Beliefs of Primary Teachers about Mathematics and its Teaching and Learning: Views from Singapore, Philippines, Mainland China, Hong Kong, Taiwan and Australia

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

Catherine Vistro-Yu
Ateneo de Manila University
<vistroyu@admu.edu.ph>

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

Ngai-Ying Wong
Chinese University of Hong Kong
<nywong@cuhk.edu.hk>

Fong Ho Keong
National Institute of Education, Singapore
<hkfong@nie.edu.sg>

The authors have been working, separately as well as collaboratively, on the area of teachers' beliefs about mathematics and its learning and teaching for many years. In this paper, they report on the use of one instrument to ascertain measures of the beliefs of a total of 1254 primary school teachers in a number of different cultural contexts. The stimulus for this combined, cross-cultural study has been the variations in results achieved by students in international studies such as the TIMSS and TIMSS-R and the strong evidence that teachers' beliefs about mathematics and its learning and teaching play a critical role in determining how teachers facilitate their students' learning. Hence, differences in teacher beliefs may be one reason for the measured differences in student achievement. The results of the study clearly show that teachers' beliefs in all of the samples can be adequately described in terms of the statements in the survey and that there are there are marked differences in response to these statements across the different groups of teachers.

Introduction

This paper has grown from the long term commitment of the authors to the impact of teachers' beliefs on their teaching and their students' learning of mathematics. Previous studies have suggested that the cultural aspects and contexts of these beliefs are critical in their implications for student learning (Conroy & Perry, 1997; Howard, Perry, & Fong, 2000; Perry & Howard, 1999; Perry, Howard, & Conroy, 1996; Perry, Tracey, & Howard, 1998; Wong, Lam, & Wong, 1998). This paper extends the earlier work, introduces data from further contexts, and builds on the link between student achievements on international, cross-cultural assessments and the beliefs of the teachers involved in the classrooms.

Background

Results of the Third International Mathematics and Science Study (TIMSS) (TIMMS, 1998) and the Third International Mathematics and Science Study – Repeat (TIMSS – R) (Martin, Gregory, & Stemler, 2000; Wang, 2001) have highlighted the approaches of mathematics teachers and the findings of mathematics education researchers in many countries. On the other hand, both studies have also motivated mathematics educators from various parts of the world to engage in smaller-scale comparative studies in mathematics achievement—USA-Japan (for example, Stigler & Hiebert, 1999) and USA-China (for example, Ma, 1999). The objectives of such studies are usually twofold—to confirm results

B. Barton, K. C. Irwin, M. Pfannkuch, & M. O. J. Thomas (Eds.) *Mathematics Education in the South Pacific* (Proceedings of the 25th annual conference of the Mathematics Education Research Group of Australasia, Auckland, pp. 551-558). Sydney: MERGA.

from the TIMSS studies and to gather more in-depth information than TIMSS has been able to collect.

With Singapore topping the mathematics achievement tests for 7th and 8th graders and for 6th and 7th graders (Population II) in TIMSS and TIMSS - R, respectively, it is only natural that some neighbouring countries would want to compare their results. One aspect of comparison is the teacher and, in particular, the beliefs of the teacher. It is well known that these beliefs are critical to what happens in the teacher's mathematics classroom (Barnett & Sather, 1992; Ma, 1999; Pajares, 1992; van Zoest, Jones, & Thornton, 1994) and that they guide the teacher in deciding what teaching and learning strategies are to be valued in that classroom (Baroody, 1987). Hence, in trying to understand fully the results of the international achievement studies, the affective aspects of teaching and learning mathematics, particularly teachers' beliefs, are likely to be important, even though some studies of the TIMSS data itself suggest that this may not be the case (Fullarton & Lamb, 2000). With this in mind, the authors of this paper embarked on their international, cross-cultural study of teacher beliefs about mathematics, and its learning and teaching.

