RESEARCH STATEMENT

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I have been conducting research in math education since January 2012. My research investigates various aspects of teaching and learning mathematics at the undergraduate level. My research started in the area of Calculus instruction but my current research interests focus on the mathematical preparation of in-service and pre-service teachers. I start by briefly describing my early work on Calculus then describe my research (past and current) in teacher preparation.

1 Calculus Instruction

Since January of 2012 I have been as a research fellow on an NSF-funded grant to the Mathematical Association of American, studying Characteristics of Successful Programs in College Calculus (CSPCC, http://www.maa.org/cspcc/). Through close collaboration with Vilma Mesa (School of Education, University of Michigan) and Helen Burn (Highline Community College, Seattle, WA), this project has been a training ground for me in my entry into the world of mathematics education research, giving me opportunities to learn both qualitative and quantitative research methodologies. My most significant contributions to the project included design of the classroom visit observation protocol [11] and an ongoing analysis of academic tasks across all 18 institutions that has so far resulted in one publication [12].

2 Mathematical Preparation of Teachers

The research about Mathematical Knowledge for Teaching gives us an idea of the kinds of knowledge teachers need to ensure student success [5]. Teachers receive much of their mathematical preparation in "math content" courses and "content-focused" professional development. However, our understanding of how to best teach these courses is still evolving [4]. I am currently most interested in contributing this to body of knowledge by pursuing projects related to Teaching and Learning in Math Content Courses for In-service and Pre-service Teachers.

In terms of learning, my projects focus on how students'/participants' learning in math content courses is affected by task design, pedagogical choices, and assessment choices. In terms of teaching, I seek to understand how new instructors decide what content to teach and what pedagogical strategies to use when teaching in-service and pre-service teachers. Further, I am interested in developing projects to support both new and experienced instructors in improving teaching of these courses.

2.1 Revision Assignments as a Learning Tool

The first project I pursued in this area was an analysis of a revision task I gave my students in Fall 2012. In this investigation I used the drafts that came out of the task along with student reflection assignments to look at what kinds of feedback sources (e.g., peers, instructors, others sources) students utilized in (re)constructing their understanding of material reflected in the problems. Although there is much work on revisions in disciplines such as English, there is little research on the role of feedback and revision in written mathematics. I found evidence that peers' presentations and class discussion affected student adoptions of examples and representations in their solutions while instructor feedback affected their mathematical accuracy and justification. This is a potentially important finding for design of courses intended to improve students' mathematical communication.

2.2 Evaluation of Oral Assessments

A meta-analysis on oral assessments by Huxham, Campbell, and Westwood in 2012 [6] lists several advantages to giving oral assessments, including that they: (1) develop communication skills, (2) are a more authentic assessment, (3) are more inclusive of different learning style and needs, and (4) are better at gauging understanding. In a funded project with co-PI Daniel Visscher, we are implementing oral examinations in combination with traditional (written) examinations in two sections of his math content course for future teachers. We are using both quantitative and qualitative analysis to examine if they have the advantages (1)–(4) predicted. Further, we are investigating how oral versus written examinations affect student confidence, study habits, and understanding of mistakes. Although we are still in the midst of collecting data, we have so far produced systemic criteria for describing what kinds of questions are particularly well-suited to the oral examination context. Assessment of student learning is a vital part of any course and this study has the potential to help us better understand advantages and disadvantages of using oral assessments with pre-service teachers.

2.3 Math Teachers' Circles for In-service Teachers

To be proficient in mathematics is to be proficient in the practices of problem-solving, critical thinking, and reasoning that guide our construction of arguments across all disciplines. Problem solving and critical thinking are widely cited as among the most important skills for college readiness, education at the college level, and participation in the 21st century workforce [8, 1, 2, 7, 9]. The Common Core State Standards for Mathematical Practice (CCSS-SMPs) are designed to build support for these important skills, particularly the five CCSS-SMPs listed below.

MP1. Make sense of problems and persevere in solving them.

