THE BELIEFS OF PRE-SERVICE PRIMARY AND SECONDARY MATHEMATICS TEACHERS, IN-SERVICE MATHEMATICS TEACHERS, AND MATHEMATICS TEACHER EDUCATORS

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This paper presents a comparison of the responses to nine beliefs items and one confidence item of samples of Australian mathematics teachers, pre-service primary teachers, pre-service secondary mathematics teachers, and mathematics teacher educators. Significant differences were found between each pair of groups. The implications of these for the effectiveness of mathematics teacher education and professional learning for mathematics teachers are discussed.

TEACHER BELIEFS

Teachers' beliefs influence practice in subtle but powerful ways (Bray, 2011). Beliefs about the nature of mathematics, mathematics teaching and mathematics learning have been considered most relevant to practice and have been the focus of much research in the area. In relation to the nature of mathematics, Ernest (1989) identified three philosophies comprising systems of beliefs. The first, an Instrumentalist view, regards mathematics as a set of useful skills for practical purposes. The second, the Platonist view, sees the discipline as a structured body of pre-existent knowledge. According to the third view, Problem-Solving, mathematics is a creative human activity and product.

Ernest and others have considered beliefs about mathematics teaching and learning that follow from these views of the discipline. Van Zoest, Jones and Thornton (1994), for example, conceptualised three views of mathematics teaching. These were Content-focused with an emphasis on performance, Content-focused with an emphasis on understanding, and Learner-focused. Beswick (2005) used a modification of Ernest's work to identify three views of mathematics learning that align with each of his philosophies. These were, Skill mastery, passive reception of knowledge; Active construction of understanding; and Autonomous exploration of own interests.

There has been a trend towards incorporating teachers' beliefs research into studies of teacher knowledge because of the practical difficulty of distinguishing them and/or theoretical arguments about their equivalence (e.g., Kuntze, 2012). This paper arose from a study of teacher knowledge, conceptualised to include their beliefs. It focuses on broad beliefs about the nature of mathematics, and mathematics teaching and learning and draws upon seminal work of Ernest (1989) and others, on conceptualising mathematics teachers' beliefs, to allow data on mathematics teacher educators' (MTEs) beliefs to be considered in the context of established understandings about pre-service teachers (PSTs) and in-service teachers' (MTs) beliefs, and for comparisons among various groups to be made. The research question that guided the

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study was: What differences are there between the beliefs of primary and secondary PSTs, MTs and MTEs?

Pre-service teachers' beliefs

PSTs commence their university study with beliefs based on their own experiences of learning mathematics at school (Van Es & Conroy, 2009). PSTs' beliefs about mathematics have been characterised as fixed and hence aligned with Ernest's Instrumentalist or Platonist views. Similarly, Philipp, et al., (2007) reported that many PSTs see mathematics as a collection of rules and procedures. This is problematic for MTEs conducting teacher education programs underpinned by constructivist views of learning, and student-centred teaching that emphasises conceptual understanding. Beswick and Goos (2012) reported that primary PSTs responded positively to beliefs items reflecting a student-centred approach to teaching but that their responses to items about the nature of mathematics were more ambiguous suggesting that the nature of the discipline may have received too little attention in their teacher education programs.

Many studies have reported favourably on the effectiveness of teacher education programs in influencing PSTs' beliefs to be more compatible with student-centred teaching but almost always accompanied by caution about depth and longevity of observed changes (e.g., Conner, Edenfield, Gleason, & Ersoz, 2011). Studies of primary PSTs appear more common than those involving secondary PSTs but the research that has been conducted with the secondary group has contributed important insights to conceptualisations of the belief structures of secondary MTs and their development (e.g., Cooney & Shealy, 1997). Implicit in this is an assumption of consistency between the beliefs of secondary PSTs and MTs.

In one of few comparative studies of the attitudes and beliefs of primary and secondary PSTs, Kalder and Lesik (2011) found that primary PSTs who had not chosen to specialise in mathematics teaching were more likely than secondary PSTs to have negative attitudes to and beliefs about mathematics.

