Beyond the Curriculum: The Mathematical Beliefs of Pre-service Primary Teachers in Hong Kong

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This study investigated pre-service primary teachers' knowledge and beliefs about mathematics, the curriculum in Hong Kong, and teaching practices. Pre-service teachers from all four years of the program who were majoring in mathematics teaching completed a questionnaire. A sample participated in an interview and provided lesson plans for analysis. This paper reports the data obtained from the beliefs section of the questionnaire. The preliminary results indicated that the mathematical beliefs of the pre-service teachers generally supported the innovative approaches recommended in the revised curriculum. Nevertheless, for some there was a contradiction between their beliefs about the role of mathematics teachers and mathematics learning in classrooms.

The curriculum model developed for the *Trends in International Mathematics and Science Study* (TIMSS) distinguished between the intended curriculum, the implemented curriculum and the attained curriculum (Mullis, Martin, Ruddock, O'Sullivan, Arora & Erberber, 2005). According to this curriculum model, the teacher is one of the key factors influencing the implemented curriculum. This is largely because teachers' curriculum decision-making and teaching approaches are influenced by their belief systems and personal theories about the nature of knowledge (Leder, Pehkonen & Törner, 2002; Pajares, 1992). As teachers' thought processes and instructional behaviours are related to their existing knowledge and personal beliefs, their understanding of mathematics and how it should be taught affects the quality of teaching in classrooms (Clark & Peterson, 1986).

To ensure the successful implementation of an innovative curriculum, pre-service teacher education and in-service professional development for teachers need to focus on the beliefs of participants as well as developing their knowledge and understanding of the new approaches (Anderson, White & Sullivan, 2005). Despite pre-service teachers having less immediate influence on the implemented curriculum, their pre-existing beliefs, usually formed from experiences as learners of mathematics, have the potential to impact on their teaching practices when they become qualified teachers (Raymond, 1997). When a new curriculum or an innovative teaching approach is advocated, it is crucial that pre-service education programs address teacher education students' beliefs to facilitate the changes of curriculum reform (Swars, Smith, Smith & Hart, 2009).

In 2000, the revised mathematics curriculum in Hong Kong (Curriculum Development Council [CDC], 2000) advocated higher-order thinking skills and real-life applications with a greater focus on student-centred approaches to the teaching and learning of mathematics. However, most students in the pre-service teacher education program in this study had experienced a more traditional, whole-class approach with the teacher as expert and students acting as passive recipients. It seems these experiences need to be challenged since the 'apprenticeship of observation' tends to lead to pre-service teachers learning to teach as they were taught (Lortie, 1975). In Hong Kong there have been a series of collaborative research projects conducted to enhance mathematics education in primary schools since the curriculum reform (Education Bureau, 2007) with many of the local studies investigating teaching strategies. Few have focused on the beliefs of pre-service

L. Sparrow, B. Kissane, & C. Hurst (Eds.), *Shaping the future of mathematics education: Proceedings of the 33rd annual conference of the Mathematics Education Research Group of Australasia.* Fremantle: MERGA.

teachers. The overall aim of this study was to investigate pre-service teachers' mathematical beliefs in the context of primary mathematics curriculum in Hong Kong.

Primary Mathematics Curriculum in Hong Kong

Since 2002, there has been considerable change in the Hong Kong primary curriculum. Quality learning and teaching as well as competencies for lifelong learning are now emphasised with knowledge organised into eight Key Learning Areas. In addition, Generic Skills, Values, and Attitudes form three interconnected components in the curriculum framework of education reform. The revised primary mathematics curriculum has five learning dimensions – number, shape and space, measures, data handling, and algebra (CDC, 2000). To cater for individual differences, topics in each learning dimension are divided into two levels – basic and enrichment. The purpose of generating enrichment topics is to "broaden pupils' view and arouse their interest" (CDC, 2000, p. 6). As enrichment topics are optional and not included in examinations, teachers' selection of enrichment topics depends on the needs and abilities of the students and the time available.

In the Curriculum Guide, teachers are advised to adopt a wider range of teaching and assessment approaches. The guide states:

> As a foundation for further study, more opportunities should be provided for pupils to observe, analyze, understand and judge events/information, and to develop their elementary thinking abilities … Pupils should learn pleasurably through various learning activities and develop their imagination, creativity and thinking skills (CDC, 2000, p. 49).

Application of information technology such as calculators, computers and multimedia equipment is recommended and for assessment, evaluation of students' thinking processes is as important as assessing students' mastery of knowledge and skills (CDC, 2000). Apart from formal assessment including tests and examinations, project work such as statistical surveys, making models, and presentations in class are all recommended as possible informal assessment activities. Compared to the previous primary mathematics curriculum, this represents a significant shift in recommended teaching strategies and assessment methods in primary mathematics education. Educational change is always a challenge, particularly when it necessitates new views about teaching and learning (Fullan, 1993). A necessary component of curriculum innovation requires a comprehensive and effective teacher preparation course to address the changes and challenge pre-service teachers' mathematical beliefs.

