BELIEFS: WHAT LIES BEHIND THE MIRROR?

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What a man (sic) believes upon grossly insufficient evidence is an index into his desires -- desires of which he himself is often unconscious. If a man is offered a fact which goes against his instincts, he will scrutinize it closely, and unless the evidence is overwhelming, he will refuse to believe it. If, on the other hand, he is offered something which affords a reason for acting in accordance to his instincts, he will accept it even on the slightest evidence. The origin of myths is explained in this way. (Bertrand Russell)

Introduction

Some years ago, Günter Törner and I, together with Erkki Pehkonen, edited a book - *Beliefs: A hidden variable in mathematics education?* (Leder, Törner, & Pehkonen, 2002). Of the reviews it received, I was particularly taken with the one by John Mason (2004) who set the context for the book as follows:

> The book arose from a working conference held in Oberwolfach in 1999. The task was to come to grips with beliefs and their role in the teaching and learning of mathematics. The first stumbling block is to work out what beliefs actually are, and where they fit into an entire alphabet of associated interlinked terms:
>
> *A is for attitudes, affect, aptitude, and aims; B is for beliefs; C is for constructs, conceptions, and concerns; D is for demeanor and dispositions; E is for emotions, empathies, and expectations; F is for feelings; G is for goals and gatherings; H is for habits and habitus; I is for intentions, interests, and intuitions; J is for justifications and judgements; K is for knowing; L is for leanings; M is for meaning-to; N is for norms; O is for orientations and objectives; P is for propensities, perspectives, and predispositions; Q is for quirks and quiddity; R is for recognitions and resonances; S is for sympathies and sensations; T is for tendencies and truths; U is for understandings and undertakings; V is for values and views; W is for wishes, warrants, words, and weltanschauung; X is for xenophilia (perhaps); Y is for yearnings and yens; and Z is for zeitgeist and zeal.*(Mason, 2004, p. 347)

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Though presumably written at least in part "tongue in cheek", Mason's creative beliefs-alphabet provided a strong impetus for a more detailed look at current research on beliefs – a topic of undoubted interest to Günter. Two recently held annual conferences, those of the *International Group for the Psychology of Mathematics Education* [*PME*][2] and of the *Mathematics Education Research Group of Australasia* [*MERGA*][3] served as convenient and timely data sources of recent research.

Conference proceedings, Leder and Grootenboer (2005) confirmed, capture a variety of research endeavors. They typically include findings from masters and doctoral work, from pilot studies, as well as data from larger projects. These are shared with the mathematics education research community in a variety of formats. For the 2007 PME conference refereed activities comprised Research Forums, Research Reports, Short Oral presentations, and Poster Presentations. For a limited number of sessions more active attendees' participation was encouraged in Discussion Groups and Working Sessions. Invitational plenary activities - Lectures and a Plenary Panel – were also part of the program. A similar, though slightly narrower, range of activities was offered at the 2007 MERGA conference.

A refereeing process is used for both conferences. For example, for the PME conference:

> The Programme Committee received 180 RR [Research report] papers for consideration. Each full paper was blind-reviewed by three peer reviewers, and then these reviews were considered by the Programme Committee, a committee composed of members of the PME international mathematics education community.... In general if there were three or two recommendations for accept, the paper was accepted…. Of the 180 proposals we received, 109 were accepted … [as research reports]. (PME31 Programme Committee, 2007, p. 1-xliii)

A similar approach was used for MERGA conferences:

> All research papers and symposia submitted were blind peer-reviewed (without the author/s being identified), by two experienced mathematics education researchers who followed strict guideline that have been honed over a number of years. Where the two reviewers, who did not know the identity of the other reviewer, disagreed about the acceptability of a paper, another blind review was carried out by a third reviewer. For consistency, a small panel of highly experienced reviewers undertook the task of reviewing papers in this category. Only those research papers that were accepted by two reviewers have been included in these conference proceedings. (Beswick & Watson, 2007, p. iii)

For both conferences Short Oral Communications were also refereed but their acceptance was based on less stringent rules.