In-service mathematics teachers' beliefs

Studies of MTs' beliefs have been in the context of professional learning (PL) initiatives aimed at influencing them in similar ways as described in relation to PSTs (e.g., Kuntze, 2012); describing and categorising them (Kalder & Lesik, 2011), or exploring their connection with practice (e.g., Beswick, 2005). Archer (1999) interviewed 17 primary teachers and 10 secondary MTs in order to compare their beliefs. She found that primary teachers were more inclined than secondary MTs to see mathematics as linked to everyday life and to other areas of the curriculum. In contrast, secondary teachers tended to see it as a self-contained, orderly and logical. It seems that primary teachers are inclined to hold Instrumental views of mathematics (Ernest, 1989) whereas secondary MTs are more likely to have a Platonist view.

Mathematics educators' beliefs

The beliefs of MTEs have received little attention, however, Callingham, Beswick, Clark, Kissane, Serow, & Thornton (2012) reported on the knowledge (including beliefs) of MTE members of the Mathematics Education Research Group of Australasia (MERGA) using the same instrument as used with primary and secondary PSTs. They reported that the MTEs found the beliefs items more difficult to endorse than did PSTs. There were no differences for different employment types (continuing, fixed term, and casual) or length of tertiary teaching experience other than for those with more than 16 years of experience who were less inclined to endorse the items.

Differences among the beliefs of various groups

Ashman and McBain (2011) investigated the beliefs about mathematics teacher education of primary MTs and PSTs. They found a tendency among both groups to value classroom experience over university study, but that both groups shifted to a more balanced view of the relative value of learning in the two contexts following a semester long intervention that involved substantial interaction between MTs and PSTs as well as liaison with MTEs.

The effectiveness of MTEs' work with PSTs, and with MTs in the context of PL, depends upon their capacity to influence. If there are important differences between the ways in which MTEs and PSTs or MTs view mathematics and its teaching and learning, and these are neither acknowledged nor addressed, MTEs' ability to influence may be compromised. Differing beliefs of experienced MTs and/or MTEs and newly graduated MTs may contribute to both the importance that PSTs place on learning during practicums (Korthagen, 2010) and to the fact that many beginning teachers perpetuate the teaching that they experienced in school (Ball, 1990). Differing beliefs may also contribute to the perceived theory-practice gap that has concerned researchers, teacher educators, and teachers (Korthargen, Loughran, & Russell, 2006). Studies, such as that reported here, that examine the nature and extent of belief differences between PSTs, MTs, and MTEs are thus important and timely.

THE STUDY

The PST data reported and discussed in this paper were part of a larger Australian study of the knowledge required to teach mathematics. Aspects of the study related to primary PSTs and the use of the survey with MTEs have been reported elsewhere (e.g., Beswick & Goos, 2012; Callingham et al., 2012). This paper focuses on the responses to beliefs items for these cohorts and for MTs and secondary mathematics PSTs.

Instrument and procedure

Data about participants' beliefs were collected as part of an online survey that also included questions designed to examine their mathematical content and pedagogical content knowledge. Due to constraints on the overall length of the survey the beliefs items were limited to the nine Likert type items listed in Figure 1. They required responses on 5-point scales from Strongly Disagree to Strongly Agree. The three items concerning each of beliefs about the nature of mathematics (Items 1, 4 and 7), mathematics teaching (Items 2, 5 and 8), and mathematics learning (Items, 3, 6 and 9), were modified from existing sources (e.g., Van Zoest et al., 1994). A tenth item asked respondents to rate on a similar scale their confidence to teach the mathematics at the level they were or would be qualified to teach.

1. Mathematics is a beautiful and creative human endeavour.
2. Periods of uncertainty and confusion are important for mathematics learning.
3. Acknowledging multiple ways of mathematical thinking may confuse children.
4. Mathematical ideas exist independently of human ability to discover them.
5. Students learn by practicing procedures and methods for performing mathematical tasks.
6. Teachers must be able to represent mathematical ideas in a variety of ways.
7. The procedures and methods used in mathematics guarantee right answers.
8. Justifying mathematical thinking is an important part of learning mathematics.
9. The teacher must be receptive to the students' suggestions and ideas.

Figure 1: The nine beliefs items

The survey was made available to PSTs at seven Australian universities, to MTs through the website of the Australian Association of Mathematics Teachers (AAMT), and to MTEs through the MERGA website. Respondents accessed the survey via an anonymous link. An analysis of variance using SPSS, was used to examine differences in mean responses among the groups to the beliefs and confidence items.

