Primary Teachers' Beliefs about Mathematics and Mathematics Instruction

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The primary objective of this study was to examine primary teachers' beliefs about mathematics and mathematics instruction. The secondary objectives were to determine whether there were significant differences in their beliefs about mathematics and mathematics instruction between male and female teachers, respectively. The researchers employed a cross-sectional survey research design and the sample comprised 168 primary teachers from 4 public National Schools (62), 4 public National Type Chinese Schools (58) and 4 public National Type Tamil Schools (48) in the state of Penang. Collier's six-point Likert scale questionnaire comprising 40 items was used to examine primary teachers' beliefs about mathematics and mathematics instruction. Analysis of the 157 complete questionnaires from the sample indicated that the teachers showed slightly informal beliefs about mathematics and mathematics instruction.

Keywords: beliefs about mathematics, beliefs about mathematics instruction, primary school teachers, gender differences.

Collier (1972) and Seaman, Szydlik, Szydlik and Beam (2005) defined an individual's beliefs about mathematics and mathematics instruction on a continuum that ranges from formal beliefs to informal beliefs. Individuals with formal beliefs about mathematics conceive mathematics as consisting of procedures like rules, algorithms and formulas which are hierarchically organized according to different branches such as arithmetic, geometry, algebra, statistics and so on. According to Roscoe and Sriraman (2011), these formal beliefs about mathematics are in alignment with Skemp's (1987) instrumental understanding or rules without reasons, Ernest's (1988) instrumentalist beliefs as well as Raymond's (1997) traditional beliefs. Individuals with formal beliefs about mathematics instruction conceive teaching mathematics as a teacher-centred activity in which the teacher shows the procedures clearly to the students and the students are then encouraged to acquire the procedures through individual drill and practice. This is because students' successful recall and proficient performance of these procedures are conceived as knowing mathematics by individuals with formal beliefs about mathematics and mathematics instruction. These formal beliefs about mathematics instruction

are in alignment with Kuhs and Ball's (1986) mathematics pedagogy which is content focused and with an emphasis on performance (Roscoe & Sriraman, 2011).

Individuals with informal beliefs about mathematics conceive mathematics as consisting of creative and investigative processes such as problem solving, proof and reasoning, communication, connection and representation as advocated by NCTM (2000). According to Roscoe and Sriraman (2011), these informal beliefs about mathematics are in alignment with Skemp's (1987) relational understanding, Ernest's (1988) problem-solving view as well as Raymond's (1997) non-traditional beliefs.

Individuals with informal beliefs about mathematics instruction conceive mathematics teaching as a student-centred activity focusing on student construction of mathematical knowledge. This is because students' abilities to actively solve problems, prove and reason, communicate, connect and represent mathematically are conceived as knowing mathematics by individuals with informal beliefs about mathematics and mathematics instruction. These informal beliefs about mathematics instruction are in alignment with Kuhs and Ball's (1986) mathematics pedagogy which is learner focused as well as Von Glasersfeld' (1989) constructivist views of teaching and learning mathematics which emphasizes active construction of mathematical knowledge (Roscoe & Sriraman, 2011). The constructivist views of teaching and learning mathematics are central to the current reform movement in mathematics education nationally as evidenced in the Primary School Standard Curriculum or *Kurikulum Standard Sekolah Rendah* (*KSSR*) (Kementerian Pelajaran Malaysia, 2011) and internationally such as NCTM's (2000) Principles and Standards for School Mathematics (Roscoe & Sriraman, 2011).

In general, both Collier (1972) and Seaman et al. (2005) found that the beliefs of elementary education students at the University of Wisconsin Oshkosh in 1968 and 1998, respectively, shifted from formal beliefs toward more informal beliefs about mathematics and mathematics instruction during the course of their teacher education programs. In addition, Seaman et al. (2005) found that at the beginning of their program, the elementary education students in 1998 held beliefs about mathematics and mathematics instruction that were significantly more informal than did their 1968 counterparts. More specifically, a majority of the students in both 1968 and 1998, initially held formal beliefs on BAMS items describing mathematics as a collection of rules, formulas, and procedures. In contrast, a majority of the students in both 1968 and 1998 at the same time held informal beliefs on BAMS items describing mathematics as a creative, flexible endeavor. This contradiction in students' beliefs about the mathematics was also reflected in their responses to BAMIS items concerning mathematics instruction. During the course of their teacher education programs, students in both 1968 and 1998 shifted toward more informal beliefs, with the most significant changes occurring in the BAMS items (describing mathematics as a collection of rules, formulas, and procedures) and BAMIS items

(concerning mathematics instruction) on which they were initially most formal. Moreover, the contradictions in beliefs about mathematics and mathematics instruction observed at the start of their teacher education programs were still present at the end of their programs.