Numerous studies on mathematics teachers' beliefs, attitudes, and conceptions have been reported (Garofalo, 1989; Sosniak, Ethington, & Varelas, 1991; Thompson, 1992) and many have offered implications for classroom reform (Battista, 1994; McLeod, 1992) and mathematics teacher education research (Thompson, 1992). Wong, Lam, & Wong (1998), in their study of students' and teachers' beliefs and views about mathematics learning, found that almost all teachers viewed mathematics as closely related to abstract concepts that required thinking and that may not necessarily be handled merely by routine manipulations. Some disparity was discovered between teachers' and students' beliefs. Nevertheless, the study provided important information on what Hong Kong teachers' believe about mathematics learning. Iida and Yamaguchi (1998) analysed novice and expert elementary teachers' views on the teaching and learning of mathematics in Japan. Both novice and expert teachers were classified as constructivist and non-constructivist. The study showed that constructivist teachers allow for situations that encourage discussion of informal ideas and that provide ease in learning. Moreover, the study showed that expert teachers were more open to arithmetic teaching based on constructivism than novice teachers. At the secondary level in Australia, this result has been supported by Perry, Howard, and Tracey (1999).

Perry and Howard (1999) and Howard, et al. (2000) reported significant differences in the beliefs among elementary teachers from Australia, Singapore and Indonesia concerning mathematics and its teaching and learning. First, they found that Singaporean and Indonesian teachers emphasised mathematics learning as a cognitive concern more than their Australian counterparts. Second, they found that the role of memorisation was more important to Singaporeans compared with Australians and Indonesians. These studies also showed that affect was a major concern in mathematics teaching and learning among teachers in these three countries. Howard, et al. (2000) also established the validity of the instrument devised by the Australian authors of the present paper as appropriate for use to measure the beliefs of teachers in a range of social and cultural contexts in other countries.

It is obviously important to investigate teachers' beliefs about mathematics teaching and learning if we are to gain a fuller understanding of differences in mathematics achievement across a variety of cultural contexts. Teacher beliefs have important consequences for mathematics teaching and learning and provide a glimpse of the teachers'

philosophies of mathematics. Hence, they may help explain some of the differences in achievement noted by the international studies.

Method

Data for this study were gathered using a questionnaire containing 18 items dealing with teacher beliefs about mathematics and its learning and teaching. The questionnaire has been used in earlier studies (see Perry, et al., 1999 for a summary of this background) including cross-cultural studies in Australia, Indonesia, the Philippines and Singapore (Howard, et al., 2000; Perry & Howard, 1999).

For this study, data were gathered from a total of 1254 primary teachers in Singapore (S) (n=162), Philippines (P) (n=189), Changchun, China (CC) (n=111), Hong Kong, China (HK) (n=379), Taiwan (T) (n=161) and New South Wales, Australia (NSW) (n=252). In Singapore, Philippines and New South Wales, the questionnaire was presented in English and in Changchun, Hong Kong, and Taiwan, it was translated into the appropriate Chinese language. These translations were checked by one of the authors using the back-translation technique. Respondents completed the questionnaire by indicating on a three point Likert scale—Disagree, Undecided, Agree—to what extent they agreed with each statement.

Results

The 18 statements which made up the questionnaire are shown below.

Table 1
Belief Statements in Questionnaire

1.Mathematics is computation
2.Mathematics problems given to students should be quickly solvable in a few steps
3.Mathematics is the dynamic searching for order and pattern in the learner's environment
4.Mathematics is a beautiful, creative and useful human endeavour that is both a way of knowing and a way of thinking
5.Right answers are much more important in mathematics than the ways in which you get them
6.Mathematics knowledge is the result of the learner interpreting and organising the information gained from experiences
7.Students are rational decision makers capable of determining for themselves what is right and wrong
8.Mathematics learning is being able to get the right answers quickly
9.Periods of uncertainty, conflict, confusion, surprise are a significant part of the mathematics learning process
10.Young students are capable of much higher levels of mathematical thought than has been suggested traditionally
11.Being able to memorise facts is critical in mathematics learning
12.Mathematics learning is enhanced by activities which build upon and respect students' experiences

13. Mathematics learning is enhanced by challenge within a supportive environment
14. Teachers should provide instructional activities which result in problematic situations for learners
15. Teachers or the textbook – not the student - are the authorities for what is right or wrong
16. The role of the mathematics teacher is to transmit mathematical knowledge and to verify that learners have received this knowledge
17. Teachers should recognise that what seem like errors and confusions from an adult point of view are students' expressions of their current understanding
18. Teachers should negotiate social norms with the students in order to develop a co-operative learning environment in which students can construct their knowledge