Participants

Participants comprised 294 primary PSTs and 86 secondary mathematics PSTs. Most (81.6%) of the primary PSTs had not studied mathematics or statistics beyond secondary school. Of these 58.3% (47.6% of the whole PST sample) had studied a Year 12 mathematics subject that could contribute to university entrance, and 18.3% (15% of whole sample) reported Year 10 as the highest level of mathematics studied. A similar percentage (13.6%) had studied some university mathematics or statistics. Nearly half (48.2%) of the secondary PSTs had studied mathematics or statistics as part of a bachelor degree and a further 5.8% reported postgraduate study of these subjects. Some of the secondary PSTs (12.9%) had studied no mathematics beyond Year 10 or had studied a Year 12 subject that did not count for university entrance.

The 57 MTEs and 65 MTs were drawn from every Australian state and territory. Most of the MTEs (77.2%) had post-graduate qualifications but 29.8% had not studied tertiary level mathematics. Almost half had been working in universities for 5 years or less and 38.4% had taught in schools for at least 15 years. Of the MTs, 35% reported having postgraduate degrees and 51.2% were more than 50 years old. Three quarters (75.4%) had studied mathematics or statistics at tertiary level. Almost two thirds (63.5%) taught secondary school mathematics. This profile is consistent with the MTs having been recruited through the AAMT website and hence likely to members of that association and to consider themselves to be specialist MTs.

RESULTS

Differences were found for all beliefs items except Items 6 and 9, and for the confidence item. For Item 1 MTs, MTEs and secondary PSTs all agreed more strongly than primary PSTs, $F(3, 470) = 37.767$, $p = .000$ in each case. For Item 2, MTs and MTEs agreed more strongly than Primary PSTs, $F(3, 470) = 4.468$, $p < .05$. In relation to Item 3 both groups of PSTs agreed more strongly than each of MTs and MTEs, $F(3, 469) = 13.152$, $p < .01$ in each case. The only difference for Item 4 was between MTs and MTEs with the former group agreeing more strongly, $F(3, 468) = 3.340$, $p = .015$. For Item 5, MTEs agreed less strongly than all other groups, $F(3, 463) = 12.201$, $p = .000$ in each case. Both groups of PSTs agreed more strongly with Item 7 than did MTEs, $F(3, 461) = 6.806$, $p = .000$ in each case. For Item 8 both MTs and MTEs agreed more strongly than Primary PSTs, $F(3, 462) = 6.772$, $p = .001$ for primary PSTS and $p = .024$ for secondary PSTs. MTs and MTEs were more confident than each of the PST groups, $F(3, 459) = 29.622$, $p < .01$ in each case.

There were significant differences between MTEs and primary PSTs for Items 1, 2, 3, 5, 7, and 8 with MTEs more likely to view mathematics as a “beautiful and creative human endeavour”, and to agree that periods of confusion and uncertainty, and justifying mathematical thinking are important to mathematics learning. PSTs were more likely than MTEs to believe that students learn by practicing procedures, that procedures guarantee right answers, and that acknowledging multiple ways of thinking mathematically could confuse students.

MTs and primary PSTs responded significantly differently to Items 1, 2, 3, and 8, with MTs, more likely than primary PSTs to view mathematics as a “beautiful and creative human endeavour”, and to agree that periods of confusion and uncertainty, and justifying mathematical thinking, are important to mathematics learning. Primary PSTs were more likely to believe that acknowledging multiple ways of thinking mathematically could be confusing.

Significant differences between MTEs and secondary PSTs were found for Items 3, 5, and 7, with secondary PSTs more likely to believe that students learn by practicing procedures, that these procedures guarantee right answers, and that acknowledging multiple ways of thinking mathematically could confuse students.

MTEs and MTs differed for Items 4 and 5, with MTs more likely to believe mathematical ideas are pre-existing and that students learn by practising procedures. The only significant difference between the PST groups was in relation to Item 1, with secondary PSTs more likely to see mathematics as a “beautiful and creative human endeavour”. MTEs and MTs were more confident than both PST groups.