Effandi Zakaria and Norulpaziana Musiran (2010) found that the beliefs of the Malaysian trainee teachers from two higher institutions of learning in the state of Selangor about the nature of mathematics and teaching mathematics were both at a moderate level and more inclined towards the constructivist philosophy. Additionally, while their results indicated that there was a significant difference in the beliefs about the nature of mathematics in terms of gender favouring the female trainee teachers, there was no significant difference in the beliefs about teaching mathematics between male and female trainee teachers. In addition, Chan (2004) found no gender differences in the conception about teaching and learning held by Hong Kong teacher education students. But, the result of the study conducted by OECD (2009) showed that the female teachers were less likely than the male teachers to hold formal or direct transmission beliefs about teaching.

Most of the research on beliefs about mathematics and mathematics instruction as defined by Collier (1972) and Seaman et al. (2005) focused on pre-service primary school teachers. Thus, this study aims to extend the literature by investigating the in-service primary school teachers' beliefs about mathematics and mathematics instruction as defined by Collier (1972) and Seaman et al. (2005). Further, as the results on gender differences in beliefs about mathematics and mathematics instruction are unclear in the literature, this study also aims to explore whether there is a significant difference in beliefs about mathematics and mathematics instruction between male and female in-service primary school teachers.

The primary objective of this study was to examine primary teachers' beliefs about mathematics and mathematics instruction. The secondary objectives were to determine whether there were significant differences in their beliefs about mathematics and mathematics instruction between male and female teachers, respectively. More specifically, this study aimed to address the following research questions:
1. What were primary teachers' beliefs about mathematics?
2. What were primary teachers' beliefs about mathematics instruction?

Methodology

Research Design and Participants

The researchers employed a cross-sectional survey research design as it was effective for providing a snapshot of the current primary teachers' beliefs about mathematics and mathematics instruction in a population (Gay, Miles & Airasian, 2011). The sample comprised 168 teachers from 4 public National Schools (62), 4 public National Type Chinese Schools (58) and 4 public

National Type Tamil Schools (48) in the state of Penang. However, 157 teachers from the sample completely answered the questionnaire. These teachers comprised 129 females and 28 males. Table 1 shows the distribution of these teachers in each type of school.

Table 1
Number of Teachers by Gender and School Type

School Type	Gender		Total
	Male	Female	
National Schools	17	40	57
National Type Chinese Schools	5	49	54
National Type Tamil Schools	6	40	46
Total	28	129	157

Instrument

The questionnaire comprised two sections, namely Section A and Section B. Section A contained items on the teachers' demographic data. Section B contained Collier's (1972) two Scales measuring individual teacher's mathematics beliefs, namely Beliefs About Mathematics Scale (BAMS) and Beliefs About Mathematics Instruction Scale (BAMIS). BAMS consisted of 20 items (Items 1 to 20) which measure individual teacher's formal or informal beliefs about mathematics. Half of the items in BAMS were phrased in a positive manner which advocate informal beliefs about mathematics while half in a negative manner which advocate formal beliefs about mathematics. BAMIS also consisted of 20 items (Items 21 to 40) which measure individual teacher's formal or informal beliefs about mathematics instruction. Half of the items in BAMIS were phrased in a positive manner which advocate informal beliefs about mathematics instruction while half in a negative manner which advocate formal beliefs about mathematics instruction. All the 40 items had a six-point Likert scale response options, namely strongly disagree, moderately disagree, slightly disagree, slightly disagree, moderately disagree and strongly agree. The teachers' responses to each item received weighted values from 1 (strongly disagree) to 6 (strongly agree). The weighted values for the negative items were reversed accordingly that is from 6 (strongly disagree) to 1 (strongly agree). BAMS was chosen because it is considered as a reasonable measure of constructivist beliefs about mathematics. Likewise, BAMIS was chosen because it is considered as a reasonable measure of constructivist beliefs about mathematics instruction (Seaman, Szydlik, Szydlik, & Beam, 2005).

The possible range of scores on each Scale was 20 to 120, with 70 being a neutral score. A score higher than 70 inclined towards informal beliefs about mathematics or mathematics instruction while a score less than 70 inclined towards formal beliefs about mathematics or mathematics instruction (Chen, 2008). The value of the Cronbach's alpha for BAMS and BAMIS were .87

and .88 respectively, indicating a high degree of internal consistency of the items in both Scales.

