Journal of Mathematics Education at Teachers College

Spring – Summer 2010
Inaugural Issue

A CENTURY OF LEADERSHIP IN MATHEMATICS AND ITS TEACHING

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The *Journal of Mathematics Education at Teachers College* is a publication of the Program in Mathematics and Education at Teachers College Columbia University in the City of New York.

This issue's cover and those of future issues will honor past and current contributors to the Teachers College Program in Mathematics and Education. Photographs are drawn from the Teachers College archives and personal collections.

This issue honors NCTM 2010 Lifetime Achievement Medalist, Dr. Henry O. Pollak, who has completed 22 years as a member of the Program in Mathematics and Education at Teachers College. Dr. Pollak has contributed so much to the mathematical preparation of the Program's graduates and to the communities of mathematics and mathematics education professionals in the United States and throughout the world.

David Eugene Smith, also pictured on the front cover, was the founding professor of the Teachers College Program in Mathematics and Education. Like Dr. Pollak, Professor Smith was widely respected by both mathematicians and educators.

Aims and Scope

The *JMETC* is a re-creation of an earlier publication by the Teachers College Columbia University Program in Mathematics and Education. As a peer reviewed, semi-annual journal, it is intended to provide dissemination opportunities for writers of practice-based or research contributions to the general field of Mathematics Education. Each issue of the *JMETC* will focus upon an educational theme. Themes planned for the 2010-2011 issues are: *Teacher Education, International Education, Curriculum, Technology, and Equity*—all centered upon mathematics and its teaching. The *JMETC* will have a distinctive niche in the world of education publishing. Our readers are educators from pre K-12 and college and university levels, and from many different disciplines and job positions—teachers, principals, superintendents, professors of education, and other leaders in education.

Manuscript Submission

We seek conversational manuscripts (2500-3000 words in length) that are insightful and helpful to mathematics educators. Articles should contain fresh information, possibly research-based, that gives practical guidance readers can use to improve practice. Examples from classroom experience are encouraged. Articles must not have been accepted for publication elsewhere. All manuscripts may be submitted electronically at www.tc.edu/jmetc. This system will help keep the submission and review process as efficient as possible.

Abstract and keywords. All manuscripts must include an abstract with keywords. Abstracts describing the essence of the manuscript should not exceed 150 words. All inquiries should be sent to Ms. Krystle Hecker, P.O. Box 210, Teachers College Columbia University, 525 W. 120th St., New York, NY 10027.

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Call for Papers

The "theme" of the fall issue of the *Journal of Mathematics Education at Teachers College* will be *International Mathematics Education*. This "call for papers" is an invitation to mathematics education professionals, especially Teachers College students, alumni and friends, to submit articles of approximately 2500-3000 words describing research, experiments, projects, innovations, or practices related to international or comparative mathematics education. Articles should be submitted to www.tc.edu/jmetc by September 1, 2010. The fall issue's guest editor, Dr. Juliana Connelly, will send contributed articles to editorial panels for "blind review." Reviews will be completed by October 1, 2010, and final drafts of selected papers are to be submitted by November 1, 2010. Publication is expected in late November, 2010.

Call for Volunteers

This *Call for Volunteers* is an invitation to mathematics educators with experience in reading/writing professional papers to join the editorial/review panels for the Fall 2010 and subsequent issues of *JMETC*. Reviewers are expected to complete assigned reviews no later than 3 weeks from receipt of the blind manuscripts in order to expedite the publication process. Reviewers are responsible for editorial suggestions, fact and citation checking, and identification of similar works that may be helpful to contributors whose submissions seem appropriate for publication. Neither authors' nor reviewers' names and affiliations will be shared; however, editors'/reviewers' comments may be sent to contributors of manuscripts to guide further submissions without identifying the editor/reviewer.

If you wish to be considered for review assignments, please request a *Reviewer Information Form* from Ms. Hecker. Return the completed form to Ms. Krystle Hecker at JMETC@tc.columbia.edu or Teachers College, Columbia University, 525 W 120th St., Box 210, New York, NY 10027.

