# Technology in Mathematics: Issues in Educating Teacher Candidates for Rural Math Classrooms

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## Abstract

*This paper examines the reality of teaching math in the rural southeast. Rural districts have low student expenditures and high transportation costs, due in part to the limited tax-base available. This leaves limited funds for technology. Universities prepare preservice teachers to teach math using the latest technology, however, many of these preservice teachers will return to classrooms with limited or out-dated technology. This paper presents a case-study of preservice students' education and field experiences in rural northern Mississippi. Further, implications for changes in how we teach technology to preservice students who will likely return to rural settings are discussed.*

## Introduction

Technology is generally perceived among educators as a vital tool for effective instruction in secondary mathematics classrooms (NETS, 1999; NCTM, 2000; AMTE, 2007). The National Council of Teachers of Mathematics (NCTM) document, Principles and Standards for School Mathematics (PSSM) (2000), highlights their position statement concerning the crucial role of technology in the PSSM Technology Principle (2000). The Principle states, "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances student's learning." Through the use of calculators, computers, and dynamic software, middle and high school students can study complex algebraic relationships, self-discover fundamental geometric theorems, and analyze large sets of data (Kaput, 1992; Hershkowitz, et al, 2002; Mariotti, 2002). Technology is also evident through the numerous websites designed to enhance instruction, provide tutoring, or serve as resources to teachers and students.

Research suggests students who use technology as a primary resource are better able to understand the application of mathematical principals (Kaput, 1992; Sfard & Leron, 1996; Mariotti, 2002). When students are freed to explore math through technology and as a result not confined to paper and pencil tasks, problems that are easy to manipulate, or workable data sets, they are able to explore the rich math present in real world math modeling. By providing a technology-rich classroom, student work is no longer limited to simple symbolic manipulation. Instead, students can interact with complex, real-world problems that enhance their understanding and pique their interest in school mathematics. The powerful influence of quality technology use in secondary classrooms is well researched (Cuban, 2001).

The International Society for Technology in Education (ISTE) released the National Educational Technology Standards (NETS) for preservice and practicing teachers in fall of 1999. Paramount to incorporating these standards is the idea that the quality use of technology should begin with the classroom teacher (Green & Gilbert, 1995; ISTE Standards, 2005). To accomplish high levels of technology adoption and effective use in the classroom, technology leaders suggest teachers need to have specific professional development in the appropriate and effective uses of technology in the classroom (Green & Gilbert, 1995). Teacher educators have acknowledged the need for specific technology training in preservice programs to meet technology needs, however, research still shows a lack of quality programs in Colleges of Education (Fleming, Motamedi, & May, 2007). An examination of math education programs shows similar patterns after students are licensed and in the field. Fundamentally, preservice teachers are taught that technology can make a difference in their own students' achievement; however, they are often not fully apprised of the differences between the ideal and the reality of technology availability.

## National Beliefs, Practices, and Opinions Concerning Technology for Math Instruction

Reforms in the teacher education process began in earnest in the early 1990's. Numerous reports on the state of mathematics education emphasized the need for teacher candidates to have a formal mathematics education accompanied by professional education courses (See: National Research Council, *Reshaping School Mathematics*, Trends in International Mathematics and Science Study, *Third International Mathematics and Science Study*, and Conference Board of Mathematical Sciences, *The Mathematical Education of Teachers*). The Conference Board of Mathematical Sciences (CBMS) issued a professional call for all mathematicians to provide instruction in all courses that will specifically benefit future teachers. Research suggests that teacher candidates with a deep and complete understanding of mathematics will be more effective classroom teachers (Ball & Cohen, 1999; Heibert & Stigler, 2000; CBMS, 2001; Lappan & Rivette, 2004).

The "highly qualified" requirements for all public school teachers enacted under the *No Child Left Behind Act* (NCLB) federal reenactment of the Elementary and Secondary Education Act (ESEA), originally written into law in 1965 (PL 89-10, 20 U.S.C. § 6301 et seq.), further underscores content knowledge requirements for both teachers and teacher candidates by mandating each state set standards for the minimum number of content courses required to teach a subject. The National Council for Accreditation of Teacher Education (NCATE) has taken all recommendations into consideration and consequently requires that all public school mathematics teachers (teacher candidates and in-service) have progressed through rigorous mathematical coursework and in-depth professional development courses (see Figure 1). This national "formula" creates a framework for producing quality math teachers. It should be noted, however, that technology is not specifically identified as an integral math course.

