

Beliefs about Mathematics, Mathematics Learning and Mathematics Teaching: Views of Some Primary Teacher Education Students in Singapore and Australia

Peter Howard

Australian Catholic University
<p.howard@mary.acu.edu.au>

Bob Perry

University of Western Sydney
<b.perry@uws.edu.au>

Fong Ho Keong

National Institute of Education
Nanyang Technological University
<hkfong@nie.edu.sg>

Teachers' beliefs about a subject and its learning and teaching are known to affect students' learning. A great deal is known about the beliefs of primary mathematics teachers in Australia and other countries but little is known about how these beliefs compare across countries or whether it is even useful to make such comparisons. This paper reports on a international pilot study in which the beliefs of Australian and Singaporean primary student teachers towards mathematics, mathematics learning and mathematics teaching are measured and compared using a validated instrument. The findings are linked to the TIMSS results in these countries and some tentative conclusions drawn which will inform future research.

In the Third International Mathematics and Science Study (TIMSS, 1998), Australian students fared reasonably well in mathematics, with a middle band result. However, a number of Asian countries, including Singapore, scored much higher than Australia, with Singapore gaining first place at each grade level tested. Naturally, there has been some effort made to compare Singaporean mathematics practices with other countries-including Australia-to ascertain possible reasons for the relative rankings. This paper is one attempt at such a comparison.

Teachers' Beliefs about Mathematics and its Learning and Teaching

It is generally agreed that teachers' beliefs about mathematics, mathematics learning and mathematics teaching play a critical role in determining how teachers help their students develop their mathematics (Barnett & Sather, 1992; Pajares, 1992; van Zoest, Jones & Thornton, 1994) even if the precise link between what teachers say (espoused beliefs) and what they do (enacted beliefs) is not nearly so clear (Bishop & Clarkson, 1998; Sosniak, Ethington & Varelas, 1991; Thompson, 1992). It is recognised that a student's prime, but by no means only, source of mathematical experiences is the classroom (Franke, 1988; National Council of Teachers of Mathematics, 1998) and what occurs in the mathematics classroom influences student beliefs (Relich, 1995). The teacher and, in particular, the beliefs of the teacher, are critical to the classroom implementation of mathematics learning and teaching. All teachers hold beliefs towards this learning and teaching. These beliefs influence and guide teachers in their decision making and implementation of teaching strategies (Baroody, 1987). Indeed, it has been suggested that the investigation of beliefs about learning and teaching may well be the most critical factor in educational research (Pajares, 1992).

Given that teachers' beliefs affect the learning and teaching of mathematics, it is important for Australian data on these beliefs to be compared to those from other countries to help understand the relative rankings in studies such as TIMSS. The pilot study reported in this paper involves two groups of primary student teachers-one from Australia and the other from

Singapore-and their responses to a 20 item survey of beliefs which has been used by the authors in previous studies (e.g., Perry & Howard, 1999; Perry, Howard, & Tracey, 1999; Perry, Tracey, & Howard, 1998). Comparisons of beliefs from these two groups are made and possible curricula and cultural reasons for the differences and similarities found are discussed.

Method

Two groups of second year primary teacher education students were the subjects of this pilot study. In Singapore, the 133 students who completed the survey were enrolled at the teacher education institution in the country either in a three year undergraduate degree or a graduate diploma program. In Australia, the 61 students who completed the survey were enrolled in a four year degree course at a Sydney university. The surveys were completed, in class, at the beginning of the students' second year. In both countries, the survey was presented in English - the language of instruction at the universities.

Results

The student teachers from Australia and Singapore responded as shown in Table 1.

Table 1

Percentage Distribution of Responses^a from Australian and Singaporean Primary Student Teachers to the Survey Belief Statements

Belief statement	Australian			Singaporean		
	D	U	A	D	U	A
1. Mathematics is computation	21	28	51	32	12	56
2. Mathematics problems given to students should be quickly solvable in a few steps	71	18	12	58	16	26
3. Mathematics is the dynamic searching for order and pattern in the learner's environment	3	23	74	7	15	78
4. Mathematics is no more sequential a subject than any other	39	33	28	35	35	30
5. Mathematics is a beautiful, creative and useful human endeavour that is both a way of knowing and a way of thinking	7	23	71	0	20	80
6. Right answers are much more important in mathematics than the ways in which you get them	93	57	2	87	8	5
7. Mathematics knowledge is the result of the learner interpreting and organising the information gained from experiences	3	12	85	7	25	68
8. Students are rational decision makers capable of determining for themselves what is right and wrong.	10	38	53	18	35	47

^a Responses: D (disagree); U (undecided); A (agree).

