MEASURING CHANGES IN TEACHERS’ BELIEFS, ATTITUDES, AND DISPOSITIONS RELATED TO EXPERIENCES IN MATHEMATICS

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This paper reports on the development of the Mathematics Experiences and Conceptions Surveys (MECS) designed to study the evolution of preservice elementary teachers’ dispositions, beliefs, and attitudes towards mathematics teaching and learning, within the context of related mathematical experiences. We report on initial factor analyses and reliability of two surveys administered in mathematics methods courses across three institutions in the Eastern United States. Results showed six highly-reliable sub-scales addressing attitudes, dispositions, confidence, past K-12 experiences, and experiences in methods courses and field work. Instrument construction, plans for continued analysis, and ideas for implementing the MECS in future research are discussed.

Objectives of the Study

This paper reports on the development of the Mathematics Experiences and Conceptions Surveys (MECS) designed to understand the evolution of preservice elementary teachers’ (PSTs) attitudes, beliefs, and dispositions towards mathematics teaching and learning. In particular, we seek to develop a comprehensive set of instruments that involve the investigation of relationships between these three distinct, yet interrelated constructs. Further, we include extensive demographic information, which, combined with measures of attitudes, beliefs, and dispositions, might be used to leverage learning opportunities within mathematics education coursework. To capture experiences (within teacher education programs) of learning to teach elementary school mathematics over time, we developed multiple iterations of the survey applicable at various stages within teacher education programs. Doing so affords opportunities for analyses of factors within teacher education that influence dispositions, beliefs, and attitudes towards mathematics teaching and learning. Here, we report on initial factor analyses and reliability on two surveys, one (MECS-1) administered at the beginning of mathematics education methods courses offered at three institutions, and a follow-up/post-survey (MECS-2) administered at the conclusion of the same methods courses.

While a number of surveys exist that measure beliefs and attitudes in mathematics, the design of these complimentary surveys have the potential to advance the field through: (a) analyses that purposefully explore the interrelated relationship of attitudes, beliefs, dispositions, and identified PST characteristics (e.g. experiences as K-12 mathematics learners, native language(s), parent education level, etc); (b) the integration of design experiments (Cobb, Confrey, diSessa, Lehrer, Schauble, 2003) to investigate how particular experiences in mathematics methods courses foster positive attitudes towards mathematics and encourage beliefs aligned with effective mathematics teaching and learning; and (c) the extension of data collection points across time and across teacher education programs. In the following section, we describe our attempts to operationalize the terms attitudes, beliefs, and dispositions, explain the construction of the surveys, and report our initial findings related to the survey instruments.

Perspectives

Research in mathematics education suggests that efforts to improve teacher quality should focus on transformative learning experiences that influence the way teachers interact with students, curriculum materials, and the teaching context (Ball & Cohen, 1999). In part, this work focuses on conceptions of the nature of mathematics and how one teaches and learns mathematics (Ball, Lubienski, & Mewborn, 2001). Here, we use the term conceptions as an umbrella to represent three central and interrelated subconstructs: dispositions, beliefs, and attitudes. To develop the survey, we operationalized the aforementioned subconstructs in the following way:

Dispositions: A tendency to act in a specified way, to take on a particular position (Bourdieu, 1984, 1986). In the case of mathematics teaching and learning, our interests center on our desire to understand how PSTs position themselves and their K-12 learning experiences with respect to reform recommendations in mathematics education.

Beliefs: “Psychologically held understandings … about the world” (Philipp, 2007, p. 259). Beliefs tend to be true/false oriented and context dependent. Further, beliefs are more cognitive, felt less intensely, and harder to change than attitudes. Beliefs are a primary focus here as research indicates the important role beliefs play in the opportunities students have to engage in significant mathematical thinking (e.g. Fennema, et al, 1996; Staub & Stern, 2002), teachers’ fidelity to curriculum materials (e.g. Collopy, 2003, Remillard & Bryans, 2004), and the integration of particular instructional materials and strategies (e.g. Walen, Williams, & Garner, 2003).