MP2. Reason abstractly and quantitatively.

MP3. Construct viable arguments and critique the reasoning of others.

MP5. Use appropriate tools strategically.

MP7. Look for and make use of structure

However, as a national study of middle school teachers' perceptions about the Common Core State Standards makes clear, teachers view the CCSS-SMPs as important, but don't necessarily feel confident teaching them [3]. Consequently, as the study recommends, professional development programs for middle school teachers need to focus on supporting teachers' use of the CCSS-SMPs in their classrooms.

In partnership with the Math and Science Center at Wayne RESA I am applying for a $150,000 Math and Science Partnership grant through the Michigan Department of Education to develop materials for and run a Math Teachers' Circle to serve grade 5-9 teachers in Wayne County and give them hands-on experiences with the CCSS-SMPs.

Our goals are to create a sustainable mathematical community or professional learners that increases teachers' enjoyment of mathematics, affects their attitudes towards mathematics, increases their problem-solving skills, increases their mathematical knowledge for teaching, and increases their tendency to use mathematically authentic problem-solving activities in their classrooms. We will use a variety of instruments to assess these measures, including the validated Learning Mathematics for Teaching instrument [10]. If we find this model of professional development to be successful, we will support the formation of more Math Teachers' Circles in the state of Michigan.

2.4 Developing Inquiry-Based Learning Geometry Materials for Pre-service and In-service Teachers

In collaboration with Dr. Yvonne Lai at the University of Nebraska, we are applying to the American Institute of Mathematics (AIM) to fund a SQuaRE to develop inquiry-based learning (IBL) materials for a geometry course for future teachers guided by the transformational approach to geometry in the Common Core State Standards (CCSS). As part of the materials' development, we will study their effect on student learning and classroom teaching.

The Common Core State Standards (CCSS) calls for two major changes to the high school geometry curriculum: (1) a transition to a transformational viewpoint, and (2) teaching this content while supporting a list of eight mathematical practices. Math departments tasked with the mathematical preparation of teachers need to redesign the materials of their "Geometry for Secondary Teachers" courses to support these new demands on the future teachers they educate. Our project proposes to develop materials for such a course, study the materials at a small group of institutions, and widely and freely disseminate the materials.

Teachers being trained now did not experience geometry in high school as the CCSS describes. Further, most future teachers do not enter their college experience with a solid background in proof from any disciplinary viewpoint. To meet the challenge of educating teachers, we must "transform" the geometric preparation of teachers. We must:

- Design experiences in geometry from a transformational approach that will cultivate teachers' mathematical practice, including perseverance, seeing and using structure, making connections between algebra and geometry, and proving and reasoning.

- Use those experiences to forge connections, now and in the future, between teachers? own learning and their future students? learning, so as to transform the way teachers apprentice students into mathematics.
- Work across institutions to continually improve the expertise of mathematics faculty in the geometric preparation of teachers.

There are currently no widely-available materials that are appropriate for nurturing teachers' mathematical growth in transformational geometry. Such materials must do more than describe relevant theorems and definitions; they must include rich, engaging problems that support teachers' growth in mathematical exploration, conjecture-making, and proving. Dr. Lai and I are forming a working group to

- Design IBL materials for geometry from a transformational approach to accompany Wu's (2013) Teaching Geometry According to the Common Core (http://math.berkeley.edu/~wu/Progressions_Geometry.pdf) and publish them in the Journal of Inquiry Based Learning in Mathematics (http://www.jiblm.org/).
- Collaborate with expert mathematics teachers and mathematics teacher educators on how to design and use these materials in mathematics courses and pedagogy courses so future teachers integrate experiences with mathematics, pedagogy, and field experiences such as practicum and/or student teaching.
- Conduct a longitudinal exploratory study on characteristics of successful use of these IBL materials on teachers? ability to introduce mathematical ideas, facilitate students? mathematical connections, and lead discussions on conjecturing and reasoning, in collaboration with education researchers and mathematics faculty from 4 sites from around the country.

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