Looking Ahead

Anticipated themes for future issues are:

Spring 2011	Curriculum
Fall 2011	Technology
Spring 2012	Equity
Fall 2012	Leadership
Spring 2013	Psychology

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Journal of Mathematics Education at Teachers College
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Inside the UTeach Program: Implications for Research in Mathematics Teacher Education

Nicholas H. Wasserman
Ph.D. Candidate, Teachers College, Columbia University

As the national impetus to advance education continues to look toward improving the teachers sent into the classroom, more research needs to be done to in the area of mathematics teacher education. A number of recent studies have summarized, synthesized, and developed useful information about what should be viewed as important in mathematics teacher training. This paper looks at some of these claims from current research and uses the UTeach program from the University of Texas at Austin as a means of elaborating on how some theoretical issues might be addressed in practice. A number of implications are proposed in response to the discussion, one in particular addressing a gap in current research about understanding when beginning mathematics teachers learn the attributes helpful for good mathematics instruction.

Mathematics education, particularly in teacher preparation, has become the subject of increasingly more research, as witnessed by the inception of the *Journal of Mathematics Teacher Education* (JMTE) in 1998 and research books such as *The Mathematics Teacher in Transition*, edited by Fennema and Nelson (1997), *Making Sense of Mathematics Teacher Education*, edited by Lin and Cooney (2001), and *The International Handbook of Mathematics Teacher Education*, edited by Wood, Sullivan, Krainer, Jaworski, and Tirosh (2008). The national urgency to produce *highly qualified teachers* for every classroom, as endorsed by No Child Left Behind, has made research into teacher preparation even more of a priority.

Since the inception of educational research into mathematics teacher preparation programs, beginning with people like David Eugene Smith of Teachers College, four general components have been highlighted: strong mathematical preparation, mathematics pedagogy, educational history, philosophy and psychology, and supervised practice teaching (Donoghue, 2006). While all of these have remained relatively consistent in teacher preparation programs, current research has attempted to broaden our understanding, and future research will need to continue to identify desirable features in teacher education programs.

Selected Current Research

In the *Second Handbook of Research on Mathematics Teaching and Learning*, Judith Sowder (2007) moves beyond some of the basic components of teacher preparation programs and summarizes other common characteristics that have been found through research to be effective in teacher education. Her list includes: a collaborative effort among different faculty at the college level; teacher candidates developing deep content knowledge; connection of content and methods courses through field experience; integration of theory, research, and practice; good modeling of teaching at the university level; content that incorporates student interests and local concerns; and the encouragement of reflective inquiry. Yet despite such efforts at synthesizing and evaluating research, obtaining consensus between mathematics educators about effective practices is difficult. Researchers and those charged with implementing educational research (e.g., teachers) often disagree.

Since researchers and teachers have been viewed on opposite ends of the spectrum with respect to what is important in teaching, Wilson, Cooney, and Stinson (2005), in a recent empirical study, looked at two questions from the perspective of nine experienced mentor teachers—what good mathematics teaching consists of and how it develops. The aim was to identify any perceived differences between researchers and teachers on these issues. A somewhat surprising result, the authors found much accord in the first part of their study between what the teachers cited as good mathematics teaching and what was viewed as good mathematics teaching in research—particularly the NCTM documents.[1] The conclusion from the teachers in response to good mathematics teaching was that it requires prerequisite knowledge, promotes mathematical understanding, engages and motivates students, and requires effective management. In the second part of their study, the researchers took an in-depth look at how these teachers believe good mathematics teaching develops. The four prominent themes for developing good mathematics teaching were that it requires experience

[1] Wilson et al. use NCTM documents to refer to the 1989 Curriculum and Evaluation Standards for School Mathematics, the 1991 Professional Standards for Teaching Mathematics, the 1995 Assessment Standards for School Mathematics, and the 2000 Principles and Standards for School Mathematics.

teaching, education, personal reading and reflection, and interaction with colleagues. In the study, the nine participants paid homage to their education, personal reflection, and colleagues. However, the theme of experience teaching seemed to be viewed as the real source of learning to teach, as opposed to other things such as content knowledge, technology, and planning lessons. Opportunities for experiencing teaching emerged as the most directly connected to improved teaching practices.

