

# Prospective Teachers' Beliefs about Mathematics: An Overview

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**Abstract:** *The Mathematics Enthusiast Special Issue (2014) presented an extensive review of the literature around the content knowledge of prospective elementary teachers (PTs). The issue excluded articles around PTs' beliefs. Understanding research around PTs' beliefs is important to understanding how to design and support their teaching preparation. Attending to PTs' beliefs helps to ensure their content knowledge and instructional methods are aligned with reform-based mathematics. This article highlights a literature review that addressed the omission of beliefs and explored how teacher preparation might address PTs' held beliefs.*

*Keywords: mathematics, beliefs, prospective teacher (PT), elementary*

The Mathematics Enthusiast Special Issue (Thanheiser & Browning, 2014) featured extensive literature reviews regarding the mathematical content knowledge of prospective elementary teachers (PTs). The intent was to inform future research and design of mathematics education coursework. Because of the content knowledge focus, articles that discussed PTs' beliefs were excluded from review (Browning et al., 2014). However, by understanding PTs' beliefs around mathematics, insight is gained about the pedagogical choices they may make in classrooms. A thorough review of the literature around PTs' beliefs about mathematics was completed (Baker, 2014). Provided next is an overview of that process with emphasis on influencing PTs' beliefs towards reformed-based mathematics.

## TERMINOLOGY

The word belief was interpreted with Pajares' (1992) lens, in that a belief is a form of knowledge in the deeply personal sense; knowledge is based on objective fact, but belief is based on judgment. Ambrose, Clement, Philipp, & Chauvot (2004) cautioned that since beliefs are personal, those who research beliefs make inferences about participants' expressed beliefs while also holding their own beliefs. That being the case, all of the studies presented are assumed true for that set of researchers within that particular context.

The term reform-based mathematics reflects the National Council of Teachers of Mathematics (2000) expectation that high quality mathematics education is based around the guiding principles of equity,

appropriate use of technology, coherent curriculum, teachers who understand what students know and are able to do, students who learn with understanding, and assessments that are useful to both teacher and learner.

## BACKGROUND

Taken together, pieces from Pajares (1992) and Battista (1994) provided a backdrop to the literature around PTs' beliefs in mathematics and aided in understanding why shifting PTs' beliefs towards reform is challenging. Much of the research on teacher beliefs referenced Pajares' (1992) in which he asserted that while one must examine the content and teacher thinking that impacts reform movements, what teachers believe and the ways they believe must also be examined. Pajares (1992) acknowledged beliefs are difficult to research because they are not easily identified and evaluated, nor is there a consistent definition for beliefs across research. However, researchers do agree that all teachers hold beliefs about the role, thus understanding beliefs is important to future initiatives.

Battista's (1994) work established a background for research on teacher beliefs within the context of mathematics. Historically, mathematics was seen as computation, so teaching mathematics meant providing students with a set of skills and learning mathematics meant remembering and progressing through set skills. Reform-based mathematics asks that students do mathematics through problem solving and sense making instead of through rote memorization. Battista (1994) felt that teachers holding traditional beliefs around mathematics

teaching and learning were “robbing their students of opportunities to ‘do’ mathematics” (p.467). However, like Pajares (1992), Battista acknowledged that beliefs are difficult to shift. If PTs experienced traditional mathematics learning as K-12 students, then traditional beliefs may be ingrained and must be addressed if reform is desired.

## **SELECTION AND ANALYSIS OF STUDIES**

The search for studies for the original review was done through ERIC using the parameters of Full Text, Peer-Reviewed, and September 2004–September 2014. The search “Preservice Teacher Beliefs” returned 97 records, and adding the key word of “Mathematics” resulted in 26 records. “Prospective Teacher Beliefs” with “Mathematics” produced seven records. The 26 and seven were taken together as 33 records and were read in order to determine their applicability to the literature review. Narrowing in on the topic meant records were disregarded if they discussed research around PT beliefs outside of the realm of mathematics. Two records that discussed practicing teacher beliefs about mathematics were retained as they suggested why examining PT beliefs might be of importance. In total, 16 records met applicability parameters and were re-read in detail, noting commonalities and emerging themes.