Thus, collectively, the Research Reports[4] and Short Oral Communications and their written representations offered a comprehensive overview of recent work judged by peers to be of a worthy standard in the mathematics education research community. The extent to which research on beliefs forms part of that body of work is discussed in the remainder of the paper. Indicative guidelines for reflecting on the quality of the research draw particularly on Hopkins and Antes' (1990) observation that educational research "focuses on the solutions of problems" and "adds to what is known by providing new

[2] The 31st annual PME conference was held in Seoul, Korea, July 8-13, 2007
[3] The 30th annual MERGA conference was held in Hobart, Tasmania, Australia, July 2-6, 2007
[4] PME uses the terminology Research Reports and Short Oral Communications. For MERGA conferences the equivalent terminology is Research Papers and Short Communications. Corresponding terms are used interchangeably in this paper.

knowledge" (p. 23) as well as on Romberg's (1992) list of research activities and in particular "build(ing) a tentative model" and "relat(ing) the phenomenon and model to others' ideas" (p. 51).

The study

The study comprised the following tasks:

1. Identify work presented as Research Reports and Short Oral Communications at the MERGA and PME conferences in 2007 in which issues related to beliefs and mathematics education were mentioned.
2. Describe the methods used to identify or measure beliefs.
3. For papers in which beliefs were considered in some depth, summarize the belief-related findings.

Method

The proceedings for both conferences are available in both hard copy and CD format. The latter readily enables a search to be made for articles which contain the words believe(s) or belief(s). As already indicated, the search focused on Research Reports and Short Oral Presentations[5]. The latter were included because of the large number of such presentations at the 2007 PME conference.

Results

The PME Conference Proceedings

One hundred and five Short Oral Presentations and 109 Research Reports were included in the PME conference proceedings.

Short Oral Presentations

Despite the restricted word length imposed on contributions in this category many authors conveyed the scope of their research effectively.

Close to 20 % of the Short Oral Presentations contained a reference to believe or beliefs. However, in the majority of these the term seemed to be used as a stylistic device or to sketch some background information through a brief reference to previous literature rather than as part of a serious attempt to engage with "beliefs". Examples of such stylistic, non technical usage included:

- "I believe that the study makes a strong case for how increasing and enhancing classroom interaction through task-based teaching can help to foster students' cognitive skills and overall mathematical ability" (Leung, 2007, 1-258)[6], and
- "In conclusion, the researcher believed that, in an effort to enhance the professional development, (the) teacher needs to explore an innovative teaching technology" (Phachana & Kongtaln, 2007, 1–274).

Context setting examples included

- " Research has found that the beliefs teachers have regarding mathematics, including their level of mathematical confidence, have a significant impact on their practice of teaching, and hence on the confidence of their students" (Burgoyne, 2007, 1-201); and
- "Learning to teach can be seen as a process of identity formation that brings together one's past experiences, present beliefs and future possibilities" (Prescott & Cavanagh, 2007,1-276).

[5] Initially I had intended to focus only on Research Reports. However, because of the exceptionally large number of Short Oral Presentations at the 2007 PME conference I was concerned that much relevant information might be missed if these presentations were ignored.

[6] Reference details are given at the end of the paper. They conveniently capture the many different topics within which belief-related concerns were embedded.

In only three of the Short Oral communications did beliefs appear to be the central focus of the research presented. These, summarised in Table 1, relied on a small sample and used multiple instruments to tap participants' beliefs. The strong reliance on qualitative, high inference measures is noteworthy.

Table 1: Short Oral Presentations with a strong focus on beliefs

Author	**Study focus**	**Measurement**	**Findings included**
Krzywacki-Vaino & Pehkonen	Exploration of teacher identity by focusing on one pre-service teacher	Semi structured interviews and some written material (Subject's work)	Feelings and beliefs about teaching mathematics and being a teacher differ.
Rughubar-Reddy	Students' beliefs and attitudes towards mathematical literacy and values transmitted by the teacher. One male and one female student were the key informants	Interviews, questionnaires, journals, and classroom observations	The two students differed in the values they acknowledged. Their beliefs were reflected in their classroom behaviors.
Sumpter	Influence of beliefs on mathematical reasoning used in problem solving	Video records of students' solving of tasks, interviews, and questionnaires	Safety / security beliefs, expectations and motivations, rather than mathematical knowledge, influenced strategy choice.