Belief statement	Australian			Singaporean		
	D	U	A	D	U	A
9. Mathematics learning is being able to get the right answers quickly	85	8	7	80	11	10
10. Periods of uncertainty, conflict, confusion, surprise are a significant part of the mathematics learning process	7	18	75	3	14	83
11. Young students are capable of much higher levels of mathematical thought than has been suggested traditionally	5	21	73	7	29	64
12. Being able to memorise facts is critical in mathematics learning	39	31	30	61	20	19
13. Mathematics learning is enhanced by activities which build upon and respect students' experiences	2	8	90	5	9	87
14. Mathematics learning is enhanced by challenge within a supportive environment	2	8	90	5	7	88
15. Teachers should provide instructional activities which result in problematic situations for learners	8	10	82	12	25	63
16. Teachers or the textbook - not the student - are the authorities for what is right or wrong	75	20	5	74	20	5
17. The role of the mathematics teacher is to transmit mathematical knowledge and to verify that learners have received this knowledge	15	25	59	31	21	48
18. Teachers should recognise that what seem like errors and confusions from an adult point of view are students' expressions of their current understanding	5	16	79	9	23	69
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	20	80	8	20	72
20. It is unnecessary, even damaging, for teachers to tell students if their answers are correct or incorrect	59	28	13	43	42	15

Beliefs about Mathematics (Items 1-6)

Very few of the respondents from either country agreed that "right answers are much more important in mathematics than the ways in which you get them" or disagreed that "mathematics is a beautiful, creative and useful human endeavour that is both a way of knowing and a way of thinking" or that "mathematics is the dynamic searching for order and pattern in the learner's environment". Opinion was much more evenly spread on the items "mathematics is computation" and "mathematics is no more sequential a subject than any

other” with the latter item proving not to be particularly useful in separating opinion among the student teachers, just as had been the case in earlier studies (e.g., Perry, Howard, & Tracey, 1999). The only real difference to be discerned between the two national groups occurred with the item “mathematics problems given to students should be quickly solvable in a few steps” with 26% of the Singaporeans agreeing and only 12% of the Australians. An independent groups t-test showed that this difference was statistically significant ($t = 2.28, p < 0.05$).

Beliefs about Mathematics Learning (Items 7-14)

Large proportions of the student teachers from both countries agreed with the statements “mathematics knowledge is the result of the learner interpreting and organising the information gained from experiences”, “periods of uncertainty, conflict, confusion, surprise are a significant part of the mathematics learning process”, “young students are capable of much higher levels of mathematical thought than has been suggested traditionally”, “mathematics learning is enhanced by activities which build upon and respect students’ experiences” and “mathematics learning is enhanced by challenge within a supportive environment”. This suggests that these student teachers have beliefs about mathematics learning which concur to a large extent with much of the current reform agenda in mathematics education (Australian Education Council, 1991; Fong, 1999; National Council of Teachers of Mathematics, 1989, 1998; Curriculum Planning Division, 1995). This suggestion is reinforced by the fact that both groups of student teachers largely disagreed with the statement that “mathematics learning is being able to get the right answers quickly”.

There were two items about mathematics learning which afforded statistically significant differences. Australian student teachers more likely than the Singaporeans to agree with the statements that “mathematics knowledge is the result of the learner interpreting and organising the information gained from experiences” ($t = 2.54, p < 0.05$), and “being able to memorise facts is critical in mathematics learning”, ($t = 2.6, p < 0.05$).