For each of the 18 items in the questionnaire, a two-way contingency table analysis was conducted to evaluate whether response to the statement was related to the respondent being a teacher in a particular geographical/cultural context. Significant relationships between response and context ($p<0.001$) were found for all of the statements. Follow up pairwise comparisons were conducted to evaluate the differences in these relationships among the different teacher groups. For every item of the questionnaire, significant differences at the 0.001 level were found between some groups, although not necessarily between all possible pairs. For the purposes of this paper, we have chosen to discuss just two items of particular interest— item 11 representing transmission approaches and item 12 representing child-centred approaches to mathematics learning and teaching (see, for example, Howard et al., 2000; Perry et al., 1998; 1999 for analyses in terms of these two factors). The distribution of responses for each of these questions across the teacher groups are shown in Table 2 and 3. The pattern of differences among the groups on each of these items are shown in Tables 4 and 5.

Table 2
Percentages of Each Teacher Group Responding to Item 11: "Being Able to Memorise Facts is Critical in Mathematics Learning"

Group	Disagree	Undecided	Agree
S	59.3	13.6	27.2
P	36.5	9.0	54.5
CC	24.3	19.8	55.9
HK	1.6	31.1	67.3
T	23.0	24.2	52.8
NSW	28.2	24.2	47.6

Table 3
Percentages of Each Teacher Group Responding to Item 12: "Mathematics Learning is Enhanced by Activities Which Build Upon and Respect Students' Experiences"

Group	Disagree	Undecided	Agree
S	1.2	3.7	95.1
P	5.8	5.8	88.4
CC	5.4	6.3	88.3
HK	23.0	54.6	22.4
T	1.9	1.9	96.3
NSW	0.4	2.8	96.8

Table 4
Differences Among Groups on Item 11: "Being Able to Memorise Facts is Critical in Mathematics Learning" (indicates statistical significance at the p<0.001 level)*

Groups	S	P	CC	HK	T
P	*				
CC	*	NS			
HK	*	*	*		
T	*	*	NS	*	
NSW	*	*	NS	*	NS

Table 5
Differences Among Groups on Item 12: "Mathematics Learning is Enhanced by Activities Which Build Upon and Respect Students' Experiences" (indicates statistical significance at the p<0.001 level)*

Groups	S	P	CC	HK	T
P	NS				
CC	NS	NS			
HK	*	*	*		
T	NS	NS	NS	*	
NSW	NS	*	*	*	NS

Analysis and Discussion

Items 11 and 12 are representative elements of the two major factors which have been identified in earlier studies using the beliefs instrument implemented in this cross-cultural study (Howard, et al., 2000; Perry & Howard, 1999; Perry, et al., 1996; 1998). These two factors—'child-centredness' and 'transmission'—have provided the basis for studying differences between the beliefs of groups of teachers and for linking these to curriculum reform and teacher education movements.

Three key findings appear immediately from an analysis of Tables 2 – 4 above. Firstly, Hong Kong teachers have made significantly different responses to all other groups on each of these statements. Secondly, there are many more significant differences between groups on the 'transmission' statement than on the 'child-centred' statement. Thirdly, both Singaporean and Philippines teachers have made significantly different responses not only to each other but to all other groups on the 'transmission' statement. Possible explanations for these findings are made below, using the experience of the authors in each of the contexts.

The relative timing of curriculum reform in the various countries and the consequent emphasis on understanding over memorisation in curricula may be a feature. Singapore's curriculum has emphasised the understanding of mathematical concepts, problem solving, thinking skills and creativity since its reform in 1997 (Fong, 1999; Kaur, 1999; Menon, 2000). The Singaporean cohort of teachers in this study may be reflecting this change. For Hong Kong, curriculum reform in mathematics came after the implementation of the beliefs survey reported here so responses would not reflect this reform, suggesting that teachers may not yet have problematised the role of memorisation in mathematics learning. Curriculum reform in Australia established constructivist approaches to learning from about 1990, while Taiwan has had two such reforms during the 1990s. The result from the Philippines suggests that the influence from the USA, Canada and Australia through the mathematics education literature coming from these countries and through various collaborations with colleagues may have contributed to the differences in the Filipino teachers' responses. Memorisation is very important to Filipinos because the examination systems encourage it. Curriculum reform, however, is not the whole story, as can be seen in Changchun where new curriculum standards were released only in 2001.