Research Reports

Approximately half of the Research Reports, 55, referred to beliefs. Despite the more generous word length permitted for Research Reports, in the majority reference to beliefs was again restricted to stylistic usage or to setting the context for the research described in the rest of the paper. Two examples are given below:

- A paper headed *Elementary education students' memories of mathematics in family context* (Hannula, Kaasil, Pehkonen, & Laine, 2007) contained a brief reference to parental and children's beliefs in the introductory section. In the general description of the project, students' "beliefs" was among the variables hypothesized to be predictive of mathematics achievement. Yet there was no further mention of "beliefs" *per se* in the remainder of the paper. Instead participants' narratives dwelled on getting help, role models, value of mathematics, encouragement / demands, independence, and helping siblings".
- In their research report *What is a beautiful problem? An undergraduate students' perspective* Koichu, Katz, and Berman (2007, 3-113) described "investigat(ing) high school students, undergraduate students and mathematics teachers' beliefs and actions through the lens of mathematical aesthetics …" as one of the aims of their project. Yet beliefs were rarely mentioned in the rest of the report. The "theoretical background section" contained a brief reference to beliefs. In a whole group discussion, students were asked to express "their beliefs about what a beautiful problem is". The rest of the paper was silent on beliefs. Instead the authors used words like opinion, perception, perspective, conception, and self esteem.

In both these papers, as well in many others in which the links between beliefs and behaviors are acknowledged, the authors' conceptualization of beliefs remained elusive and intangible.

Those papers, 14 (i.e., 13 %), in which belief-related concerns comprised a core component, and in which attempts are made to measure beliefs, are summarized in Table 2. Table entries focus on the "belief" aspects even if other issues were also covered in the paper.

Table 2: Research Reports with a strong focus on beliefs, PME 2007 conference

Author	**Study focus**	**Measurement**	**Findings included**
Baturo, Cooper, & Doyle	Professional development (PD) program for 11 indigenous mathematics teacher assistants.	Observations during the PD program, interviews, and a 5-point rating scale which included assessing "affects and beliefs"	Participants' affects, "motivation and confidence" about mathematics and mathematics tutoring improved.
Chapman	Use of inquiry approaches by secondary pre-service mathematics teachers, N = 2	Interviews, classroom observations, and teaching documents	Beliefs about mathematics and beliefs about students' learning contributed to the participants' "sense making of using inquiry approaches".
Ng, Stillman & Stacey	Effect of interdisciplinary project work on Singapore students' perceptions of mathematics, N = 409 students aged 12-14.	5-point Likert scales administered before and after specially devised project work	Perceptions of interconnectedness comprised two broad factors: inter-subject learning and beliefs and efforts in making connections. Some gender and stream differences were found.
Forgasz & Mittelberg	Comparison of 215 grade 9 Israeli Jewish and Israeli Arab students' beliefs about the gender stereotyping of mathematics	Mathematics as a Gendered Domain instrument	The Arab Israeli students' gendered views of mathematics were ambiguous and differed from those of the Jewish Israeli students and grade 9 students in Australia and the USA.
Halverscheid & Rolka	Eliciting mathematical beliefs through pictures and associated text	Ratings of drawings created by 5th grade students "to express their views about mathematics"	With training, high inter-rater reliability was achieved coding the pictures as reflecting "instrumentalist", "Platonist" and "problem-solving" views of mathematics.
Kapetanas, & Zachariades	Beliefs and attitudes about studying mathematics, N = 1645 10-12th graders	28 item questionnaire, 10 of which probed beliefs (and 14 focused on attitudes)	Two of the five factors identified concerned beliefs: about "utility of proofs and mathematics" and "mathematical understanding through procedures". Positive correlations were found between these factors and students' performance.
Markovits & Pang	Comparison of Korean and Israeli students' beliefs about mathematics (as well as their performance on mathematical tasks), N = 275 grade 6 students	Six questionnaire items about beliefs. These items were not included in the paper	Korean students preferred exact calculations; Israeli students were more likely to rely on number sense. In the body of the paper reference to beliefs was implicit rather than explicit.
Melo & Pinto	Exploration of affective processes through which one student's "self-image	Attitude questionnaire, written task – a movie script about mathematics, semi structured interviews, and classroom	Intensive interrogation of the data enabled the researchers "to identify beliefs which are grounded in her socio-cultural