Attitudes: Judgments made about particular places, events, people, or objects. Attitudes are, to some degree, either positive or negative (Breckler & Wiggins, 1992). Attitudes change more quickly and are less cognitive than beliefs (Philipp, 2007), thus evidence of change can be seen in shorter time increments than beliefs.

Here, we argue these three subconstructs to be critical in understanding PSTs developing conceptions of mathematics teaching and learning, within a teacher education program and into their first years of teaching. Furthermore connections between teachers’ knowledge and their beliefs about mathematics teaching and learning have been demonstrated as the most significant influence on teachers’ instructional practices (Pajares, 1992; Philip et al, 2007). Consequently, designing appropriate and comprehensive measures of teachers’ conceptions of mathematics teaching and learning is critical in supporting PSTs within teacher education programs and into the teaching profession.

Prior survey work in mathematics education has focused on beliefs (e.g. Perry, Wong, & Howard, 2006; Szydlik, Szydlik, & Benson, 2003) and attitudes (e.g. Fennema & Sherman, 1976; White et al, 2000) independently, with little, if any, specific attention to dispositions. Furthermore, through a review of the literature, no surveys exist that collect extensive demographic information on PSTs which might be used as explanatory factors for certain conceptions of mathematics teaching and learning and as leverage for supporting PSTs in mathematics education coursework.

Methods

Participants and Context

Participants for the MECS-1 included a total of 106 preservice elementary teachers among three universities in the Eastern United States. For the MECS-2, a subset of 79 of these teachers from two of the three universities participated. All participants were enrolled in an elementary
mathematics methods course in teacher education programs for initial licensure during the fall of 2010. MECS-1 was administered at the beginning of the mathematics methods course and MECS-2 was administered at the end of the same semester. The mathematics methods course served as a common point of interest as it was taken late in all three teacher education programs.

**Instrumentation**

MECS-1, a 60 Likert-item and four open-ended item survey was designed to measure constructs related to preservice teachers’ past K-12 experiences in mathematics and their beliefs about mathematics, dispositions toward teaching mathematics, and attitudes about mathematics, upon entering their teacher education programs. Furthermore, the MECS-1 survey included 17 demographics-related items. MECS-2, a 75-item survey was designed to measure constructs related to preservice teachers’ fieldwork experiences in mathematics, experiences in the mathematics methods course, beliefs about mathematics, dispositions toward teaching mathematics, and attitudes about mathematics (see Appendix for sample items). The items were reviewed by three mathematics educators and a mathematician for clarity and appropriateness. We created two instruments with similar constructs to avoid a form of single-method bias and to measure growth after a mathematics methods course and over time. All Likert items were answered on a five-point scale (1 = strongly disagree, 2 = disagree, 3 = uncertain, 4 = agree, and 5 = strongly agree). Earlier versions of this survey were piloted and modified. Realizing that there are limitations to Likert-scale measures, we included open-ended questions in each survey to better understand preservice teachers’ conceptions about mathematics and to triangulate with Likert-scale responses. However, for the purposes of this paper, we focus on analyses of the Likert-scale items.

Eight constructs were developed with four shared constructs across both surveys and two unique constructs in each. The four shared constructs across MECS-1 and MECS-2 include Attitudes toward Mathematics, Beliefs about Mathematics, Mathematics Teaching Confidence, and Social Justice. Attitude toward Mathematics consisted of items that required a positive or negative judgment about mathematics, such as “Mathematics is one of my favorite subjects.” Mathematics Teaching Confidence included items that measured preservice teachers’ perceived confidence in both their teaching and mathematics abilities, such as using multiple representations of mathematical concepts. Beliefs about Mathematics attempted to get at preservice teachers’ beliefs about the nature of mathematics and their understanding about its role. We used Social Justice to measure the extent to which mathematics could and should be used to critically analyze the world and inequities within. Two unique constructs in MECS-1 included Dispositions toward Mathematics and Experience as K-12 Learner of Mathematics. The Dispositions toward Mathematics examined preservice teachers’ stance on how mathematics should be taught. While there are some items on MECS-2 that get at dispositions, there were not enough to develop its own scale. As a result, future versions of MECS-2 will include more items to ensure we can look at dispositions across time. Items included statements such as “Mathematics instruction at the K-5 level should incorporate the use of calculators” and “I plan to encourage students to solve mathematical problems in more than one way.” Experience as K-12 Learner of Mathematics gathered data about past K-12 school experiences that preservice teachers brought with them. This set of questions in the pre-survey asked about their experiences as learners of mathematics at the elementary, middle, and high school levels. Two unique constructs in MECS-2 included Field Experience and Mathematics Methods Course Experience.