DISCUSSION

Primary PSTs were less likely than other groups to agree that “Mathematics is a beautiful and creative human endeavour” (Item 1), and less likely than both MTs and MTEs to agree that “Periods of uncertainty and confusion are important for mathematics learning" (Item 2) and that "Justifying mathematical thinking is an important part of learning mathematics" (Item 8). Both of these results are consistent with the well-documented unease that this group have with the discipline (Kalder & Lesik, 2011). Many regard mathematics with fear and dislike and many of their own experiences of uncertainty and confusion in learning mathematics may not have resulted in eventual understanding. Similarly, they may not have had positive experiences of having to justify their mathematical thinking.

Both groups of PSTs were more likely than MTs or MTEs to agree that "Acknowledging multiple ways of mathematical thinking may confuse children" (Item 3), and more likely than MTEs to agree that "the procedures and methods used in mathematics guarantee right answers" (Item 7). Acknowledging multiple ways of mathematical thinking is broadly consistent with progressive views of mathematics teaching as described by Beswick (2005) and so this result suggests that the PSTs had views less aligned with reform teaching than did MTEs and MTs. The results for this item are, however, difficult to interpret because some may have agreed because they regarded confusion as a negative experience to be avoided whereas others may have agreed but regarded confusion as a necessary to achieving greater understanding. Item 7 is consistent with an Instrumentalist view of mathematics (Ernest, 1989). The results for this item are thus consistent with the stronger Problem solving view of the discipline of MTs and MTEs than primary PSTs evident from the data for Item 1.

MTEs were less likely than all other groups to agree that "Students learn by practicing procedures and methods for performing mathematical tasks" (Item 5). This statement is broadly consistent with a Skill mastery, passive reception of knowledge view of mathematics teaching (Beswick, 2005) and contrary to an emphasis on teaching for understanding that is prevalent in mathematics education literature. It is also consistent with the apparent counteractive effect of the practicum on the changes in beliefs that MTEs strive to instil in PSTs (e.g., Conner et al., 2011). Given that the MTs in this study were well qualified, largely experienced, and engaged with their profession, this result should not be dismissed lightly. It could be that distance from the reality of mathematics classrooms causes MTEs to adopt less nuanced rhetoric in regard to this and possibly other pedagogical issues.

MTs were more likely than MTEs to agree that, "Mathematical ideas exist independently of human ability to discover them". This item expresses a broadly Platonist view of the discipline (Ernest, 1989) and so the result is consistent with that for Item 1. The greater confidence of MTs and MTEs than PSTs is consistent with their relative experience.

Consideration of Items 1, 4 and 7 together suggests that the MTEs tended to hold views of the nature of mathematics most closely aligned with a Problem Solving view of the discipline, MTs were more likely to be Platonists, and PSTs, particularly primary PSTs, more inclined to hold Instrumentalist views. In relation to mathematics learning as reflected in Items 2, 5, and 8, a similar ordering of perspectives is evident. For mathematics teaching there was, however, a difference between the groups only for

Item 3. That result is consistent with MTs and MTEs having more learner-focussed views of mathematics teaching than PSTs but given the interpretative difficulties associated with Item 3 and the absence of differences for other teaching related items it is not clear that beliefs about teaching fit the same pattern. Rather, the teaching practices endorsed by the four groups are little different in spite of differences in their beliefs about the nature of mathematics and how it is learned. This accords with evidence that beliefs about mathematics and its teaching and learning manifest in practice in subtle ways (Bray, 2011) and that some MTs confound the discipline with the mathematics of the school curriculum (Beswick, 2012).

CONCLUSION

This study represents an initial attempt to compare the beliefs of MTs, MTEs and primary and secondary PSTs. Beliefs of MTEs are particularly under-researched. The extent to which MTEs appear to hold different beliefs from either MTs or PSTs points to a need for further exploration of the bases of these differences. It could be that MTEs, a relatively small community in Australia, are susceptible to adopting accepted rhetoric without appropriate critique. Although few, the differences between MTEs and experienced, professionally engaged MTs are relevant considerations in PL work with teachers; to what extent might MTEs be perceived as, or actually be, out of touch with classroom realties? The even greater differences between MTEs and the PSTs, especially Primary PSTs, with whom they work have implicitly been acknowledged but these data should prompt reflection on the extent to which MTEs are able to communicate with PSTs credibly. The beliefs measure used in this study was necessarily crude and so there is scope for far more detailed studies of the issues raised.