*Figure 1.*
Conference Board of Mathematical Science's Recommended Courses for Math Education Programs.

| Undergraduate Math Courses |
| --- |
| Calculus Sequence |
| Geometry |
| Descrete Math |
| Proof-based Math |
| Probability |
| Statistics |
| Abstract Algebra |

(CBSM, 2001)

## The Complicated Issues of Rural Math Classrooms

Keeping the national perspective at the forefront is important when developing goals for education programs; however, acting at the local level to meet the specific needs of a region still must be addressed. Universities in the southeastern United States work to prepare students to enter both urban and rural settings. Urban settings are sparsely located throughout the region (e.g. Jackson, Mississippi, New Orleans, Louisiana, Birmingham, Alabama, for example). However, the large majority of teacher candidates prepared in southeastern universities return to rural settings to practice. Rural schools have specific issues related to "ruralness" (Bush, 2005). Teacher education programs are out of necessity training teachers to be highly effective, rural mathematics teachers. Consider the following issues faced by one university, one not dissimilar to many of the universities in the southeast.

A Case Study:

One land-grant university located in the rural southeast prepares the majority of teachers for the region. Through the university's teacher education program, approximately 100 secondary teacher candidates are placed per year into the surrounding local systems. Within the local school systems, Algebra II is the highest *consistently* offered mathematics course. Most systems have a very small math faculty (<4). These high schools do not have the faculties, personnel, or student numbers to justify offering more advanced mathematics classes.

Computer labs are small and frequently outdated in these schools. During a recent Southern Association of Colleges & School accreditation review for a local school district the Limitations, Challenges, and Recommendations included the recommendation to determine the district's technology needs, locate funding sources, and then acquire sufficient technology. School systems in this district generally have one computer lab with the primary function of this solitary lab reserved for researching and writing compositions and other papers. Additionally, only a select few of the faculty are highly experienced with quality math specific technology. With poor tax bases, large transportation costs and aging facilities, many of the local school districts struggle to meet their budgets. Thus, district expenditures on sophisticated calculators, data collection devices, and software are not a priority. Upgrading might require major classroom renovations and possible large bond issues depending on the district involved.

With so many important issues to address, teachers in other rural districts surrounding the university have also chosen not to upgrade the district's calculators due to the limited budget. For example, one area high school elected to keep using the out-moded TI-82. Teachers making this decision cited comfort with the TI-82s and limited opportunities for training with new calculator systems as their main reason for keeping the dated calculators. Another school district uses graphing calculators in the pre-calculus and calculus classes only instead of integrating calculator use throughout all high school math courses. Finally, schools in the rural southeast have internet access in every classroom, but most classrooms have only one computer. Competition for computer use is heavy, so students have limited to no access to the one classroom computer.

## Status of Education in the Rural Southeast

A snapshot of rural education issues in the southeast would not hold any surprises for all but a casual traveler through the region. Vast rural areas are dotted with small towns characterized by low socioeconomic development and schools run by dedicated teachers working to improve both the lives of attending students and community residents at large. For purposes of further discussion, the term rural is defined using the U.S. Census Bureau's definition as a school "that is not urban" (Johnson, 2005).

The most recent report of rural schools by The Rural School and Community Trust Policy Program included an analysis of 22 separate statistical indicators to determine the status of rural education at the individual state level. The resulting report, *Why Rural Matters 2005*, found that in categories related to rural education such as importance of rural education to a particular state, poverty levels, socioeconomic issues in rural vs urban schools in each state, and policy outcomes such as graduation rates, states in the southeast ranked in the lowest levels. These indices emphasize that rural education challenges are more urgent and problematic in southeastern states than in other areas of the country. Rankings from each of these four areas were then averaged to establish an overall score (Johnson, 2005). States in the southeast were given the following "rural education priority" scores (see Figure 2):

*Figure 2.*
Rural Education Priority Scores.

| Southeastern States | Rural Education Priority Score |
|---|---|
| Mississippi | 1 |
| Louisiana | 4 |
| Alabama | 5 |
| Arkansas | 7 |
| Georgia | 12 |
| Tennessee | 13 |

Other challenges listed in NEA's *Issue Paper on Rural Education* include funding, teacher shortages, and inadequate school facilities (2007). The Rural Education Initiative (REI) was subsequently passed by Congress to address these particular issues.

According to the U.S. Department of Education's National Center for Educational Statistics, the following table documents student expenditures by state for the 2003-2004 school year as compared to the national average (see Figure 3).

*Figure 3.*
Expenditures by state, 2003-2004.

| Southeastern States | Expenditure Per Student | Number of Enrollees |
|---|---|---|
| Mississippi | $6,199.00 | 220,845 |
| Tennessee | $6,466.00 | 276,920 |
| Alabama | $6,581.00 | 264,945 |
| Arkansas | $6,842.00 | 157,909 |
| Louisiana | $7,271.00 | 183,623 |
| Georgia | $7,742.00 | 396,096 |
| United States Average | $8,310.00 | 148,579 (median) |

## Reality of Math Education

A review of ten southeastern universities reveals the curriculum requirements for math education varies from program to program. However, all ten math education programs have similar elements. 1) Students major in math. 2) Students must pass a culminating math content exam. 3) Students are required to use math technology. Surveys of these programs indicate students work with MapleSoft, Geometer Sketchpad, statistics programs, various calculators, and computers. 4) Teaching with math specific technology *may be* integrated into courses. 5) Students take professional education courses and specific pedagogical content courses. 6) Students have culminating field experiences. Finally, NCATE accredited programs have pedagogy related to technology integrated throughout the program to meet accreditation standards because NCATE Standard 1 specifically states that technology should be integrated throughout candidates' course work. Unfortunately, the reality preservice teachers will face when practicing in a rural classroom is potentially a very different scenario than they experience in the university classroom.