Pre-service Teachers' Mathematical Beliefs

For the purpose of this paper, 'pre-service teachers' mathematical beliefs' refers to those belief systems held by pre-service teachers about mathematics teaching and learning. Given the range of definitions of beliefs among specialists in mathematics education (Furinghetti & Pehkonen, 2002), this study has adopted Schoenfeld's (1992) definition since it encompasses both cognitive and affective components: "an individual's understandings and feelings that shape the ways that the individual conceptualizes and engages in mathematical behaviour" (p. 358).

In reviewing earlier research on initial teacher preparation in mathematics education, Raymond (1997) noted that past school experiences, early family experiences and the teacher education program have greatest influence on developing pre-service teachers' mathematical beliefs. Uusimaki and Nason (2004) conducted semi-structured interviews with eighteen pre-service primary mathematics teachers in Australia to reveal the origins of

their negative beliefs and mathematics anxiety. It was found that 12 out of the 18 pre-service teachers experienced negative mathematics learning in their primary schools. Their negative experiences included feeling stressful in mathematics tests and feeling anxious during practicum when they had to teach mathematics lessons.

Pre-existing beliefs about teaching and learning mathematics can be resistant to change (Pajares, 1992) with Kagan (1992) claiming pre-service teachers tend to leave pre-service programs holding much the same beliefs with some having even stronger negative biases towards mathematics. More recent studies (e.g., MacNab & Payne, 2003; Scott, 2005) suggested graduating pre-service teachers usually have more favourable beliefs than beginning pre-service teachers. MacNab and Payne (2003) studied Scottish pre-service primary teachers' beliefs, attitudes and practices in mathematics teaching and concluded the final year pre-service teachers had more confidence in teaching but they were less positive about mathematics itself. Scott (2005) examined 163 commencing and 186 graduating pre-service teachers' beliefs about teaching and learning primary mathematics in Australia. The data indicated that the graduating pre-service teachers were much more capable of teaching numeracy by means of building on their students' experiences.

Investigations of teachers' beliefs about mathematics frequently reveal a range from more traditional beliefs to more contemporary beliefs with many teachers holding a mixed set of beliefs (Anderson, White & Sullivan, 2005). At one end of a continuum of beliefs, teachers tend to view mathematics as a fixed body of knowledge, with teachers as experts and students memorising rules and procedures. At the other extreme, teachers may view mathematics as socially constructed with teachers and students working together to explore mathematical ideas, negotiating meanings, and creating ways to represent their thinking. These more contemporary beliefs are likely to support the implementation of curriculum reform as described in the revised Hong Kong curriculum. As noted by Szydlik, Szydlik and Benson (2003), many pre-service primary teachers have beliefs which are narrow, formal and rigid hence the focus in many studies is to change pre-service teachers' beliefs.

Methodology

The study reported here did not aim to explore the changes of primary pre-service teachers' beliefs but to investigate the types of beliefs held by these student teachers in the Hong Kong context and to consider the possible differences in mathematical beliefs across the stages of a pre-service program. Unlike many Western countries, these pre-service teachers were all majoring in primary mathematics teaching so that when they graduated, they would have responsibility for teaching mathematics to several different primary classes. The research methods used for the study comprised questionnaires, interviews and lesson plan analysis. For investigating the mathematical beliefs of pre-service teachers, two instruments including a self-report questionnaire and a semi-structured interview schedule were utilised. Of the 152 respondents to the questionnaire, 19 were selected for the interviews. This paper reports some background data about the students as well as the data obtained from the beliefs section of the questionnaire.

There were three sets of questions in the questionnaire that aimed to investigate pre-service primary teachers' mathematics curriculum knowledge, mathematical beliefs as well as their mathematical content knowledge and pedagogical content knowledge. In the beliefs section, a set of four-point Likert scale questions was designed to explore pre-service teachers' mathematical beliefs. Eighteen of the Likert scale items had been used to reveal in-service and pre-service teachers' mathematical beliefs in previous international research (Perry, Vistro-Yu, Howard, Wong & Fong, 2002; Perry, Way & Southwell,

2005). Seven more items were added to specifically address the Hong Kong context. These 25-item statements were grouped as: beliefs about mathematics, beliefs about mathematics teachers, beliefs about mathematics learning, beliefs about mathematics teaching, and beliefs about the social context in relation to primary mathematics education.