Beliefs about Mathematics Teaching (Items 15-20)

Both groups of student teachers agreed in large measure with the statements “teachers should provide instructional activities which result in problematic situations for learners”, “teachers should recognise that what seem like errors and confusions from an adult point of view are students’ expressions of their current understanding”, and “teachers should negotiate social norms with the students in order to develop a cooperative learning environment in which students can construct their knowledge”, although there were statistically significant differences between the groups on the first ($t = 2.28, p < 0.05$) and last ($t = 2.13, p < 0.05$) of these. In both cases, the Australian group of student teachers was more likely to agree with the statements. Almost identical aggregate responses from the two different groups of student teachers occurred for the statement “teachers or the textbook-not the student-are the authorities for what is right or wrong”, with about three quarters of each response group disagreeing. The statement “it is unnecessary, even damaging, for teachers to tell students if their answers are correct or incorrect” seemed to cause some confusion among both groups with large numbers (28% for the Australian cohort and 42% for the Singaporeans) undecided.

The final statistically significant difference ($t = 2.17, p < 0.05$) between the two country groups of student teachers occurs for the statement “the role of the mathematics teacher is to transmit mathematical knowledge and to verify that learners have received this knowledge”, with more Australians agreeing with the statement than Singaporeans and twice as many Singaporeans than Australians disagreeing with it.

Discussion

As a result of its success in the TIMSS, Singaporean mathematics education has been looked upon with some envy by other countries, particularly Western countries such as the USA and Australia (Menon, 2000; Stigler & Hiebert, 1999). This study represents the beginning of an attempt to map teacher beliefs about mathematics, mathematics learning and mathematics teaching in a number of countries, including Australia and Singapore.

One of the purposes of this pilot study was to identify any difficulties which might arise in the cross-cultural application of the beliefs survey. As well as the perennial problem of the language of the survey not necessarily matching the first language of the respondents—something which can happen in Australia as well as in Asian countries—there is also the possibility that some of the statements have been interpreted in ways which are different from one country to another. While it appears that the survey instrument which was found to be valid for use with teachers in Australia (e.g., Perry, Howard, & Tracey, 1999) seems to be appropriate in eliciting the opinions of student teachers, both in Australia and Singapore, it is intended to interview a sample of the students from each group as a follow up study.

In earlier work with the beliefs survey used in this study, the authors have established the existence of two separate factors upon which most of the items in the survey load for the sample of teachers considered (e.g., Perry, Howard, & Tracey, 1999). These two factors—which have been called ‘transmission’ and ‘child-centredness’—are also confirmed in the student teacher data although not as clearly as for the earlier teacher data. However, they do provide a mechanism for the discussion of differences in the beliefs of the two country groups of student teachers.

There are a great many similarities between the responses of the two groups of student teachers to the belief statements, possibly indicating that the influence of the major studies on mathematics teacher education in Great Britain and the USA (e.g., Cockcroft, 1982; Department for Education and Employment, United Kingdom, 1998; National Council of Teachers of Mathematics, 1989, 1998) has been felt in both Australia and Singapore by mathematics teacher educators and their students. Perhaps these similarities are partly a result of what Nebres (1987) called the ‘canonical mathematical curriculum’. He suggests that:

This canonical mathematical curriculum was simply transplanted to developing countries ...

The result of this long and single-source history of the canonical mathematics curriculum is a very special place for mathematics in the curriculum and a remarkable uniformity of content in mathematics curricula all over the world. This seems strange, of course, considering how diverse the world is in terms of culture and of needs. (Nebres, 1987, p. 14)

Perhaps, the influence of the major reports referred to earlier is further evidence of the implementation of a canonical curriculum, even up to the present day. Whatever is the case, the similarities in beliefs of the two groups of student teachers suggests that there may be an acceptable way in which mathematics education can be, and has been, viewed internationally.

Both groups of student teachers in this study had completed at least a one semester long subject in mathematics education and it must be expected that this would have influenced their responses to the survey. Similarities between the content and approach of these subjects in both universities could be expected to have some effect on the responses of the student teachers.

However, the schooling experiences of the two groups of student teachers has some quite marked differences. For example, in Singapore schools, compared to those in Australia, there is:

- greater time allocated to mathematics;
- an emphasis on examinations and results-including public ranking of schools on the basis of results; and, in many cases,
- a teaching force which has been more successful in mathematics during their own schooling (Menon, 2000).