A number of pertinent issues surface from these two studies regarding teacher preparation programs. Sowder (2007) offers a list of common characteristics of teacher education programs that are effective, which includes some programmatic ideas to have in place (i.e., collaboration among faculty, deep content knowledge, field experience, etc.), as well as some critical theoretical ideas (i.e., integration of theory and practice, fostering reflection, etc.). The study by Wilson et al. (2005) adds balance to the research by taking into account teachers' perspectives about attributes that are critical for mathematics teachers to have, including: deep content knowledge, experience teaching, personal reflection, and interaction with colleagues. These conclusions are insightful, as they help determine what is important, yet they leave out more descriptive practices. For example, both studies claim that fostering reflection is significant; simply stating this, however, does not develop what fostering reflection looks like. As a means of elaborating on some of these research ideas, we will look more closely at one program, the UTeach program. We will look into the specifics of the program not as a means of elevating one model of teacher preparation onto a pedestal, but rather as a vehicle to develop these research ideas through the particular contextual aspects of the UTeach program. Specifically, we will further expand on the various programmatic ideas—*collaboration among faculty, field experience,* and *deep content knowledge*—and theoretical practices—*integration of theory and practice, fostering personal reflection,* and *collaboration with colleagues*—cited in the selected research.

About UTeach

The University of Texas at Austin pioneered the UTeach program in 1997 to prepare secondary mathematics and science teachers. The program "emerged from the conviction that deep content mastery is essential for excellent teaching, but it is not enough" (UTeach 2007, p. 2). It represents one path in the preparation of secondary mathematics and science teachers, combining an undergraduate degree with teacher certification (as opposed to other paths that offer certification via an undergraduate degree, require a master's degree for certification, or convert graduates into teachers through an alternative certification program). It has garnered some national political support—President Obama made reference to the program in relation to fostering the next generation of math and science teachers. He proposed "launch[ing] programs like UTeach at UT Austin that allow aspiring teachers to get a math or science degree and teaching certificate at the same time" (http://www.whitehouse.gov/the_press_office/Remarks-by-the-President-at-the-Department-of-Education/) as a viable way for states to become involved in the process of attaining qualified teachers. The program is currently in the process of replicating itself at other universities that are a part of the UTeach Institute.[2]

Programmatic Ideas: A Course of Study

During the beginning stages of development on the UTeach program, the College of Natural Sciences and the College of Education collaborated to identify how to recruit students, to provide financial support through internships, stipends, and tuition-free introductory courses, and to design a course of study that would combine mathematics/science course requirements with a synthesis of education courses oriented towards secondary mathematics/science teaching (UTeach Institute, 2007). Their ideas evolved into nine courses: Step 1: Inquiry Approaches to Teaching, Step 2: Inquiry-Based Lesson Design, Knowing and Learning in Mathematics and Science, Classroom Interactions, Functions and Modeling, Perspectives on Science and Mathematics, Research Methods, Project-Based Instruction, and Apprentice Teaching. An essential thread in the design of the program was the incorporation of classroom field experiences beginning in the first semester with Step 1, which become progressively more involved throughout the University experience. Nel Noddings (1992) notes that most teacher knowledge is learned on the job, in the classroom. Thus, the faster pre-service teachers gain entrance to the classroom, the quicker they learn practical teacher knowledge.

The rationales for these courses vary, but overall they serve to introduce educational ideas deemed critical by the University for mathematics/science teachers. Step 1 and Step 2 require teaching at elementary and middle schools and aim to foster an understanding of inquiry-based teaching. Knowing and Learning is an introduction to broader fields (like psychology, philosophy, development theory, etc.) as they relate to mathematics/science

[2]The UTeach Institute consists of the University of Texas at Austin, University of Houston, University of Florida, Florida State University, University of Colorado, Western Kentucky University, Temple University, University of Kansas, University of California Berkeley, University of California Irvine, University of Texas at Dallas, Louisiana State University, Northern Arizona University, and the University of North Texas.

education, while the Classroom Interactions course serves to foster reflection as students begin to implement these learning theories into the complex world of teaching that includes issues of equity and equality, classroom management, and administration. Functions and Modeling is a course aimed to strengthen and develop connections in the secondary mathematics curriculum from Algebra to Calculus, and Project-Based Instruction seeks to teach how to design curriculum that engages students in real-world activities. The Perspectives and Research Methods courses help develop historical and philosophical underpinnings of the mathematics and science fields and actively engage students in the world of research. The culminating experience is Apprentice Teaching, where students are assigned cooperating classroom teachers and are observed by University facilitators and course instructors.