Teacher education and the quality of the teachers as mathematicians may also be a telling difference between Hong Kong and Singapore. All Singaporean teachers undertake their teacher education in one university which is closely linked to the Ministry of Education. There is a coherence of purpose which results from both the quality of the mathematical experiences which teachers have experienced during their own schooling (Menon, 2000) and their teacher education. In Hong Kong, many elementary teachers don't have a degree and of those who do, very few have majored in mathematics. As well, the level of support from professional associations of teachers of mathematics in Singapore is much higher than in Hong Kong. These features may combine to make the Singaporean teachers more open to reform and more comfortable in their own abilities to undertake such reform.

On Item 12, the high averages recorded by the Singaporean, Taiwanese and Australian teachers (almost total agreement in the three cases) suggests that the rhetoric of reform has been heard. This may also be the case for the Philippines teachers where influences from the field of psychology are very strong among elementary teachers. Thus, belief in child-centred methods may be strongly held but not concretely translated into action. On the other hand, Changchun and Taiwan teachers seem to reflect the respect they have for their students and their experiences (see, for example, Ma, 1999) without having this reinforced by recent reform documents. The response by the Hong Kong teachers is consistent with their response to Item 11 and further emphasises the importance of traditional transmission modes of learning and teaching to this cohort of teachers. As one Hong Kong teacher suggested:

Transmission is direct, fast and objective. The process of discovery is a long process in which students might discover something that is outside of teachers' expectations. Teachers also have difficulty knowing whether or not what students have discovered is correct. On the other hand, transmission is more direct. Teachers only have to check the numerical answer to see if students are correct.

Conclusion

In this paper, we have been able to only just scratch the surface of the data which has been gathered in this study. Nevertheless, there are many clear distinctions which can be seen in terms of the differences in educational practices and policies of the different groups of teachers. Whether we can explain some of the differences that have been measured on international achievement tests in terms of the beliefs pattern measured is a moot point. However, we do know that the beliefs of teachers do make a difference in what happens in the classroom and that what happens in the classroom is an important factor in students' learning of mathematics.

The collaboration which is evident in this study, along with much higher profile studies such as those by Ma and by Stigler and his colleagues, augurs well for future work in the area of cross-cultural studies of mathematics learning and teaching. Our contribution is to suggest that the area of teacher beliefs is one which is critical to this work.

Acknowledgment

The research reported in this paper was made possible though internal research grants from the University of Western Sydney and the Australian Catholic University.

The authors wish to acknowledge the assistance of Professor Y. Ma, North Eastern Normal University and Professor P. J. Lin, Hsinchu Teachers College in the collection of data in Changchun and Taiwan respectively and Mella Cusack for her data entry skills.

References

Barnett, C., & Sather, S. (1992). Using case discussions to promote changes in beliefs among mathematics teachers. Paper presented at the American Educational Research Association Meeting. San Francisco, May.

Baroody, A. (1987). *Children's mathematical thinking*. New York: Teachers College Press.

Battista, M. T. (1994). Teacher beliefs and the reform movement in mathematics education. *Phi Delta Kappan, 75*(6), 462-470.

Conroy, J., & Perry, B. (1997). Australian and Indonesian student teacher beliefs about mathematics and performance on a classic ratio task. In E. Pehkonen (Ed.) *Proceedings of the Twenty-first Conference of the Psychology of Mathematics Education Group* (pp. 177-184). Lahti, Finland: PME.

Fong, H. K. (1999). *Top marks.* Singapore: Pearson Education Asia.

Fullarton, S., & Lamb, S. (2000). Factors affecting mathematics achievement in primary and secondary schools: Results from TIMSS. In J. Bana & A. Chapman (Eds.) *Mathematics education beyond 2000* (pp. 258-266). Perth: MERGA.

Garofalo, J. (1989). Beliefs and their influence on mathematical performance. *Mathematics Teacher, 82*(7), 502-505.

