2016 NCTM RESEARCH CONFERENCE
April 11-13 • San Francisco

Measuring Teachers' Beliefs in Relation to the Standards for Mathematical Practice

Iris Riggs, Davida Fischman, Matt Riggs, and Madeleine Jetter
California State University, San Bernardino

Brief Research Report

April 13, 2016

San Francisco, California

Introduction

The research described here was conducted in the context of a comprehensive and intensive five-year Mathematics and Science Project funded by the National Science Foundation. Participants were teachers of grades 4-8, and the focus of the project was on enhancing teachers' mathematical knowledge for teaching (MKT) and pedagogy in order to increase student success in algebra and future mathematics courses. Participants engaged in challenging mathematics and pedagogy learning in 2-week summer institutes, monthly seminars, long-term lesson study, and self-facilitated collaboration in each of the five years. We were curious to learn to what extent teachers' knowledge, dispositions, and practice changed as a result of participation in this work; areas of investigation included mathematical knowledge for teaching (MKT) (Ball, Thames, & Phelps, 2008; Hill, Schilling, & Ball, 2004), self-efficacy (SE) and outcome-expectancy (OE) beliefs (Bandura, 1977), proclivities for teaching mathematics (PTM) (Lewis, J., Fischman, D., & Riggs, M., 2014), and classroom instruction as measured by the Mathematical Quality of Instruction (MQI) rubric (Learning Mathematics for Teaching Project, 2011), along with correlations among these.

While we found that existing instruments were suitable for our use in analyzing MKT and classroom instruction, the PTM is a new construct and did not yet have an instrument, and the SE/OE instruments did not sufficiently take into consideration the Common Core State Standards in Mathematics (CCSS-M) (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010), particularly the Standards for Mathematical Practice, so project researchers designed instruments for both of these. This talk will describe the research involved in designing, implementing, and validating a SE/OE instrument, the Mathematics Teaching Efficacy and Expectancy Beliefs Instrument (MTEEBI).

Theoretical Framework

Investigation of teacher beliefs can help researchers better interpret teacher behaviors. Phillips (2006) summarized the literature to define beliefs as “psychologically held understandings, premises, or propositions about the world that are thought to be true.” (p. 39). Beliefs are different from affect, “...a disposition or tendency or an emotion or feeling attached to an idea or object.” (p. 39). Koballa and Crawley (1985) described a relationship between a person’s beliefs, attitudes and behaviors and applied it to teachers. For example, a teacher might believe she has the ability to teach mathematics, which relates to her positive disposition for teaching mathematics. Her teaching behaviors, then, also relate to her positive beliefs and dispositions, resulting in a teacher more likely to spend more classroom time in the teaching of mathematics.

We can trace the description of this relationship of beliefs, attitudes, and behaviors to Bandura (1977) who described people as having a generalized expectancy about action-outcome contingencies based upon life experiences (outcome expectancy). They also hold specific beliefs regarding their own coping abilities (self-efficacy). Bandura described these two constructs as related to a person's behavior. People act related to their own belief that certain behaviors will produce desirable outcomes (outcome expectancy) and when they also believe in their own ability to perform the related behaviors (self-efficacy). Thus, both factors are important to investigation of behavior.

Gibson and Dembo (1984) applied Bandura's theory in their work with teachers, stating "teachers who believe student learning can be influenced by effective teaching (outcome expectancy) and who also have confidence in their own teaching abilities (self-efficacy) should persist longer, provide a greater academic focus in the classroom, and exhibit different types of feedback..." (Gibson and Dembo, 1984, p. 570). These constructs have been used to create instruments that measure teacher self-efficacy and outcome expectancy in various content areas. Riggs and Enochs (1990) developed the Science Teaching Efficacy Belief Instrument (STEBI) to measure teachers' science self-efficacy and outcome expectancy. The STEBI's two sub-scales were modified to reference mathematics by Enochs, Smith, and Huinker, resulting in the Mathematics Teaching Efficacy Belief Instrument (MTEBI) (2000). The MTEBI self-efficacy subscale includes items that assess teachers' belief in their own ability to teach mathematics:

- I know how to teach mathematics concepts effectively.
- I do not know what to do to turn students on to mathematics.

The outcome expectancy subscale includes items that assess teachers' beliefs about students' ability to learn mathematics, given effective instruction:

- When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach.
- The inadequacy of a student's mathematics background can be overcome by good teaching.

As we reviewed the MTEBI's items in the context of CCSS-M, we wondered if we could supplement its general items with more specific ones, in order to engage teachers in reflection upon their beliefs related to the eight SMPs. The resulting instrument will be more helpful to professional developers and researchers who are working in efforts that support teachers' implementation of the CCSS-M.