Extensive summaries of the 16 records were written and three prominent themes emerged. The records were organized within the following themes: Teachers’ Beliefs and Student Achievement, Revealing Prospective Teachers’ Beliefs about Mathematics, Influencing Prospective Teachers’ Beliefs About Mathematics. Tables were created for each theme and are provided in Appendix A for reference of the organization and context of the reviewed studies. What follows is a glimpse into the themes to shed light on efforts to influence and maintain PTs’ beliefs towards reform-based mathematics.

### **THEME 1: TEACHERS’ BELIEFS AND STUDENT ACHIEVEMENT**

Polly et al. (2013) helped validate the importance of attending to teacher beliefs about mathematics by studying how beliefs are related to student performance. Polly et al. (2013) found that those teachers whose beliefs aligned with traditional teaching and learning had a higher frequency of teacher-centered practices, such as presenting mathematics as a set of facts to students in a

didactic manner. In turn, teachers whose beliefs aligned with reformed approaches to teaching and learning used more student-centered pedagogies that relied on experiences to help students explore and make connections among mathematical concepts. Students in the traditional-oriented, teacher-centered classrooms had significantly smaller gains on curriculum-based assessments, whereas the students in reform-based classrooms saw higher growth from pre-test to post-test.

The study highlighted the importance of attending to teacher beliefs about mathematics teaching and learning for the sake of students. However, the findings were from practicing teachers’ classrooms. The remainder of the studies examined how teacher preparation programs might uncover and address the mathematical beliefs of PTs before entering the profession.

### **THEME 2: REVEALING PROSPECTIVE TEACHERS’ BELIEFS ABOUT MATHEMATICS**

Understanding the effects of teacher beliefs on student performance is crucial, but in order to address beliefs, PTs’ held beliefs must be uncovered. Two approaches from this theme’s literature are highlighted next: (a) constructed response and (b) drawing.

Ambrose, Clement, Philipp, & Chauvot (2004) described the process of assessing the mathematical beliefs and belief change of PTs through a self-designed instrument called the Integrating Mathematics and Pedagogy (IMAP) Web-Based Belief Survey. The instrument development was based around free-responses rather than Likert scale responses because free-response allowed for rich description and greater insight into PTs’ beliefs. The survey was designed around three overarching belief systems: beliefs about mathematics, beliefs about knowing/learning mathematics, and beliefs about children’s doing and learning of mathematics. The IMAP Web-Based Belief Survey contains constructed responses around teaching scenarios, such as videotapes of student/teacher interactions, and also asks PTs to explain their thinking around mathematics problem structures and various student solution strategies. In development stages, the survey was administered to PTs at the beginning and end of a course to evaluate its sensitivity in capturing individuality amongst PTs’ beliefs and belief changes. Findings revealed varied responses from

PT to PT in the pre-survey, and revealed that some PTs' beliefs changed towards reform ideals from pre to post survey and other PTs' beliefs did not change. These findings supported the researchers' aim of eliciting PTs' beliefs and any belief changes in order to provide insight on instrument development and a potential tool for others.

Burton (2012) used the task of drawing to elicit and analyze PT perceptions about mathematics. She asserted that through PT self-examination and reflection of their perceptions, PTs can "begin to explore and deepen their own understanding, overcome anxiety, and connect the content to elementary students" (p.2). Burton asked 62 PTs to "draw math" (p.4) at the beginning and end of a mathematics methods course. Grounded theory (Strauss and Corbin, 1994) was used to explore the drawings and they were coded as positive, neutral, or negative. At the beginning, 52% of the drawings expressed negative emotions, but 0% of the post-drawings were negative. Instead, post-drawings became 39% neutral and 61% positive. An unexpected outcome was that PTs referred to their drawings throughout the entirety of the course. Burton believed that this reflection, and the openness for it, allowed PTs to acknowledge and evaluate their own perceptions, leading to changing beliefs and emotions around mathematics.