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References

Archer, J. (1999). *Teachers' beliefs about successful teaching and learning in mathematics*. Paper presented at the combined meeting of the Australian Association for Research in Education and the New Zealand Association for Research in Education, Melbourne, Australia.

Ashman, D., & McBain, D. (2011). Teacher and preservice teacher beliefs about mathematics teacher education. In J. Clark, B. Kissane, J. Mousley, T. Spencer, & S. Thornton (Eds.), *Mathematics: Traditions and [new] practices*: *Proceedings of the joint conference of the Australian Association of Mathematics Teachers and the Mathematics Education Research Group of Australasia* (pp. 50-58). Adelaide: AAMT and MERGA.

Ball, D. L. (1990). Breaking with experience in learning to teach mathematics: The role of a preservice methods course. *For the Learning of Mathematics*, *10*(2), 10-16.

Beswick, K. (2005). The beliefs/practice connection in broadly defined contexts. *Mathematics Education Research Journal*, *17*(2), 39-68.

Beswick, K. (2012). Teachers' beliefs about school mathematics and mathematicians' mathematics and their relationship to practice. *Educational Studies in Mathematics*, *79*(1), 127-147.

Beswick, K., & Goos, M. (2012). Measuring pre-service primary teachers' knowledge for teaching mathematics. *Mathematics Teacher Education and Development*, *14*(2), 70-90.

Bray, W. S. (2011). A collective case study of the influence of teachers' beliefs and knowledge on error-handling practices during class discussion of mathematics. *Journal for Research in Mathematics Education*, *42*(1), 2-38.

Callingham, R., Beswick, K., Clark, J., Kissane, B., Serow, P., & Thornton, S. (2012). Mathematical knowledge for teaching of MERGA members In J. Dindyal, L. P. Chen & S. F. Ng (Eds.), *Proceedings of the 35th annual conference of the Mathematics Education Research Group of Australasia* (Vol. 1, pp. 162-169). Singapore: MERGA.

Conner, A., Edenfield, K. W., Gleason, B. W., & Ersoz, F. A. (2011). Impact of a content and methods course sequence on prospective secondary mathematics teachers' beliefs. *Journal of Mathematics Teacher Education*, *14*(6), 483-504.

Cooney, T. J., & Shealy, B. E. (1997). On understanding the structure of teachers' beliefs and their relationship to change. In E. Fennema & B. Nelson (Eds.), *Mathematics teachers in transition* (pp. 87-109). Mahwah, N.J.: Lawrence Erlbaum.

Ernest, P. (1989). The impact of beliefs on the teaching of mathematics. In P. Ernest (Ed.), *Mathematics teaching: The state of the art* (pp. 249-253). New York: Falmer.

Kalder, R. S., & Lesik, S. A. (2011). A classification of attitudes and beliefs towards mathematics for secondary mathematics pre-service teachers and elementary pre-service teachers: An exploratory study using latent class analysis. *Issues in the Undergraduate Mathematics Preparation of School Teachers*, *5*, 20-20.

Korthagen, F. A. J. (2010). How teacher education can make a difference. *Journal of Education for Teaching*, *36*(4), 407.

Korthagen, F., Loughran, J., & Russell, T. (2006). Developing fundamental principles for teacher education programs and practices. *Teaching and Teacher Education*, *22*(8), 1020-1041.

Kuntze, S. (2012). Pedagogical content beliefs: Global, content domain-related and situation-specific components. *Educational Studies in Mathematics*, *79*(2), 273-292.

Philipp, R. A., Ambrose, R., Lamb, L. L. C., Sowder, J. T., Schappelle, B. P., Sowder, L.,…Chauvot, J. (2007). Effects of early field experiences on mathematical content knowledge and beliefs of prospective elementary school teachers: An experimental study. *Journal for Research in Mathematics Education*, *38*(5), 438-476.

Van Es, E. A., & Conroy, J. (2009). Using performance assessment for California teachers to examine preservice teachers' conceptions of teaching mathematics for understanding. *Issues in Teacher Education*, *18*(1), 83-102.

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.