformers about the need for problem solving, but in actual disagreement with reformers about what that meant (p. 10).

Other recent examples of conflicting views and demands in the implementation of educational reform in mathematics have been documented by Anderson and Piazza (1996), Desforges and Cockburn (1987), Moreira and Noss (1995) and Wilson (1990). It can be argued therefore that policy-makers and implementers have largely neglected mathematics teachers' beliefs in the process of reform and the training process that all innovative enterprise should take into account in order to prevent confusion and anxiety. In this respect, it is noteworthy to acknowledge the lack of relevant training that accompanies many innovations in mathematics education (Stephen & Varble, 1995). Many teachers feel sceptical about innovation as they have not been properly informed of the technicalities involved or given the support that is necessary. Hassall (1986), for example, reports cases of confused teachers reluctant to ask questions to curriculum implementers for fear of being labeled as incompetent.

Conclusion

Successful curriculum change is more likely to occur when the curricular reform goals relating to teachers' practice take account of teachers' beliefs. Argyris (1978, 1993) refers to this as a 'theory of action' making a distinction between an individual's espoused theory and his or her theory-in-use (what they actually do). For Argyris, this behaviour can be in conflict not only at the personal but also at the organisational level. This tension can be addressed through honest consultation, looking beyond the symptoms, self reflection and at improved communication within the organisation itself.

The times of the well-polished, 'teacher-proof' curricular documents are gone. Policy-makers should no longer assume that curriculum implementation is a process that translates directly into the classroom reality. Teachers are those who ultimately decide the fate of any educational enterprise. Consequently, teachers' attitudes, feelings, and perceptions must be recognised well before the launching of any innovation. Likely discrepancies between teachers' opinions and the ideas underpinning a curriculum innovation need to be identified, analysed, and addressed.

The current trends in mathematics education towards constructivist learning environments and assessment of learning based on demonstrable outcomes will only succeed if teachers' beliefs about these reforms are considered and confronted. Otherwise, teachers will maintain their hidden agendas in the privacy of their classrooms and the implementation process will result in a self-

deceiving public exercise of educational reform and a waste of energy and resources.

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