### **THEME 3: INFLUENCING PROSPECTIVE TEACHERS' BELIEFS ABOUT MATHEMATICS**

If it is acknowledged that beliefs about mathematics teaching and learning matter to PTs' future students' learning, and if instruments are available to reveal those beliefs, then examination is needed around what to do upon reveal. Embedding interviews into coursework to enact belief change was a common thread in the studies within the third theme and is explored next.

Ambrose (2004) challenged the university role of blindly tearing down beliefs and instead asked that coursework build upon held beliefs and help PTs form new ones. She proposed field experiences in PTs' first mathematics course and using the experiences as a "stimulus for expanding their views of teaching and affecting their beliefs about learning mathematics" (p.92).

Ambrose offered four possible mechanisms to affect PTs' beliefs: create emotion-filled experiences in courses, develop a positive community to instill positive beliefs in relation to mathematics, reflect on

beliefs so that hidden beliefs become overt, and offer experiences or reflections that help PTs connect beliefs to other beliefs. Ambrose used a field experience with PTs in which they worked in pairs to interview individual children about their inherent problem-solving skills and mathematical sense making. The interview partnerships developed questions, reflected on the interviews, and adjusted methods for subsequent interviews. Ambrose's goal was to provide the aforementioned four mechanisms for belief change within this fieldwork with children. After the experience, many of the PTs' reflections showed changes in beliefs about teaching and learning towards reformed ideals, suggesting that this intensive work with children can spur belief evolution for PTs.

The PTs' reflection responses allude to the Circles of Caring model (Philipp, 2008). The Circles of Caring model asserts that in order to see improvement in the mathematics skills in our country, PTs must understand and value children's mathematical thinking. The Circles of Caring model assumes that PTs chose a career in teaching because they care about children and through this care of children, teacher educators can help PTs care about mathematics.

Philipp (2008) suggested the use of interviews in which a PT asks students to solve rigorous mathematics problems. This hooks a PT's interest in engaging with children's mathematical thinking and then in turn, hooks the PT's interest in mathematics content. Interviews can address the false belief held by many PTs that elementary mathematics content is simplistic. When PTs watch, students solve problems they begin to understand that elementary content is complex and that their content and pedagogical skills must be expanded if they are to meet students' instructional needs.

The literature in this theme emphasized that PTs become interested in student learning when they can hear how students think and watch how students solve problems. Interviews can challenge PTs' preconceived ideas of what students know or are able to do mathematically, and can reveal that children are capable of far more than is expected. Interviews also take the intimidation out of teaching situations, as they allow for PTs to work with students one-on-one. This removes the complicating factor of management of a group and allows a PT to concentrate on the mathematical thinking at hand.

## IMPLICATIONS FOR FUTURE RESEARCH AND TEACHER EDUCATION

Within the body of literature on PT beliefs, there is an emphasis on identifying the beliefs of PTs. The more challenging aspect of this work is how to impact beliefs in a manner that best supports the initiatives of teacher education coursework and the reform-based mathematics initiatives. When studies discuss influencing PT beliefs, they typically do not follow the PTs outside particular coursework or beyond teacher preparation. The field needs future research around if and how reformed beliefs hold when PTs are faced with their own classroom decisions during student teaching practicums and induction years. Reform-based beliefs instilled during PT preparation might mean that PTs provide a more meaningful and successful mathematics experience for their future students.

