Measuring Early Elementary Teachers' Knowledge and Beliefs about Mathematics Teaching and Learning

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Knowledge of Teaching Early Elementary Mathematics (K-TEEM)

Sample

Participants comprised two samples of teachers (total *n* = 405) participating in two separate randomized-controlled trials. Sample 1 comprised 199 teachers from two public school districts, and Sample 2 comprised 206 teachers from 26 public school districts. Both samples completed the Knowledge of Teaching Early Elementary Mathematics (K-TEEM) spring 2014. Sample 1 was predominantly Grade 1 and 2 teachers and Sample 2 was predominantly Grade K-2 teachers. Both samples included some non-classroom teachers (e.g., math coaches): ~10% in Sample 1 and ~5% in Sample 2.

Analytic Strategy

Several stages were followed in the development and evaluation of the K-TEEM, including a cyclical approach to vetting and refining the item bank that involved consultation and discussion with experts in mathematics and mathematics education research, (2) cognitive interviews with teachers; (3) field testing, and (4) development of rubrics to score the constructed-response items and adjudication to consensus of all ratings. All items on the questionnaire were ultimately scored dichotomously (i.e., correct, incorrect), and statistics for the full scale and individual items were examined using Rasch models.

Figure 1. *Item-Person Plot for the K-TEEM*

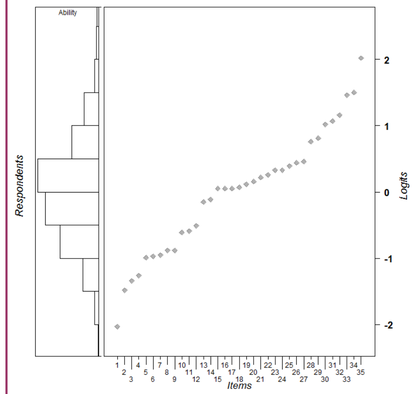

Table 1. *Item Blueprint for the K-TEEM*

Facets	Number of Items
Common Content Knowledge	
Meaning of the Equal Sign and Related Notation	5
Properties of Operations	4
Solve Problems in Many Ways	2
Specialized Content Knowledge	
Interpreting Student Strategies	4
Naming Student Strategies	4
Naming Word Problem Types	5
Knowledge of Content and Students	
Predicting Student Strategies	3
Relative Problem Difficulty	4
Knowledge of Content and Teaching	
Selecting Word Problems in Service of Specific Instructional Goals	4
Total	35

Results

The K-TEEM instrument measures teachers' knowledge in the domain of number, operations, and algebraic thinking at the early elementary level (see Table 1 for item blueprint). Data gathered with the 35-item K-TEEM were modeled using a Rasch-based IRT model. The model accounted for over 75% of the variance within the measure overall, with person-separation reliability estimated at .75 and item-separation reliability estimated at .97. Plotting IRT item difficulties against the distribution of person ability scores (see Figure 1) ,we found the range and concentration of item difficulties to be commensurate with the range and concentration of estimated person abilities.

Background and Purpose

We created two original instruments to measure early elementary in-service teachers' mathematical knowledge for teaching (MKT) and beliefs about mathematics teaching and learning. An immediate goal of our work was to measure the impact of a teacher professional development program. A broader goal was to (a) develop a valid measure of early grades mathematics knowledge for teaching and (b) develop a beliefs instrument that may enable testing and advancement of theory with respect to the role of teacher beliefs in moderating the effects of teacher attributes and practices on student learning outcomes.

The purpose of the present study was to investigate the validity and reliability of questionnaires designed to measure practicing elementary teachers' mathematics knowledge and beliefs about mathematics teaching and learning.

The studies of both instruments drew from a cluster-randomized trial of teacher professional development programs for in-service teachers of primary grades mathematics occurring from summer 2013 through spring 2015. The primary sample was comprised of approximately 200 individual teacher participants working in 22 schools in two districts located in a Southeastern U.S. state. The study for the knowledge instrument also pooled data from a second randomized field trial that started in spring 2014 (i.e., Sample 2) and included another approximately 200 teachers from 26 districts in the same state.