Field Experience and Mathematics Methods Course Experience were two scales on the post-survey, which sought to measure preservice teachers’ experiences in the two areas.

**Data Analysis**

Exploratory factor analyses were completed to examine psychometric properties of the instruments. Reliability was examined in terms of the instruments’ internal consistency with the split-half method and Cronbach’s alpha levels of the sub-scales. We addressed issues of internal validity by creating items with opposing statements to account for correct interpretation of our constructs. For example, the items, “I like mathematics” and “I think mathematics is boring” were included to make observe whether participants were thinking about the statements rather than assuming that all scales were unidirectional. Content validity was verified by having mathematics educators and a mathematician scrutinize wording of and adequacy of items. In addition, Principal Components Analysis (PCA) was conducted on the core items of the questionnaire in order to investigate how different subsets of items might correlate well together to account for construct validity. Future analyses of the surveys’ open-ended responses will be used to further establish validity of the Likert scale items by scrutinizing the level of consistency between the open-ended and Likert responses.

**Results**

**Factor Analysis**

Principle Components Analysis (PCA) was conducted for data reduction and to examine the dimensionality of the items. A factor extraction yielded fourteen and sixteen factors with eigenvalues greater than one, for the pre-survey and post-survey respectively. The Kaiser-Meyer-Oiken measure of sampling adequacy yielded a moderate level of compactness for the MECS surveys (.673; .624, respectively); however, Bartlett’s test yielded significant results (p < .001) indicating that factor analyses were appropriate for these data. Factor rotation was determined through a comparison of the scree plot and the amount of variance explained by each factor. Although there were fourteen factors with eigenvalues greater than one, it made greater sense to have six factors that were both conceptually and psychometrically sound. Thus, six factors were rotated using a Varimax rotation procedure. The rotated component matrix served as a guide to group items appropriately. Six factors on the pre-survey accounted for about 52% of the total variance of the instrument and six factors on the post-survey accounted for about 55% of the total variance of the instrument.

**Reliability**

We assessed the internal consistency of each of the six subscales of our instrument by calculating a Cronbach’s α for split-half reliability. Table 1 displays the names and the alpha level of each sub-scale.

<table>
<thead>
<tr>
<th>Construct</th>
<th>MECS-1</th>
<th>MECS-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitudes toward Mathematics</td>
<td>.875</td>
<td>.883</td>
</tr>
<tr>
<td>Beliefs about Mathematics</td>
<td>.379</td>
<td>.469</td>
</tr>
<tr>
<td>Dispositions toward Teaching Mathematics</td>
<td>.820</td>
<td></td>
</tr>
<tr>
<td>Mathematics Teaching Confidence</td>
<td>.918</td>
<td>.917</td>
</tr>
<tr>
<td>Social Justice</td>
<td>.618</td>
<td>.575</td>
</tr>
<tr>
<td>Experience as K-12 Learner of Mathematics</td>
<td>.797</td>
<td></td>
</tr>
<tr>
<td>Field Experience</td>
<td></td>
<td>.748</td>
</tr>
<tr>
<td>Mathematics Methods Course Experience</td>
<td></td>
<td>.938</td>
</tr>
</tbody>
</table>

It was clear that four of the six sub-scales in each of the instruments had high reliability in terms of internal consistency yielding alpha levels of .748 - .938. The same two constructs were the lowest sub-scales in each instrument, namely Beliefs about Mathematics and Social Justice. Upon reexamination of the items with these problematic scales, we realized that multiple interpretations existed within some of the items and required revision. For example, one item stated, “Memorizing facts and formulas is essential to knowing mathematics.” While we all agreed that this is an important part of mathematics, the wording could be interpreted differently. The word “memorizing” can carry a negative connotation. Thus, we changed the wording to “Mastering facts and developing skills for carrying out calculations is essential to knowing mathematics.” Ongoing data collection and analyses will determine whether the changes we made strengthened the weak sub-scales.