In each of the groups of beliefs, some statements represented more traditional beliefs while others represent more contemporary beliefs. Some of the more traditional belief statements included 'mathematics is computation', 'the role of the mathematics teacher is to transmit knowledge and to verify that learners have received this knowledge' and 'right answers are much more important in mathematics than the ways in which you get them'. More contemporary belief statements included 'mathematics is the dynamic searching for order and pattern in the learner's environment' and 'mathematics teachers should negotiate social norms with the students in order to develop a cooperative learning environment in which students construct their knowledge'.

All pre-service teachers from one teacher education institution who had enrolled in a four-year Bachelor of Education (Honours) (Primary) Program and had selected mathematics as their major were invited to participate in the study at the end of the academic year. The population of the study was approximately 210. As there were 152 questionnaires returned (63 responses from Year 1, 41 responses from Year 2, 19 responses from Year 3 and 29 responses from Year 4), the response rate was over 65%.

Preliminary Results and Analysis

Among the 152 respondents, there were 112 female and 39 male students while one did not provide a response for the gender item. A total of 132 of the participants had completed their six-year primary education in Hong Kong and their graduation years ranged from 1992 to 2001. It is typical of Hong Kong tertiary education intakes to have mainly local students. As the revised primary mathematics curriculum was not implemented until 2002, all participants would have experienced the previous traditional mathematics curriculum.

The reasons given for the student teachers choosing mathematics as their major in their teacher education training were varied. Over 88% of the respondents gave at least one positive reason for choosing to study mathematics with 84% of them indicating they were 'interested' in mathematics. Only 15% of the respondents chose mathematics education because they were 'good' at it, and 24% of them made their choice because they 'loved' mathematics (see Table 1 – note that some respondents chose more than one category).

Table 1
Reasons for choosing mathematics as a major in the teacher education training

	"I am good at mathematics."	"I am interested in mathematics."	"I love mathematics."	Other reasons
Year 1, *n = 63*	14	55	21	9
Year 2, *n = 41*	6	31	6	9
Year 3, *n = 19*	0	16	3	2
Year 4, *n = 29*	3	26	7	3

In order to compare the results between the pre-service teachers from different study stages, the respondents were divided into three groups: Year 1; Year 2; Years 3 and 4 (see Table 2). The results obtained from Years 3 and 4 were combined because it is during these years that the students do practicum in schools so all of the students from these year

groups had completed at least one practicum experience. To gauge overall positive and negative views, the responses to the categories "agree" and "strongly agree" have been combined in Table 2. Similarly for the disagree categories. These responses were used to construct a picture of the pre-service teachers' mathematical beliefs at each of the three study stages.

Table 2
Frequencies of responses in 25-item beliefs statements at different study stages

		Strongly agree or Agree (%)			Strongly disagree or Disagree (%)		
		Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
	Item number	*Year 1* *n = 63*	*Year 2* *n = 41*	*Year 3 & 4* *n = 48*	*Year 1* *n = 63*	*Year 2* *n = 41*	*Year 3 & 4* *n = 48*
Mathematics	1*	66	76	69	33	22	31
	2	85	93	96	14	5	4
	3	95	96	98	5	5	0
	4	89	98	100	12	2	0
Mathematics Teachers	5	83	83	96	14	17	4
	6*	92	78	67	8	22	33
	7	73	78	65	27	22	35
	8	79	68	69	21	31	31
	9	83	93	85	18	7	15
	10	49	44	35	51	53	65
	11*	30	26	27	70	73	69
Mathematics Learning	12	95	100	98	5	0	2
	13	89	93	98	11	7	2
	14	64	82	69	35	15	31
	15*	43	41	38	57	56	60
	16	94	96	98	5	5	2
	17	97	100	98	4	0	2
	18*	63	58	60	36	42	25
	19	76	56	67	24	43	33
Mathematics Teaching	20*	45	41	40	55	56	60
	21*	21	7	8	79	93	92
	22	63	83	85	35	17	15
Social Context	23*	27	12	6	73	88	92
	24*	38	27	13	61	70	88
	25	87	92	100	11	7	0

*Items represent more traditional beliefs.

Belief characteristics of Year 1 pre-service teachers

Although the beginning pre-service teachers had not been into schools for their practicum, their mathematical beliefs were generally considered to reflect more contemporary views. For instance for their beliefs about the discipline of mathematics and mathematics learning, over 90% of the Year 1 pre-service teachers agreed or strongly agreed with the following contemporary belief statements:

- Item 3 - Mathematics is an interesting subject (95%);
- Item 12 - Mathematics learning is enhanced by challenge within a supportive environment (95%);
- Item 16 - Periods of uncertainty, conflict, confusion, surprise are a significant part of the mathematics learning process (94%);
- Item 17 - Mathematics learning is enhanced by activities that build upon and respect students' experiences (97%).