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## **ABOUT THE AUTHOR**

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## APPENDIX A

**Table 1:** Theme 1–Teachers’ Beliefs and Student Achievement

<b>Author(s)</b>	<b>Year</b>	<b>Number of PTs in study</b>	<b>Methodology: Quantitative or Qualitative Belief Measure</b>	<b>Means of Access to Beliefs and Assessment</b> (questionnaire, instrument, interview, etc.)	<b>Context</b> (Mathematics Methods Course, Mathematics for Teachers Content Course, etc.)
Polly, D., McGee, J. R., Wang, C., Lambert, R. G., Pugalee, D. K., & Johnson, S.	2013	0 (53 Elementary Classroom Teachers, 688 students)	Quantitative	Teachers: Teachers’ Belief Questionnaire and Teachers’ Practices Questionnaire (Swan, 2007), The Mathematical Knowledge for Teaching assessment (Hill, Rowan, & Ball, 2005),  Students: Investigations in Number, Data, and Space student assessment (TERC, 2008)	N/A
Staub, F. C., & Stern, E.	2002	0 (487 students, 22 teachers)	Quantitative	Teachers: Fennema et al. Belief Survey  Students: Pre and Post word problem assessments, speed fact tests	N/A

**Table 2:** Theme 2- Revealing Prospective Teachers' Beliefs about Mathematics

<b>Author(s)</b>	<b>Year</b>	<b>Number of PTs in study</b>	<b>Methodology: Quantitative or Qualitative Belief Measure</b>	<b>Means of Access to Beliefs and Assessment</b> (questionnaire, instrument, interview, etc.)	<b>Context</b> (Mathematics Methods Course, Mathematics for Teachers Content Course, etc.)
Ambrose, R., Clement, L., Philipp, R., & Chauvot, J.	2004	150	Qualitative (data later quantified for comparison)	Self-designed belief survey with free response, evaluated by self-designed rubrics	Methods Course
Burton, M.	2012	62	Qualitative	Drawings (around "What is math?") and Open Coding	Methods Course
Bursal, M., & Paznokas, L.	2006	65	Quantitative	Revised-Mathematics Anxiety Survey (R-MANX), Math Teaching Efficacy Belief Instrument (MTEBI)	Methods Course
Gülten, D. Ç.	2013	152	Quantitative	Survey utilizing the Self-Efficacy Scale	N/A
Hart, L. C., Oesterle, S., & Swars, S. L.	2013	12	Qualitative	Interviews and Observations	Mathematics For Teachers (MFT) Content Course
Malinsky, M., Ross, A., Pannells, T., & McJunkin, M.	2006	279 (of 481 students with other majors)	Quantitative	Mathematics Anxiety Scale- Revised (MARS-R)	N/A
Peker, M.	2009	205 (of 506 prospective teachers of all levels)	Quantitative	Learning Style Inventory (LSI), Mathematics Teaching Anxiety Scale (MATAS)	N/A
Uusimaki, L., & Nason, R.	2004	18	Qualitative	Semi-structured interviews	Methods Course

**Table 3:** Theme 3- Influencing Prospective Teachers' Beliefs about Mathematics

<b>Author(s)</b>	<b>Year</b>	<b>Number of PTs in study</b>	<b>Methodology: Quantitative or Qualitative Belief Measure</b>	<b>Means of Access to Beliefs and Assessment</b> (questionnaire, instrument, interview, etc.)	<b>Context</b> (Mathematics Methods Course, Mathematics for Teachers Content Course, etc.)
Ambrose, R.	2004	15	Qualitative	Analyzing videotapes and audiotapes, PT reflections, pre and post open-ended belief surveys, and pre and post interviews	Special Course with Methods Course
Philipp, R. A.	2008	-	-	Reflections based on the 2007 Philipp et al. study	N/A
Philipp, R. A., Ambrose, R., Lamb, L. L., Sowder, J. T., Schappelle, B. P., Sowder, L., & Chauvot, J.	2007	159	Mixed (Experimental Study)	Online belief survey with open-ended responses (The Integrating Mathematics and Pedagogy Web Based Belief Survey),	
Paper-and-pencil Content Assessment	Math Content Course				
Thanheiser, E., Philipp, R. A., Fasteen, J., Strand, K., & Mills, B.	2013	13	Qualitative	Interviews	Math Content Course
Timmerman, M. A.	2004	24	Quantitative	Baroody and Coslick (1998) Belief Survey (pre-and post semester)	Methods Course
Wilkins, J. L., & Brand, B. R.	2004	89	Quantitative	Hart's (2002) Mathematics Belief Instrument (MBI)	Methods Course