Results

Primary Teachers' Beliefs about Mathematics

Table 2 shows the means and standard deviations of the 157 primary teachers' beliefs about mathematics for each item in BAMS and overall beliefs about mathematics. As seen in Table 2, the means of the primary teachers' beliefs about mathematics for all items in the questionnaire were above 3.5 (neutral), except for Item 4 and Item 8, suggesting that the teachers generally showed slightly informal beliefs about mathematics. The mean for Item 4 (3.41) was slightly lower than 3.5, indicating that the teachers showed slightly formal beliefs that 'The laws and rules of mathematics severely limit the manner in which problems can be solved'.The mean for Item 8 (2.62) was moderately lower than 3.5, suggesting that the teachers showed moderately formal beliefs that 'In mathematics there is usually just one proper way to do something'. The highest mean of the teachers' beliefs about mathematics was 4.90 (Item 5), indicating that the teachers showed moderately informal beliefs that 'Studying mathematics helps to develop the ability to think more creatively'.

Primary teachers' beliefs about mathematics instruction

Table 3 shows the means and standard deviations of the 157 primary teachers' beliefs about mathematics instruction for each item in BAMIS and overall beliefs about mathematics instruction. As illustrated in Table 3, the means of the primary teachers' beliefs about mathematics instruction for all items in the questionnaire were above 3.5 (neutral), except for Item 37 and Item 39, suggesting that the teachers generally showed slightly informal beliefs about mathematics instruction. The mean for Item 37 (3.33) was slightly lower than 3.5, indicating that the teachers showed slightly formal beliefs that 'Students should be expected to use only those methods that their text or teacher uses'.The mean for Item 39 (3.34) was also slightly lower than 3.5, suggesting that the teachers showed slightly formal beliefs that 'All students should be required to memorize the procedures that the text uses to solve problems'.The highest mean of the teachers' beliefs about mathematics instruction was 4.78 (Item 21), indicating that the teachers showed moderately informal beliefs that 'The teacher should always work sample problems for students before making an assignment'.

Table 2
Descriptive Statistics of Primary Teachers' Beliefs about Mathematics

Item	Statement	Mean	SD
1	Solving a mathematics problem usually involves finding a rule or formula that applies.	4.40	.71
2	The field of math contains many of the finest and most elegant creations of the human mind.	4.50	.86
3	The main benefit from studying mathematics is developing the ability to follow directions.	4.11	.84
4	The laws and rules of mathematics severely limit the manner in which problems can be solved.	3.41	.95
5	Studying mathematics helps to develop the ability to think more creatively.	4.90	.78
6	The basic ingredient for success in mathematics is an inquiring nature.	4.56	.94
7	There are several different but appropriate ways to organize the basic ideas in mathematics.	4.48	.71
8	In mathematics there is usually just one proper way to do something.	2.62	1.21
9	In mathematics, perhaps more than in other fields, one can find set routines and procedures.	4.24	.63
10	Math has so many applications because its models can be interpreted in so many ways.	4.53	.79
11	Mathematicians are hired mainly to make precise measurements and calculations for scientists.	4.24	.90
12	In mathematics, perhaps more than in other areas, one can display originality and ingenuity.	4.24	.94
13	There are several different but logically acceptable ways to define most terms in math.	4.38	.73
14	Math is an organized body of knowledge which stresses the use of formulas to solve problems.	4.19	.79
15	Trial-and-error and other seemingly haphazard methods are often necessary in mathematics.	4.11	.99
16	Mathematics is a rigid discipline which functions strictly according to inescapable laws.	3.89	.91
17	Many of the important functions of the mathematician are being taken over by the new computers.	4.17	1.00
18	Mathematics requires very much independent and original thinking.	4.40	.82
19	There are often many different ways to solve a mathematics problem.	4.74	.89
20	The language of math is so exact that there is no room for variety of expression.	3.81	1.00
	Overall beliefs about mathematics (total score)	75.78	6.00

Descriptive Statistics of Primary Teachers' Beliefs about Mathematics Instruction