Deep Content Knowledge

Aside from education courses, it has been perceived that mathematics courses for teachers often are "watered-down" versions, leading to the conclusion that teachers are incapable of high levels of mathematics (Noddings, 1992, p. 201). In addition to the nine courses mentioned above, the UTeach program requires that graduates have taken the equivalent content course load of all other mathematics majors. Research claims that a primary advantage in the classroom comes from strong content knowledge, because less time is required to understand the material and more time can be geared toward instructional strategies (Brown & Borko, 1992). Having mastery over content frees the educator to consider not the mathematics, but how best to present the mathematics. Yet Jean Carroll (2005) rightly observes that it is not simply the level of mathematics that one has attained that determines this confidence, nor the formal qualifications, but the nature of the subject knowledge that has been acquired—i.e., ability to make conceptual connections within and between subject matter. The mathematics courses, Functions and Modeling, and Problem Solving, perhaps serve to address this need. One limitation, however, is that deeper conceptualizations and the nature of subject knowledge acquired are difficult to evaluate. The degree to which academic courses are successful in effecting change in students' thoughts and inner beliefs or in their ability to assess conceptual connections can be questioned (for more studies about difficulties in changing beliefs in mathematics and education, see Brown & Borko, 1992; Cobb, Wood, & Yackel, 1990; Jaworski, 1998; and Thompson, 1992). Discussing the development of certain ideas at UTeach—such as faculty collaboration, field experience, and incorporating deep content knowledge into the program—has addressed some programmatic aspects of the research done by Sowder (2007) and Wilson et al (2005).

Theoretical Practices: Inside a Course of Study

Besides the specific structure behind a course of study, a number of other educational ideas presented by the selected research need to be developed. The three ideas mentioned in the following paragraphs—integration of theory and practice, fostering personal reflection, and collaboration with colleagues—are not easily addressed by naming a course of study, but rather by looking inside the particular practices of these courses.

Integration of Theory and Practice

The issue of integrating theory and practice is itself worthy of an entire volume, but only a few ideas can be highlighted here. Incorporation of theory and practice can happen by literally merging the two into one, something similar to a course such as Step I; or it can be achieved by ensuring that theories learned in previous courses are considered during field experiences teaching through some sort of rubric or other device. Besides merging the two into individual courses with field experiences, UTeach has tried bridging the gap by adopting a 5-E model for lesson plans[3] throughout the program in order to develop good habits of thinking about lessons. Similar to the Singapore bar model (Hoven & Garelick, 2007), the consistency is intended to help students become fluent in using this lesson model while also implementing theory. One limitation with such a model is that it can be turned into knowledge about lesson planning, and not about teaching. And while the two are linked, the research by Wilson et al. (2005) suggests they are distinct: ability to lesson plan did not necessarily translate into good mathematics teaching. As such, the 5-E model's effectiveness in allowing students to connect theory and practice requires further study.

Fostering Personal Reflection

Both Sowder (2007) and Wilson et al (2005) speak to the merit of developing reflection, and as Goodell (2000) notes, facilitating reflection in future teachers is important, if not most important, in changing beliefs and practices. Thus, programs must explore ways to help teachers "examine their beliefs and practices, develop intrinsic motivations for considering alternatives to their current practices, and develop personal reasons for justifying their actions" (Thompson, 1992, p. 143). Michael Marder, Co-Director of UTeach, phrases it this way: "I don't think you can sit students in a row and give them a lecture three times a week on why they should not teach using lectures" (http://www.utexas.edu/features/2007/uteach/). In a number of the UTeach courses, students are expected to

[3] The 5-E's stand for: Engage, Explore, Explain, Extend/Elaborate, and Evaluate throughout.

prepare written reflections of the kind McNaught (2007) has studied, as a tool to promote quality self-reflection and also submit analyses of videotaped lessons, which Towers (2007) cites as an effective tool to enhance pedagogical reflection. Much of how reflection is used and applied, however, depends on the particular teacher teaching the course and the willingness of the student(s) to engage in honest reflection. Therefore, any tools meant to enhance reflection are only as useful as they are thoughtfully applied by both instructor and student.

Collaboration with Colleagues

Lastly, requirements of the program force colleagues to interact, since many of the early classroom field experiences involve co-planning and co-teaching, which Bobis (2007) indicates is advantageous. Partners allow students the added benefit of acclimating to the classroom in small increments, since some of the fears associated with teaching and planning a lesson become less intimidating while working together. The use of co-planning, in conjunction with a designated common workspace set up at the University, aims to develop what Lave and Wenger describe as a "community of practice" (in Cavanagh 2007, p. 183), which encourages accountability, creativity and reflection. The importance of working with colleagues and the definition of "community of practice" can extend far beyond peers and might benefit from incorporating mentor figures, master teachers, cooperating teachers, and local experts into the prospective teacher's sphere of influence.