However, the Year 1 pre-service teachers also agreed with some of the more traditional belief statements. For example, nearly two thirds of the Year 1 respondents agreed or strongly agreed with Items 1 and 18:

- Item 1 - Mathematics is computation (66%);
- Item 18 - Being able to memorise facts is critical in mathematics learning (63%).

Another notable result was that beginning pre-service teachers' beliefs about the role of mathematics teachers were also more traditional. A high proportion of the respondents agreed or strongly agreed with:

- Item 6 - The role of the mathematics teacher is to transmit mathematical knowledge and to verify that learners have received this knowledge (92%).

This statement does not support the innovative approaches advocated from the revised curriculum since it suggests a more teacher-centred approach. It could be implied that the Year 1 pre-service teachers' responses represented a mixed set of beliefs with agreement with some contemporary beliefs combined with agreement with more traditional beliefs.

Belief characteristics of Year 2 pre-service teachers

For the Year 2 pre-service teachers, the data indicated that a high proportion held contemporary beliefs about mathematics, mathematics teachers, mathematics teaching, and mathematics learning and also had favourable beliefs about the social context of teaching mathematics in primary schools. Over 90% of the respondents agreed or strongly agreed with the following contemporary belief statements:

- Item 2 - Mathematics is the dynamic searching for order and pattern in the learner's environment (93%);
- Item 3 - Mathematics is an interesting subject (96%);
- Item 4 - Mathematics is a beautiful, creative and useful human endeavour that is both a way of knowing and a way of thinking (98%);
- Item 9 - Good mathematics teachers should love mathematics (93%);
- Item 12 - Mathematics learning is enhanced by challenge within a supportive environment (100%);
- Item 13 - Mathematics knowledge is the result of the learner interpreting and organising the information gained from experiences (93%);
- Item 16 - Periods of uncertainty, conflict, confusion, surprise are a significant part of the mathematics learning process (96%);
- Item 17 - Mathematics learning is enhanced by activities which build upon and respect students' experiences (100%);

- Item 25 - The idea of specialist mathematics teacher is promoting primary education (92%).

Also, over 90% disagreed or strongly disagreed with the following statement representing a more traditional belief:

- Item 21 - Right answers are much more important in mathematics than the ways in which you get them (92%).

Even though the results indicated that Year 2 pre-service teachers generally supported more contemporary mathematical beliefs, it is interesting to note that 76% of them still deemed mathematics to be focused on computation; a view that largely contradicts the approach recommended in the Hong Kong curriculum with a focus on problem-solving and higher-order thinking skills.

Belief characteristics of Year 3 and Year 4 pre-service teachers

Similar to the results in Year 2, the Years 3 and 4 pre-service teachers generally supported the more contemporary mathematical beliefs. One difference from the results in Year 1 and Year 2 is that a large proportion of the Year 3 and Year 4 prospective teachers had favourable beliefs about the social context in relation to primary mathematics education. Ninety-two percent of the respondents disagreed or strongly disagreed with the statement suggesting English and Chinese languages were more important than mathematics in primary education while 88% of them disagreed or strongly disagreed that "learning language was more useful than learning mathematics for a primary student". In addition, all of the respondents from Years 3 and 4 fully supported the idea of specialist mathematics teachers in primary education. Clearly the pre-service teachers had strong beliefs about professionalising primary mathematics education in Hong Kong.

Conclusion

The data presented in Table 2 reveal a promising tendency towards support for more contemporary mathematical beliefs among the pre-service teachers in this program. Although, these pre-service teachers experienced a more traditional curriculum in primary and secondary mathematics classes, they have all chosen to major in mathematics teaching in their primary pre-service education. The responses to particular beliefs about mathematics (Items 2, 3 and 4), beliefs about mathematics teachers (Items 5 and 9) as well as beliefs about mathematics learning (Items 12, 13, 16 and 17) suggest the pre-service teachers from all of the study stages positively support the approaches recommended in the 2000 revised primary mathematics curriculum in Hong Kong. However, some traditional mathematical beliefs such as beliefs about mathematics (Item 1), beliefs about mathematics teachers (Item 6) as well as beliefs about mathematics learning (Item 18) are still supported. Interestingly, for one traditional belief statement, a decreasing number of respondents across the study stages supported the statement 'right answers are much more important in mathematics than the ways in which you get them'.

The beliefs survey gave a general picture of the beliefs characteristics among pre-service primary teachers in Hong Kong. In short, the data reveal the evolving nature of contemporary beliefs throughout the teacher education program. The reasons for these differences are unclear but these will be further explored during analysis of additional questionnaire items and during interviews. In addition, to verify the accuracy of the data collected from the survey and explore the contextual factors impacting on the mathematical beliefs of the respondents, the data obtained from the interviews and lesson plan analysis will be considered in the further qualitative analysis.

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