Item	Statement	Mean	SD
21	The teacher should always work sample problems for students before making an assignment.	4.78	.77
22	Teachers should make assignments on just that which has been thoroughly discussed in class.	3.99	1.06
23	Children should be encouraged to invent their own mathematical symbolism.	3.61	1.10
24	Each student should be encouraged to build on his own mathematical ideas, even if his attempts contain much trial and error.	4.19	.83
25	Each student should feel free to use any method for solving a problem that suits him or her best.	4.52	.86
26	Teachers should provide class time for students to experiment with their own mathematical ideas.	4.35	.88
27	Discovery methods of teaching tend to frustrate many students who make too many errors before making any hoped for discovery.	3.61	.95
28	Most exercises assigned to students should be applications of a particular rule or formula.	4.23	.73
29	Teachers should spend most of each class period explaining how to work specific problems.	4.11	.91
30	Teachers should frequently insist that pupils find individual methods for solving problems.	3.94	.86
31	Discovery methods of teaching have limited value because students often get answers without knowing where they came from.	3.89	.93
32	The teacher should provide models for problem solving and expect students to imitate them.	3.83	.79
33	The average mathematics student, with a little guidance, should be able to discover the basic ideas of mathematics for her or himself.	3.99	.78
34	The teacher should consistently give assignments which require research and original thinking.	4.37	.72
35	Teachers must get students to wonder and explore even beyond usual patterns of operation in math.	4.42	.78
36	Teachers must frequently give students assignments which require creative or investigative work.	4.38	.73
37	Students should be expected to use only those methods that their text or teacher uses.	3.33	1.21
38	Discovery-type lessons have very limited value when you consider the time they take up.	3.64	.85
39	All students should be required to memorize the procedures that the text uses to solve problems.	3.34	1.10
40	Students of all abilities should learn better when taught by guided discovery methods.	4.27	.68
	Overall beliefs about mathematics instruction (total score)	73.29	5.68

Discussion

The results of the study showed that the means of the primary school teachers' beliefs about mathematics for all BAMS items were above 3.5 (neutral), except for Items 4 and 8 indicating that they generally held slightly informal beliefs about mathematics. But, the teachers held slightly formal belief on Item 4 (mean 3.41) that 'The laws and rules of mathematics severely limit the manner in which problems can be solved'. In addition, their formal belief on Item 8 (mean 2.62), 'In mathematics there is usually just one proper way to do something', was stronger than that of Item 4. Nevertheless, the teachers held the strongest informal belief on Item 5 (mean 4.90) that 'Studying mathematics helps to develop the ability to think more creatively'.

These results in general are consistent with the results of Seaman et al. (2005) who found that the elementary education students in 1998 held beliefs about mathematics which were significantly more informal than did their 1968 counterparts at the beginning of their teacher education program. In particular, a majority of the students in both 1968 (Collier, 1972) and 1998 (Seaman et al., 2005), initially held formal beliefs on BAMS items describing mathematics as a collection of rules, formulas, and procedures but in both cohorts the students at the same time held informal beliefs on BAMS items describing mathematics as a creative, flexible endeavor. These results are also consistent with the results of Effandi Zakaria and Norulpaziana Musiran (2010) who found that the beliefs of the Malaysian trainee teachers about the nature of mathematics were more inclined towards the informal or constructivist philosophy. This might be attributed, in part, to the constructivist views of teaching and learning mathematics which are central to the current reform movement in Malaysian mathematics education and advocated by the Malaysian Ministry of Education as evidenced in the Primary School Standard Curriculum (Kementerian Pelajaran Malaysia, 2011).

The results also indicated that the means of the primary school teachers' beliefs about mathematics instruction for all BAMIS items were also above 3.5 (neutral), except for Items 37 and 39, suggesting that the teachers generally showed slightly informal beliefs about mathematics instruction. But, the teachers held slightly formal beliefs on Item 37 (mean 3.33) that 'Students should be expected to use only those methods that their text or teacher uses' and Item 39 (mean 3.34) that 'All students should be required to memorize the procedures that the text uses to solve problems'. Nevertheless, the teachers held the strongest informal belief on Item 21 (mean 4.78) that 'the teacher should always work sample problems for students before making an assignment'.

Generally, these results are also in alignment with the results of Seaman et al. (2005) who found that the elementary education students in 1998 held beliefs about mathematics instruction which were significantly more informal than did their 1968 counterparts at the beginning of their teacher education program. A majority of the students in both 1968 (Collier, 1972) and 1998

(Seaman et al., 2005), initially held formal beliefs on BAMIS items concerning mathematics instruction. These results are also in alignment with the results of Effandi Zakaria and Norulpaziana Musiran (2010) who found that the beliefs of the Malaysian trainee teachers about teaching mathematics were more inclined towards the informal or constructivist philosophy. These results might also be attributed, in part, to the constructivist views of teaching and learning mathematics which are central to the current reform movement in Malaysian mathematics education and advocated by the Malaysian Ministry of Education as evidenced in the Primary School Standard Curriculum (Kementerian Pelajaran Malaysia, 2011).

Acknowledgements

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