Each of the three theoretical ideas discussed above has yielded practices from the UTeach program as illustrations within a course to address the ideas presented in research. Each can be seen in response to conclusions made by researchers about teacher education programs that include a need for deep content knowledge, field experiences, and fostering personal reflection and collaboration with colleagues, and address those questions posed by Wilson et al. (2005): What is good mathematics teaching? And how can it be developed? The difficulty with any of these responses, the shortcoming in simply looking at the UTeach program, or any program for that matter, to develop these research ideas is that perhaps these program structures and theoretical tools were not the real source of learning to teach. It is important to determine whether program components responding to research needs were the source of teaching competence. Perhaps the necessary deep content knowledge did not come during a course like Functions and Modeling; perhaps completing written assignments and videotape analyses had little to do with learning personal reflection. If good mathematics teaching did not develop through these things, then *When*?

Implications for Research

The discussion thus far contributes to our understanding of research in mathematics teacher education and presents illustrations of programmatic ideas and theoretical practices used in teacher preparation. The specific context of the UTeach program has opened a window to research in a variety of areas. The ideas from the selected research discussed in depth—deep content knowledge, field experiences, integrating theory and practice, fostering personal reflection, and collaboration with colleagues—need to be developed further. More studies that expand how these can be achieved in practice are necessary. What types of courses best prepare students for the necessary, deep mathematics knowledge? How can students' depth of knowledge be measured more effectively? Do field experiences genuinely integrate theory? What are effective ways to encourage honest reflection that is meaningful and insightful? Is it more imperative for prospective teachers to collaborate with colleagues or master teachers? How can collaboration be facilitated most productively? These are just a few of the directions that looking into one teacher education program can open up. The remainder of this article will focus on one other implication for research.

When?

The research discussed has expanded on particular ideas about good mathematics teaching. And yet the development of the attributes necessary for good mathematics teaching could be acquired at any time, whether it is during the course of a teacher education program or not. Taking into consideration the research of Wilson et al. (2005), which looked at experienced teachers responses to the questions of *What*? And *How*?, a future study might ask *When*? When do teachers really learn what good mathematics teaching looks like? Is it from a teacher preparation program, an induction program, or from a favorite high school teacher? When do beginning teachers really learn how to reflect on teaching? Is it from requirements in a teacher preparation program or from parents while growing up? When do teachers become confident in their teaching ability? When do they become competent?

It is understood that a teacher education program cannot, and should not, attempt to teach everything a teacher needs to know before entering the profession. Yet, as the research into mathematics teacher education continues to move forward, programs will need to revise and improve practices based on how the program actually affects the ability of graduates to teach mathematics with some level of success. One possible way of organizing when beginning teachers report learning attributes of success would be to examine three stages: pre-, during, and post-program. This might give further insight into what a teacher education program not only should be doing but also could be doing better. To find some personality trait or knowledge pre-program that has helped with success gives insight into what types of students a program should try to attract or recruit. To find some components graduates are doing well helps distinguish successful aspects of a teacher education program. And to find knowledge learned post-program helps define areas of a program where practicum or internship components might best be utilized. Linking current research about *what* factors were tied to successful mathematics teaching with *when* they were learned has interesting implications, particularly in regard to teacher education programs.

Conclusion

Since the national impetus to reform education continues to look toward improving the teachers sent into the classroom, more research needs to be done in the area of mathematics teacher education. As we have seen, a number of recent studies have summarized, synthesized, and developed useful information about what should be viewed as important in mathematics teacher training. And in describing the UTeach program, we have discussed what some of these theoretical research ideas might look like in practice, realizing that a look into any program will not yield a comprehensive picture of all possible solutions, but rather a glimpse into one particular program. From a reflection on current research and practices, a variety of research directions have been suggested, with one proposed study aiming to fill a void in understanding *when* beginning mathematics teachers learn the attributes helpful for good mathematics instruction. The categorization involved in this future research would build on previous research that addresses *what* good mathematics teaching consists of and *how* it develops, and help identify *when* some of the complex tasks and skills associated with teaching are developed, or might best be developed, in regard to teacher education.

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