Purpose

Our interests relate to how can we measure teachers' self-efficacy and outcome expectancy in relation to the SMPs, and to what extent do these measures correlate with classroom instruction. The purpose of our study was to develop and begin validation of a self-reporting math teacher efficacy and expectancy belief instrument. This research maintained the constructs of self-efficacy and outcome expectancy and kept them distinct to allow evaluation of each. The instrument built upon the work of Enochs, Smith and Huinker (2000) by modifying existing and developing additional items that examine beliefs about instruction that support SMPs. The more specific nature of the items is consistent with Bandura's (1981) description of self-efficacy as a situation-specific rather than global construct. Teachers' beliefs related to mathematics teaching in general may not be the same as their beliefs about their teaching in relation to the SMPs.

Methodology
Content validity was evidenced by having subject matter experts develop and examine the items to ensure they were consistent with the SMPs and Bandura's theory. Additional item construction was initiated by a mathematics professor, who developed items for each of the eight SMPs. This mathematician joined three additional reviewers with expertise in either the CCSS-M or Bandura's theory to review all old and new items. Each expert independently categorized items by the SMPs, self-efficacy, and outcome expectancy, followed by discussion and consensus. The panel attempted to assure that items included only one belief and were clearly stated. Those items seen as complex or awkwardly worded were distributed to additional experts in mathematics teaching for review.

Factorial validity was evaluated, using both exploratory and confirmatory factor analysis (EFA and CF). Data collected using the scales were subjected to internal consistency reliability assessment (Cronbach's alpha) and item analysis (item level and item-total correlation). Finally, evidence of predictive (criterion), convergent, and discriminant validity was tested by correlating the MTEEBI scores with relevant variables.

Results
For the factor analysis, a total of 490 sets of responses were randomly split. Approximately, 246 cases were subjected to an EFA. Factorial validity of the two-scale solution was supported by the simple structure of the rotated loading matrix (pattern matrix). The Pearson correlation between the two resulting factors (self-efficacy and outcome expectancy) was .54, a magnitude consistent with theoretical expectations.

The Cronbach's Alpha for the 21 item self-efficacy scale was .91. The corrected item-total correlations all were positive and adequate in magnitude (ranging between .39 and .68). The Cronbach's Alpha for the 12 item outcome expectancy scale was .84. Corrected item-total correlations ranged between .42 and .62.

Given the strong results of the EFA, confirmatory factor analysis (CFA) was conducted on the remaining holdout sample of 244 cases. EQS was used to evaluate the fit of the model to the data. Omnibus fit indices indicated a good fit of the data [Satorra-Bentler Scaled Chi-Square (488) = 648.58, CFI = .90, RMSEA = .039]. Standardized path coefficients from the latent constructs to specified items ranged from .40 to .75 for SE and from .38 to .56 for OE. The standardized covariance between the two latent constructs was .65. In summary, both the EFA and the CFA provided robust support for the psychometric properties of the two measures.

Further evidence of validity was evaluated by correlating the obtained SE and OE scores from the MTEEBI with external criteria. Math teaching knowledge (measured using the LMT) correlated with SE ($r = .23$) and OE ($r = .26$) in the expected positive direction, both with small to medium magnitude Pearson r's. The correlations between SE and OE with the six measured teaching proclivities showed a pattern of Pearson r's that moved from negative to positive as the proclivities moved from teacher-centered to student centered tendencies. Finally, correlations between SE and OE were calculated with four measures obtained from structured scoring of a small number of teachers videotaped teaching math in the classroom. The following correlations were obtained between SE and OE with: "Math Richness" (.34 and .30), "Working with Students" (.29 and .44), "Errors" (.04 and .13), and "Meaning/Reasoning" (.46 and .56). Both SE and OE correlated positively at moderate to large magnitudes with three of the four observed teaching behaviors. Overall, the MTEEBI scales produced a consistent, meaningful pattern of correlations with variables they might be expected to predict.

Discussion and Limitations

The MTEEBI is a valid and reliable instrument that provides researchers with information on teachers' beliefs regarding their ability to teach in a way that supports student engagement in the Standards for Mathematics Practices and also their beliefs about students' ability to learn mathematics, given teaching that aligns with those standards. These measures can help further researchers' understandings of teachers' beliefs, attitudes, and behaviors as they attempt to implement changes in the classroom. As with any self-report instrument, evaluation based upon such measures should be seen as somewhat limited, but as an important starting point for probing teachers' beliefs as they experience professional development and additional teaching experience.

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