For the split-half coefficients, the instruments were split into two halves such that the two halves would be as equivalent as possible. Split-half reliability coefficients, .866 and .803 for the MECS-1 and MECS-2 respectively, imply satisfactory internal consistency. Spearman-Brown coefficients of .873 and .814 further indicate that items within MECS can be considered a fairly homogeneous set, possibly consisting of one or more individual components.

Discussion

Measuring Conceptions

Establishing instrument validity and reliability is an ongoing, iterative process. As our instrument is adopted at additional institutions and we expand our data set, we will continue to analyze and refine the items and constructs of our MECS instruments. Initial analyses of Likert-scale items have identified six highly reliable sub-scales within our instruments: Attitudes toward Mathematics, Dispositions toward Teaching Mathematics, Mathematics Teaching Confidence, Experience as K-12 Learner of Mathematics, Field Experience, and Mathematics Methods Course Experience. These results highlight the fact that we were able to achieve high reliability on multiple sub-constructs of teachers’ conceptions within a single survey, including attitudes, dispositions, and confidence in regards to mathematics and teaching. Given the dearth of research specific to dispositions as defined here, these findings are significant to understanding how PSTs position themselves with respect to reform recommendations in mathematics education. Furthermore, high reliability of measures of Dispositions toward Teaching Mathematics alongside Attitudes toward Mathematics provided promising findings regarding the MECS instrumentation’s ability to provide a more comprehensive picture of PSTs conceptions.

Items within the two sub-scales found to have weak-moderate internal consistency, Beliefs about Mathematics and Social Justice, have been edited on MECS-1 and a modified version of the original survey is currently undergoing a second administration. Modifications will also be made to items addressing these sub-scales on MECS-2, prior to its second administration. Furthermore, additional items are now included on the MECS-2 designed to address dispositions toward teaching mathematics, as initial results indicate that this construct is not currently being adequately addressed. Using subsequent collection points, MECS survey results will be analyzed using structural equation modeling software (EQS) to perform a more rigorous confirmatory factor analysis of the items on the revised MECS-1 and MECS-2 surveys. This level of analysis with support further verification the construct validity identified through the exploratory factor analysis described above.

We acknowledge the limitations imposed by surveys containing Likert-scale items alone and have therefore included open-ended response items on each of our MECS instruments. Although Wiest, L. R., & Lamberg, T. (Eds.). (2011). Proceedings of the 33rd Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education. Reno, NV: University of Nevada, Reno.
initial analyses have focused on establishing reliability and validity for the constructs addressed through our Likert-scale items, our continued analyses will include a qualitative investigation of the responses to open-ended items for triangulation purposes.

**Future Research**

We believe that the developed instruments will be useful to researchers across a variety of contexts in studying the attitudes, beliefs, and dispositions of elementary teachers of mathematics. Two characteristics make our surveys particularly powerful: 1) they are being designed to measure conceptions longitudinally, and 2) they collect extensive demographic information, including questions about the teachers’ past experiences as learners of mathematics.

Ongoing modifications to the MECS-2 instrument will result in a third survey, MECS-3, designed to measure changes in teacher conceptions into the first years of teaching. In place of items specific to methods courses and field work experiences, MECS-3 will include items addressing the mathematics teaching practices that the participants are implementing or planning to implement in their classrooms. The purpose of constructing this survey is to have an additional instrument that can be used repeatedly with pre/inservice teachers at various times throughout their teacher preparation programs and into their beginning years of teaching.