Author	Study focus	Measurement	Findings included
	as a mathematics learner" is developed, N = 1	observations	context and in her relations with others, as well as feelings built during her life experience with mathematics … in the classroom". An experienced teacher was not able to modify the student's negative mathematics-related self-image as a learner.
Novotná & Hošpesová	Possible link between the Topaze effect ("spoon feeding" students towards the correct answer) and teachers' beliefs (and influence of this on students' work) N = one 8th grade class	Videotaping of lessons and post-lesson video-stimulated interviews	Evidence that teachers believed their prompts were needed for students to complete assigned tasks successfully.
Olson, Olson, & Okazaki	Parents' competence beliefs for their children's success in mathematics and their children's "self-efficacy and interest in mathematics", and language used when solving mathematical tasks, subset of N = 66 students and 44 parents	Parallel parent and child survey focusing on self-efficacy, value/usefulness, and competency beliefs; videotapes	Major focus on development and validation of instruments and coding procedures. Gender differences were found: "the mother asked more perceptual questions that … require one-word responses whereas the father asked more conceptual questions that focused on relationships and more abstract ideas".
Perger	Link between espoused theory (what students say is best practice) and theory in use (what they do), N = Pasifika 11-13 year olds in one large co-educational school	Semi-structured interviews exploring beliefs about successful mathematics learning; classroom observations	Students believed that they used practices valued and promoted by the teacher: listening to the teacher, listening to others, having time to think, working with others, and asking for teachers' clues. High and low achieving students differed in their understanding of what these practices entailed.
Rolka, Rösken, & Liljedahl	Change in beliefs as conceptual change, N = 39 pre-service primary school teachers	Reflective journal in which participants documented beliefs. Three prompt questions were given.	Whether changes in beliefs occurred depended on the presence of cognitive conflict (identical / approximate / incomplete fit) between the participants' existing beliefs and their course experiences.
Sakonidis & Klothou	Assessment of pupils' written work in mathematics, N = 553 primary school teachers	Assessment of four 10 year old students' solutions to word problems requiring operations with whole numbers.	Teachers' beliefs about the nature of mathematics included: "mathematics is the route to the result", "the student's thought is mathematically logical", "the

Author	Study focus	Measurement	Findings included
			student uses the shortest route and this shows intelligence and correct mathematical thinking".
Wang & Chin	Intervention by mentors in the mathematics teaching of pre-service teachers, N = 8 mentor-practice teachers & their students	Classroom observations focusing on critical incidents of teaching, pre- and post-lesson interviews, mentor-tutor conferences	A mentor's knowledge, beliefs and experiences about (teaching and) mentoring influence intervention decisions and follow-up mentoring strategies. Mentors experience their own critical incidents.

The MERGA Conference Proceedings
Eighty-one Research Reports and 28 Short Communications were presented at the MERGA conference.

Short Oral Presentations
Only two of the Short Communications mentioned beliefs. Because of the severe word length constraints imposed on the written format of these presentations it is difficult to grasp the scope of the research presented from the contents of the proceedings alone. Thus no further analyses were attempted.

Research Reports
Approximately half (46) of the Research reports referred to belief or believe; of these 11, i.e., 14 % of all the research papers, had a sustained focus on beliefs. These latter reports are summarized in Table 3. As for the PME proceedings, papers in which aspects of beliefs featured in the literature review but were not a focal point of the research described are omitted from the table[7].