The disconnect between the ideal and the practical does not escape teacher candidates during their supervised internships. Consider, for example, the anecdotal evidence gathered for this case study. Teacher candidates were amazed at the lack of math-specific technology used in the local high school. One teacher candidate described the experience as disappointing to realize that students only utilized the special keys of the TI-83 in the Statistics class, otherwise, students have a very expensive calculator to compute large numbers. Another teacher candidate reported with surprise that calculators were not allowed in the Pre-Algebra classes. The teacher candidate continued with, "The teacher was only interested in making sure the students completed the problems her way. Since she didn't need a calculator, the students didn't either." Some experiences do provide hope that technology practices are changing in some of secondary math classrooms located in the northern part of the case study area. Several public school teachers from different districts seek to have the university methods students complete a practicum in their classes. These teachers indicate that they themselves learn valuable information about technology and the latest math practices from new teacher candidates. This scenario further emphasizes that math education students receiving instruction in using math-specific technology will be of benefit systemically. Understanding the state and national standards for using technology in the math classroom and identifying funding resources to purchase technology for their classrooms will enhance this situation as well.

Math courses, or the accompanying technology, are typically not taught with future teachers in mind. A professor of mathematics at the case study university stated, "Technology, such as MapleSoft or other math software, is designed to help the students understand math, not to help them learn how to teach math to others." Most math courses are taught for multiple audiences, for example the third and fourth courses in the calculus sequence are required of all engineering majors, math education majors, and pure math majors. But still, the current model is mathematicians providing instruction to future mathematicians who will teach; i.e., content is taught, but the pedagogy involved is not directly passed on. Interestingly, professional development opportunities for mathematicians such as the NSF-funded Preparing Mathematicians to Educate Teachers or the focus of Mathematical Association of America's section meetings on Math Education indicate this traditional model may have flaws. These issues of mathematics for future math teachers do not even address the pertinent issues concerning rural classrooms that preservice teachers may eventually face.

## A Call to Action

National technology leaders have issued challenges to increase the quality of technology education in all classrooms (ISTE, 2005). However, in rural classrooms issues of poverty, low expectations, closed communities, and poor facilities are just some of the challenges (Annenburg, 1999; Bush, 2005). Technology improvement in a rural classroom is, at best, far down the list. Future teachers need to be equipped to return to the rural classroom to meet challenges that are uniquely different. In the Annenburg Rural Challenge (1999), high academic standards and community leadership were major points of the challenge. The Rural Math Educator addresses the need for math to be meaningful to the student, but interestingly, technology is not even mentioned.

Pedagogy courses need to teach teacher candidates how to be effective math teachers, no matter what classroom they are assigned. In order to improve instruction in secondary math methods courses to equip teacher candidates for effective math instruction in area rural schools, particularly with regards to technology use, there are definite challenges ahead. Teacher candidates need to learn 1) technology, 2) how to effectively teach with limited and potentially out-dated modes of technology, 3) how to evaluate technology and make wise choices when funds become available, and 4) how to seek out and procure their own funds. As methods courses evolve to address these challenges, benefits for teacher candidates will increase.

Working collaboratively at the university and with local rural school districts to develop an effective model course for teacher candidates will ultimately impact 6-12 learning across the southeast. The following are specific recommendations for consideration: Strong ties should be maintained with teacher candidates as they enter the classroom so university faculty can provide support. Seminars could be routinely offered by university faculty, for example, such as how-to-classes about educational grant writing with the purpose of generating financial support for technology. Candidates should be directly taught how to evaluate technology so that good choices are made when technology dollars are available.

Among the many actions southeastern universities, such as the one presented in the case study model, can initiate to more fully prepare teacher candidates for rural classrooms are the following:

University faculty must receive greater support for working with rural 6-12 faculties to improve technology use and resources available in secondary classrooms. Both faculties, 6-12 and university, need to work collaboratively to procure grants, provide professional development, and provide first the technology, and then the support needed for the best math-specific technology in the schools. Further, collaborative work between 6-12 math faculty and university education faculty is necessary to set the foundation for this initiative. If math teacher candidates enter methods courses already proficient in the use of various types of technology, they can concentrate on the pedagogical issues of teaching with the appropriate available technology in real 6-12 classrooms. Finally, expertise in the use of math-specific technology based on up to date research should be continuously developed. This includes both 6-12 and university faculty participating routinely in conferences for the purpose of reviewing the latest information concerning technology use. Other professional development opportunities such as Preparing Mathematicians to Educate Teachers (PMET) or short courses should ideally be funded and made available to all levels of faculty as well.

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