Preparing Future Secondary Mathematics Teachers to Use Technology Effectively in Their Classrooms

Technology is becoming more commonly used in the mathematics classroom everyday. To help entry level teachers become effective users of the technology it is important for institutions of higher education who prepare teachers to provide their students with experiences that enable them to be knowledgeable, skilled and comfortable at using up-to-date technology for daily mathematics instruction. This article provides examples of student experiences provided by one such institution with the intent of preparing these future teachers to use whatever technology is available and to use it effectively whether they go on to teach in a technology rich school district or one with little technology. They are also encouraged to become an advocate for the district to obtain more technology for classroom instruction, if it is needed.

Recommendations from Other Professional Groups

The Conference Board of the Mathematical Sciences (CBMS, 2001) in its Recommendation for Technology in Teacher Preparation has indicated that although "technology has revolutionized many jobs and substantially increased the mathematical skills needed across the workforce, its impact, in contrast, on instructional practices has been more modest and varies greatly from classroom to classroom." To help overcome this void is a responsibility, in part, of the college teacher preparation programs in mathematics education. Colleges need not only use technology in their mathematics classes but provide and require a course for future teachers who focus on the selection and integration of appropriate and varied technologies (Niess, 2006).

Smith & Shotsberger (2001) in a study of college pre-service teachers determined that future mathematics teachers do not feel prepared to teach mathematics using technology. However, as summarized in a technology position statement prepared by the Technology Committee for the Association of Mathematics Teacher Educators (2005) and approved by the AMTE Board in 2006,

> "Teacher preparation programs need to focus on strengthening the preservice teachers' knowledge of how to incorporate technology to facilitate student learning of mathematics through experiences that: (1) Allow teacher candidates to explore and learn mathematics using technology in ways that build confidence and understanding of the technology and mathematics. (2) Model appropriate uses of a variety of established and new applications of technology as tools to develop a deep understanding of mathematics in varied contexts. (3) Help teacher candidates make informed decisions about appropriate and effective uses of technology in the teaching and learning of mathematics. (4) Provide opportunities for teacher candidates to develop and practice teaching lessons that take advantage of the ability of technology to enrich and enhance the learning of mathematics."

A Course for Future Mathematics Teachers

The author began teaching a second "methods" course in 2005 that he developed and that is now required of all university pre-service students preparing to teach secondary school mathematics. This two-semester hour course was designed to prepare students to be comfortable, knowledgeable and experienced at using technology with their future students. The need for the University to offer the course was identified in part by previous students from their responses on senior and alumni surveys from 2001 to 2006 in which they were asked questions regarding the experiences they received as an undergraduate on campus. For one item "Training in the use of computers," they were to rank as Poor, Fair, Good, or Excellent (1 to 4, respectively). The average on this item by alumni was 2.87 and for graduating seniors the average was 2.55. Both values are lower than the averages of many other items on the survey. It was also obvious from the author's perspective, that although calculators and computers were integrated into students' mathematics classroom experiences, it was not sufficient for entering the teaching profession.

Although the students come into the course with various technology experiences in their previous high school and college mathematics classes, they were experienced only from a student's perspective and these skills do not transfer over easily to teaching secondary school mathematics. The familiar phrase, "it your really want to learn something, try teaching it," is most applicable for these students in regard to using technology to teach mathematics. During the course, their confidence level evolves from thinking that they know a lot about using technology for instruction, to an uneasiness with some anxiety as they are now required to use technology to develop classroom presentations, computer lab explorations, student in-class and out-of-class assignments, as well as for assessment. However, about midway though the semester the students begin to gain confidence in their ability to use these instructional tools to develop learning opportunities for high school mathematics students with the technology they are now learning as a classroom teacher. By the end of the semester they are comfortable, knowledgeable, and have some experience viewing themselves as a classroom teacher and using technology for instruction.

The students have "hands-on" experiences in teaching with such technologies as: graphing calculators, dynamic geometry software, dynamic data analysis software, computer algebra systems, Internet mathematical resource, online calculators, and dynamic mathematics software applets. For example, they capture multiple representations of a family of functions from their calculators, paste them into a word processing document and write related questions for their phantom algebra students to address. They also use an overhead projector with a *TI-Viewscreen*, the *TI-Viewscreen* computer software, or the *TI-Nspire Computer Software - Teacher Edition* with projection on a *SMART Board* and while presenting ask questions of their colleagues who either play the role of secondary mathematics students, or ask questions for class discussion regarding the quality of the presentation and was to improve it (see Figure 1).