Howard, P., Perry, B., & Fong, H. K. (2000). Beliefs about mathematics, mathematics learning and mathematics teaching: Views of some primary teacher education students in Singapore and Australia. In J. Bana & A. Chapman (Eds.) *Mathematics education beyond 2000* (pp. 331-338). Perth: MERGA.

Iida, S., & Yamaguchi, T. (1998). The analysis of teachers' views on teaching and learning mathematics from the constructivist perspective. In H. S. Park, Y. H. Choe, H. Shin, & S. H. Kim (Eds.), *Proceedings of the ICMI-East Asian Regional Conference on Mathematical Education, Volume 2* (pp. 433 - 446). Chungbuk, Korea: Korea Society of Mathematical Education.

Kaur, B. (1999). Mathematics classrooms of Singapore schools: Implications for fostering thinking and creativity. In E. B. Ogena and E. F. Golla (Eds.). *Mathematics for the 21st Century* (pp. 193-198). Manila, Philippines: 8th South East Asian Conference on Mathematics Education.

Ma, L. (1999). *Knowing and teaching elementary mathematics.* Mahwah, NJ: Lawrence Erlbaum.

Martin, M. O., Gregory, K. D., & Stemler, S. E. (2000). *TIMSS 1999: Technical report.* Chestnut Hill, MA: TIMSS International Study Center.

McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. In D. A. Grouws (Ed.), *Handbook of Research on Mathematics Teaching and Learning* (pp. 575 - 596). New York: Macmillan.

Menon, R. (2000). Should the United States emulate Singapore's education system to achieve Singapore's success in the TIMSS. *Mathematics Teaching in the Middle School, 5*(6), 345-347.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307-322.

Perry, B., & Howard, P. (1999). Beliefs about learning and teaching of mathematics: views from Australia, Singapore and Indonesia. In E. B. Ogena and E. F. Golla (Eds.). *Mathematics for the 21st Century* (pp. 311-318). Manila, Philippines: 8th South East Asian Conference on Mathematics Education.

Perry, B., Howard, P., & Conroy, J. (1996). K-6 teacher beliefs about the learning and teaching of mathematics. In P. C. Clarkson (Ed.), *Technology in Mathematics Education* (pp. 453-460). Melbourne: Deakin University Press.

Perry, B., Howard, P., & Tracey, D. (1999). Head mathematics teachers' beliefs about the learning and teaching of mathematics. *Mathematics Education Research Journal, 11*(1), 39-53.

Perry, B., Tracey, D., & Howard, P. (1998). Elementary school teacher beliefs about the learning and teaching of mathematics. In H. S. Park, Y. H. Choe, H. Shin, & S. H. Kim (Eds.). *Proceedings of the ICMI-East Asian Regional Conference on Mathematical Education, Volume 2* (pp. 485-498). Chungbuk, Korea: Korea Society of Mathematical Education.

Sosniak, L. A., Ethington, C. A., & Varelas, M. (1991). Teaching mathematics without a coherent point of view: Findings from the IEA Second International Mathematics Study. *Journal of Curriculum Studies, 23*(2), 119-131.

Stigler, J., & Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom.* New York: The Free Press.

TIMSS (1998). *TIMSS highlights from the primary grades.* Available on-line from http://www.csteep.bc.edu/TIMSS1/HiLightA.html.

Thompson, A. G. (1992). Teachers' beliefs and conceptions: A synthesis of the research. In D. A. Grouws (Ed.), *Handbook of Research on Mathematics Teaching and Learning* (pp. 127 - 146). New York: Macmillan.

Van Zoest, L. R., Jones, G. A., & Thornton, C. A. (1994). Beliefs about mathematics teaching held by pre-service teachers involved in a first grade mentorship program. *Mathematics Education Research Journal, 6*(1), 37-55.

Wang, J. (2001). TIMSS primary and middle school data: Some technical concerns. *Educational Researcher, 30*(6), 17-21.

Wong, N., Lam, C., & Wong, K. P. (1998). Students' and teachers' conceptions of mathematics learning: A Hongkong study. In H. S. Park, Y. H. Choe, H. Shin, & S. H. Kim (Eds.), *Proceedings of the ICMI-East Asian Regional Conference on Mathematical Education, Volume 2* (pp. 375 - 404). Chungbuk, Korea: Korea Society of Mathematical Education.