Conclusions

- The types of knowledge measured by K-TEEM build upon MKT theory and advance new ideas within the MKT theoretical constructs that have not previously been identified or measured at a large scale.
- B-MTL reliably measures an existing teacher beliefs construct (Transmissionist) as well as two constructs that have not previously been identified or measured at a large scale (Facts First; Textbook-driven).
- The iterative procedure we followed to evaluate and respecify the B-MTL questionnaire resulted in a structurally valid measurement model that (a) was free of moderate to large differential item functioning associated with treatment status, (b) had full measurement invariance and partial structural invariance across time, (c) had scales that were reliable for the current sample, and (d) significantly correlated with other, related psychological traits.
- These instruments have been used to detect treatment effects through large-scale, randomized-controlled trials of two different teacher professional development programs in early elementary mathematics.
- The K-TEEM and B-MTL may provide new options available to researchers and evaluators for the purpose of measuring teachers' knowledge and beliefs about mathematics teaching and learning specific to early elementary grades.

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Beliefs about Mathematics Teaching and Learning (B-MTL)

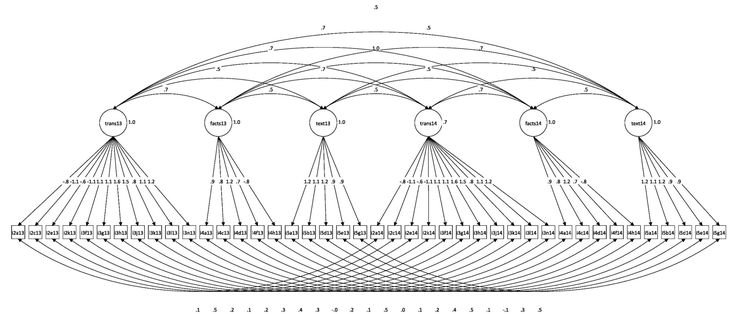
Sample

Participants included 207 teachers from two public school districts participating in a randomized field trial. Two hundred six teachers completed the Beliefs about Mathematics Teaching and Learning (B-MTL) questionnaire summer 2013 (Time 1), 200 completed it spring 2014 (Time 2), and 199 completed it at both time points. Approximately 90% of the sample were classroom teachers, evenly distributed across Grades 1 and 2, and 10% of the sample was comprised of non-classroom teachers (e.g., math coaches).

Analytic Strategy

There were seven sub-studies to our investigation of the validity and reliability of the B-MTL questionnaire. Our aim for Phases 1 through 4 was to determine the best specification for the measurement model. Our aim for Phases 5 through 7 was to assess the psychometric properties of the respecified questionnaire. In total, our analyses of data from the beliefs questionnaire included an investigation of factorial validity, differential item functioning, longitudinal measurement and structural invariance, scale reliability, and convergent validity.

Figure 2. Longitudinal and structural invariance model for the B-MTL



Results

The final model included 21 items representing three constructs: Transmissionist, Facts First, and Textbook-driven (see Table 2 for example items). The data were fit to a correlated trait item factor analysis, with RMSEA and TLI indicating reasonable fit and the CFI indicating close fit: $\chi 2(186) = 347.157$, $p < .001$; RMSEA = 0.065; 90% CI [0.054, 0.075]; CFI = 0.954; and TLI = 0.948. Sufficiently high reliability was also estimated for the three constructs: Transmissionist (11 items, $\alpha = .92$), Facts First (5 items, $\alpha = .83$), and Textbook-driven (5 items, $\alpha = .80$). Further, after imposing invariance constraints between Time 1 and Time 2, analyses demonstrated full measurement invariance and partial structural invariance (see Figure 2).

Table 2. B*eliefs Constructs Example Items*

Construct	Example Item
Transmissionist	It is more effective to show students how to solve problems than to let them solve problems in their own way.
Facts First	Students should master some basic facts before they are expected to solve word problems.
Textbook-driven	Following the textbook closely ensures that the teacher is focused on the right sequence of mathematical topics.