Table 3: Research Reports with a strong focus on beliefs, MERGA 2007 conference

Author	Study focus	Measurement	Findings include
Bailey	Narrative inquiry by one pre-service teacher educator to investigate her professional practice	Researcher's journal entries, pre-service teachers journals, audiotapes, interviews & observations	"Valuable personal learning" took place: previously unrecognized beliefs about learning and the nature of mathematics were identified; beliefs and teaching practice changed.
Brady	Link between teachers' role, learners, Learning and mathematics, and prospective teachers' views of their ideal primary mathematics classroom, N = 22	Analysis of 750 -1000 word report by students of their personal philosophy of teaching primary mathematics, including a description of an ideal primary mathematics classroom.	Idealized views of learners and learning dominated the descriptions of the imaginary classroom. Classrooms were going to be "safe havens", mathematics was "fun and enjoyable", and lessons would be varied, "interactive and relevant".
Cavanagh & Prescott	Exploration of factors which influence the pre-service teachers' classroom practice, N = 8	Three clinical interviews about practicum experiences, including major influences, lesson style, and (in)consistencies with pedagogical focus of the course	Participants identified a mismatch between reform teaching approaches advocated in the university course and observed classroom practices. The researchers gained "the distinct impression that the participants were telling us what they thought

[7] As already mentioned, a strong emphasis on beliefs in developing the context of the study did not necessarily imply that there was "sustained" focus on beliefs in the research aspect described in the paper.

Author	Study focus	Measurement	Findings include
			we wanted to hear rather than what they really believed".
Frid & Sparrow	Factors influencing the implementation of innovative nontraditional mathematics teaching and learning practices, N = 8	Interview	The recent graduates (1-4 years since graduation revealed "how aspects of their pre-service education provided them with the knowledge, skills, and confidence to enact their beliefs about effective mathematics teaching".
Goos & Bennison	Interactions between teachers' knowledge and beliefs, their professional contexts, and their formal and informal PD experiences, N = 2	Semi structured, theory-guided interview, 40 item questionnaire, and videotaped classroom observations	Valsiner's (1997) zone theory, which builds on Vygotsky's Zone of Proximal Development by adding descriptors of the social setting and the goals and actions of participants, was useful for studying the "interactions between teachers' knowledge and beliefs, their professional contexts, and their formal and informal PD experiences".
Goos, Dole, & Makar	Examination of teacher learning through evaluating the effectiveness of a theoretically based PD model, N = 4 pairs of teachers	Whole group interview, 40 item Mathematics Belief questionnaire, lesson notes, student work, and classroom observations	Different configurations of *teacher knowledge and beliefs* (Zone of Proximal Development), *professional contexts* (Zone of Free Movement), and *sources of assistance* (Zone of Promoted Action) were identified. How these factors combined to shape opportunities for teacher learning was also illustrated.
Ingram	In depth study of mathematical identities and negative affective responses to mathematics, N = one 14 year old student.	Audiotaped and videotaped observations, interviews, student and parent auto-biographical questionnaires, an anxiety questionnaire, student work, journal entries, achievements, and subject choices.	Capturing the student's multiple mathematical identities provided a context for understanding his affective responses in mathematics. His "rare, but increasing, instances of negative affective responses can be seen as a result of a gap between his designated and actual identities".
McNaught	Mathematics autobiography of a student who showed no mathematics anxiety, N = 1	Mathematics autobiography	An autobiography can provide insights for teachers and teacher educators into students' classroom experiences and beliefs about mathematics teaching and learning. The study also highlighted the value of reflective writing as a tool for pre-service teachers' "self-growth".
Rogers	An examination of the relationship between professional learning, classroom practices, and teacher beliefs and	25 item survey, observations, video footage, and written comments and reflections by the participating teacher	"Guskey's (1986) argument that it is when teachers use new ideas *and* gain evidence of positive change that a change may occur in their beliefs" is supported. His