Perhaps this can help explain some of the differences which were found among the responses from the student teachers from Australia and Singapore.

Even for the statements on which there was a statistically significant difference between the two groups of student teachers, these differences were not large-all were at the 5% level. Nonetheless, the results demand discussion. The Australian teacher education students, as a group, responded significantly more positively than their Singaporean counterparts to the following items:

- Mathematics knowledge is the result of the learner interpreting and organising the information gained from experiences;
- Teachers should recognise that what seem like errors and confusions from an adult point of view are students' expressions of their current understanding;
- Teachers should negotiate social norms with the students in order to develop a cooperative learning environment in which students can construct their own knowledge.

As well, the Australians responded significantly more negatively than the Singaporeans on the statement:

- Mathematics problems given to students should be quickly solvable in a few steps.

These results would suggest that the Australian group of student teachers is tending to be more 'child-centred' and less 'transmission' oriented than their Singaporean colleagues, reinforcing the stereotypical view that Australian teachers 'facilitate' children's mathematics learning while Asian teachers-in this case, Singaporean-actually teach. Menon (2000) suggests that issues such as teachers being appraised on "the number and frequency of exercises and worksheets given to the students" (p. 347) and schools being financially rewarded on their students' performance in public examinations are critical differences between a Western education system, such as in Australia, and the Singaporean system. Such differences could help explain the results described for these four items.

On the other hand, the Australian student teachers, on average, responded significantly more positively to the following statements:

- Being able to memorise facts is critical in mathematics learning; and
- The role of the mathematics teacher is to transmit mathematical knowledge and to verify that learners have received this knowledge.

In the previous work using this survey with teachers, these two items have loaded quite heavily onto the 'transmission' factor. It would seem that the Australians are considering mathematics education in a more traditional manner than their Singaporean counterparts. Perhaps the new primary mathematics in Singapore (Curriculum Planning Division, 1995; Ministry of Education, 1997) and the preparation for teaching this which these students have received has had some effect. The curriculum's emphasis on understanding mathematical concepts and problem solving, thinking skills and creativity (Fong, 1999; Kaur, 1999; Menon,

2000) may mean that the student teachers have, at least to some extent, de-emphasised some of the traditional approaches to mathematics learning and teaching. From the other point of view, the fact that the current New South Wales Mathematics K-6 syllabus was written in the mid-1980s and does not have as strong an emphasis on problem solving, thinking and creativity, might suggest a reason why the Australian teacher education students seem more ready to maintain the traditional approaches, at least in terms of their espoused beliefs. Another possible reason could be the form of secondary courses through which the Australian students would have passed. The formal mathematics courses leading up to the Higher School Certificate examination may very well have emphasised memorisation and transmission, while the corresponding courses in Singapore contain more about the development of particular strategies to solve mathematical problems.

The apparently varying directions of the differences between the beliefs of the two groups of student teachers is a good example of the inconsistency shown on individual belief statements which has been mentioned earlier (Sosniak et al., 1991). It may be that the Australian students feel more comfortable in being eclectic in their approaches while the Singaporean students feel more pressure to conform to the approaches suggested by the central policy makers. It may be that there is less direction in the Australian teacher education course than in that in Singapore about appropriate ways to teach mathematics and this is being reflected in the apparent inconsistencies in response.

Conclusion

In this study, we have investigated the beliefs of two groups of primary student teachers about mathematics, mathematics learning and mathematics teaching. Using an established instrument to measure these beliefs, we have found that the two groups are more alike than not and, perhaps more alike than might have been expected, given their different educational experiences. However, there are some significant differences on some of the belief statements. These may be able to be explained through consideration of the structures of curricula and the nature of experiences in schools and teacher education programs.

This is a pilot study and the real work will involve the analysis of responses of practising teachers in a number of countries, including Australia and Singapore, to the beliefs survey. This will be followed by classroom observations, discussions with teachers and analysis of curriculum documents. There is obviously much more work to be done and this has commenced through the partnerships forged with mathematics educators in Australia and several Asian countries, including Singapore.

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