Our instruments are of the few that are designed to observe the evolution of teacher’s conceptions longitudinally over time, with specific iterations based upon the context of teacher preparation programs. Baseline beliefs, attitudes, and dispositions of entering teacher candidates can be measured by the MECS-1 when students join teacher preparation programs. Changes in conceptions can then be measured by repeatedly administering MECS-2 and MECS-3 as students meet significant benchmarks throughout their programs, such as the completion of mathematics content courses, methods courses, and/or fieldwork experiences. Using multiple testing points over time, the researchers will be able to study the impact of particular experiences within teacher education programs. This information may help teacher educators understand how preservice teachers’ attitudes, beliefs, and dispositions are formed throughout teacher education programs and identify factors that contribute to preservice teachers having certain conceptions that may positively or negatively impact their teaching practices. These instruments could also be used by teacher educators to study the impact of particular design experiments within specific aspects of teacher preparation programs, such as a teaching experiment conducted in a mathematics methods course. Ultimately, we support making the development of teacher conceptions a goal of teacher education programs and hope that this work will help teacher educators identify and implement strategies that will positively impact the beliefs, attitudes, and dispositions of their students.

In addition to informing teacher education, continued longitudinal studies could investigate if changes in conceptions are being sustained by teachers upon entering the teaching profession. Marbach-Ad and McGinnis (2009) note that beginning teachers often face a variety of obstacles that interfere with their ability to apply the pedagogical strategies that were encouraged throughout their teacher preparation programs. We believe that similar challenges may also affect the sustainability of beliefs, attitudes, and dispositions developed through teacher education. Yet few studies have looked at if or how changes in PSTs conceptions have been fully integrated into their long term practices as first novice and eventually expert teachers. By continuing to study the development of teacher conceptions as PSTs make the transition to practicing teachers, we can also explore how teachers’ beliefs, attitudes, and dispositions influence their practices, classroom behaviors, and ultimately student achievement.

Lastly, unlike other surveys designed to measure teacher attitudes and beliefs, our instrument collects extensive demographic information, including information about participants’ past experiences as K-12 learners of mathematics. Once our survey has been administered to a large, diverse set of teachers across multiple US institutions, demographic data may inform group differences in teachers’ conceptions of mathematics. Ultimately, the influence teachers’ conceptions of mathematics have on their instructional practices and consequently, their students’ opportunities to learn mathematics, make context-specific and comprehensive measures of teachers’ conceptions of mathematics a critical area of inquiry in mathematics teacher education.

End Note
All authors contributed equally to this work.

References
Hong Kong and Australia. *Mathematics Education in Different Cultural Traditions-A Comparative Study of East Asia and the West*, 435-448.


### Appendix: MECS Sample Items

#### Table A1. Sample Likert-Scale Items

<table>
<thead>
<tr>
<th>Survey</th>
<th>Construct</th>
<th>Sample Likert-Scale Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>MECS-1 &amp; 2</td>
<td>Attitudes toward Mathematics</td>
<td>Mathematics is one of my favorite subjects.</td>
</tr>
<tr>
<td>MECS-1</td>
<td>Dispositions toward Teaching</td>
<td>I plan to encourage students to solve mathematical problems in more than one way.</td>
</tr>
<tr>
<td>MECS-1 &amp; 2</td>
<td>Mathematics Teaching Confidence</td>
<td>I am confident in my ability to teach mathematics using:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a. calculators.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. computers, including software and Internet sources.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. interactive whiteboards.</td>
</tr>
<tr>
<td>MECS-1</td>
<td>Experience as K-12 Learner of</td>
<td>I used hands-on materials (for e.g. blocks, cubes, spinners) to learn mathematics as a:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. 6-8 student.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. 9-12 student.</td>
</tr>
<tr>
<td>MECS-2</td>
<td>Field Experience</td>
<td>My cooperating teacher(s) contributed greatly to my knowledge about the teaching and learning of mathematics.</td>
</tr>
<tr>
<td>MECS-2</td>
<td>Mathematics Methods Course</td>
<td>My math methods course(s) emphasized using and managing manipulatives to teach mathematical concepts.</td>
</tr>
</tbody>
</table>

*Note* All Likert-scale items were answered on a 5-point scale:
1=strongly disagree, 2=disagree, 3=uncertain, 4=agree, 5=strongly agree