Author	Study focus	Measurement	Findings include
	attitudes, N = 1 teacher		model is more effectively considered to be cyclic rather than linear.
Skalicky	Link between teachers' beliefs and practices and student learning, N = 2 grade 8 teachers and 6 students	Teacher and student semi-structured interviews, and samples of student work	The teachers' beliefs about numeracy and its value and role in the curriculum were able to be explored through the interviews. These beliefs were further reflected in the discourse of the six students in this study.
Wilson	Exploration of bibliotherapy as a reflective tool in teacher education by analyzing affective responses of pre-service primary teachers studying an elective number theory unit, N = 11 pre-service primary teachers	Description of participants' critical learning incident and guided reflections on mathematics education readings which collectively addressed psychological and sociocultural aspects of learning mathematics and focussed on affective and cognitive factors.	"The juxtaposition of bibliotherapy with mathematics teacher education units has proved to be a powerful strategy to address mathematics anxiety in pre-service teachers." The "catharsis, insight, universalisation, and projection allow(ed) the pre-service teachers to reflect more coherently on their beliefs about mathematics learning and teaching."

Summary

Papers containing references to beliefs

The similarity in the numbers of research papers in the two sets of proceedings in which belief-related issues were addressed is striking: in both cases approximately half referred to beliefs. Of these, 13 % and 14 % of the PME and MERGA research papers respectively focused in more detail on beliefs and indicated how beliefs were tapped or measured. In the remainder the term "beliefs" was typically used generically or as a synonym for one of the words in Mason's list reproduced earlier in the paper. The papers in the latter group did not add substantively to the body of research on beliefs. Nor, however, did they reflect Bloom's (1981) warning issued almost three decades ago that "in education, we continue to be seduced by the equivalent of snake-oil remedies, fake cancer cures, perpetual-motion contraptions, and old wives' tales. Myth and reality are not clearly differentiated, and we frequently prefer the former to the latter (p. 15).

Measurement / instruments used

Approaches to the measurement of beliefs were diverse: Likert questionnaires, semi-structured interviews, observations with or without audio/videotape backing, and reflective writings were strongly favoured. Reliance on interview or reflective writing excerpts to capture participants' beliefs was common. Studies in which the author(s) clearly elucidated the theoretical underpinnings of the analyses adopted were relatively rare. Studies in which neurological or physical phenomena were used to probe participants' beliefs, increasingly prevalent in the wider research community, were glaringly absent.

Yet there were a number of interesting attempts to go beyond popular measures. These included ratings of student drawings and assessment of their reliability, production of a movie script about mathematics, use of a mathematics biography, and an adaptation of bibliotherapy as ways of tapping beliefs about various aspects of mathematics.

Issues explored

How beliefs influenced teacher practices and student learning, were formed or changed – often as a result of participation in a professional development program or pre-service course activities - attracted considerable research attention. Small sample / in-depth or case study / multiple instrument studies predominated. The latter observation mirrors the findings of Adler et al. (2005) who concluded after their extensive review of research on mathematics teacher education that there was "a notable absence of large scale studies" (p. 370). For the work presented at the PME and MERGA conferences, it should be added that reference was made in a number of reports to a larger research study of which the material presented at the conference was a only a subset.

Concluding comments

Inspection of the 2007 PME and MERGA conference proceedings confirmed the mathematics education research community's continuing interest in the ways students' and teachers' beliefs affect mathematics learning and instruction, the persistent usage of belief / believe as a convenient synonym for a host of other words, and the frequent failure to distinguish carefully and consistently between beliefs and other affective factors. Small sample, qualitative methods studies, of questionable generalizability, were particularly favored. The extent to which such studies generate new theories, test the limits of a specific theory, "add to what is known by providing new knowledge" (Hopkins & Antes, 1990, p. 23) or constructively relate "the phenomenon and model to others' ideas" (Romberg, 1992, p. 51) is far from clear.

At the same time, examination of the two sets of conferences proceedings identified studies with painstakingly crafted, theoretically driven explorations and creative projective techniques. These not only exemplified Hopkins and Antes' (1990) description of educational research as "a structured scientific inquiry into an educational question that provides an answer contributing toward increasing the body of generalizable knowledge about educational concerns" (p. 24) but point to promising new avenues for capturing more effectively students' and teachers' multi-faceted beliefs, and their impact on mathematical learning and behaviors.

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