The students collect various data with probes and use the calculator to view and analyze the data. They also collect data from the Internet and other resources and then view and analyze the data with *Fathom*. The students link their calculator to their computer for downloading applications and programs, and uploading data or graphics into a word processing, spreadsheet or a software application document for classroom demonstrations of mathematical concepts and as computer labs for their students. From the Internet, students are made aware of some of the high quality websites that can be used for classroom instruction. This includes NCTM's *Illuminations* and *E-Resources,* as well as *MathTools* from Math Forum and *The National Library of Virtual Manipulatives* from Utah State University. The students work with the *Geometer's Sketchpad* or *GeoGebra* addressing secondary school geometry topics. They learn to use a computer algebra system (*Studyworks* from Math CAD) as well as CAS calculators.

These experiences with classroom technology not only make the students aware of mathematics topics and appropriate technology for classroom instruction, but the hands-on experiences with the technology enable them to gain some level of knowledge, skill, and comfort at selecting and using different classroom technologies. Each student finishes the course by teaching secondary school mathematics lessons to the class using one or more forms of technology.

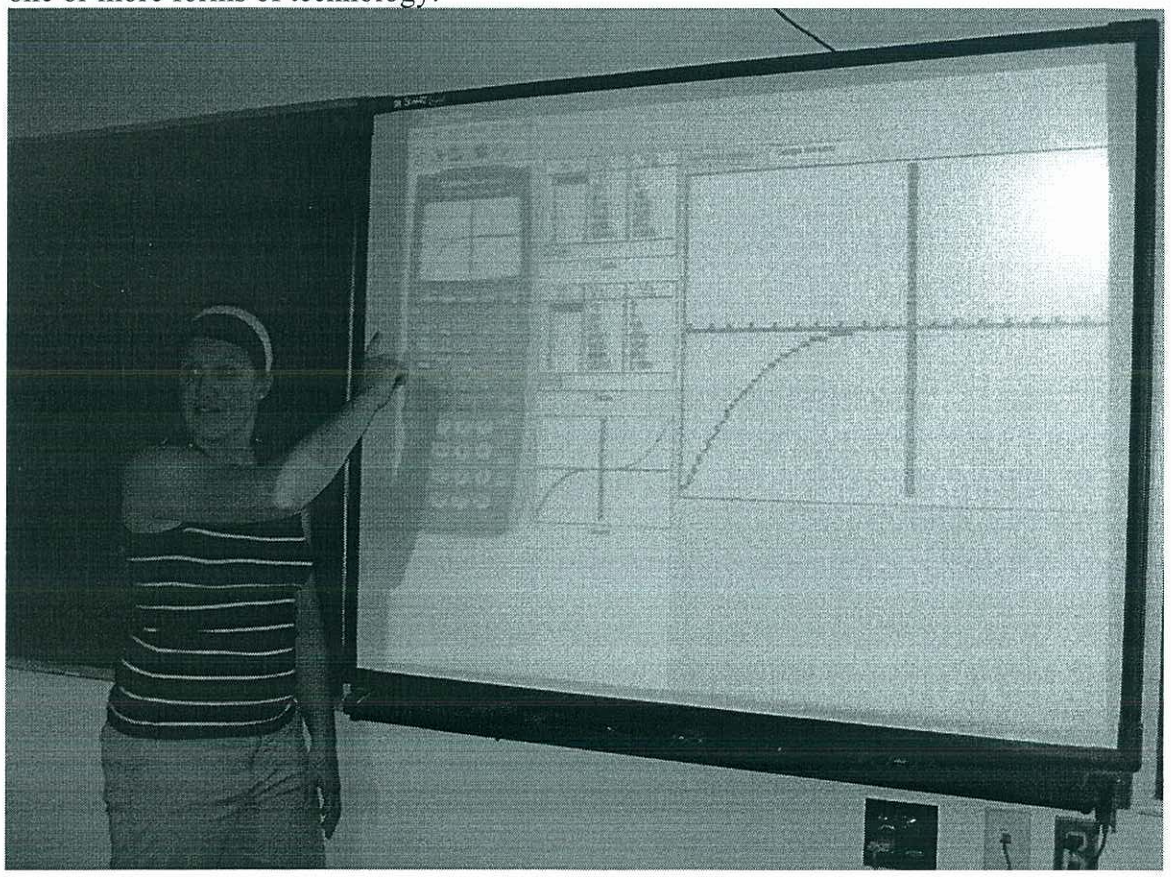


Figure 1: A student presenting an algebra lesson to the class using a *TI-Viewscreen* software and *SMART Board.*

The students move from experiencing mathematics instruction involving a graphing calculator, to experiencing the Internet as a tool for mathematics instruction in which students are first required to go online to read the short version of NCTM's *Principles and Standards of School Mathematics*, view and participate in several of NCTM's *Illumination* applet activities, and a few other high quality web sites for instruction in high school mathematics such as *ENC*, *Interactive Math World*, and *PBS TeacherLine.* Theses experiences provide them with a sense of what mathematics topics can be presented and learned effectively within a technology environment. The Internet enables mathematics students to gain access to the fundamental websites for teaching and learning through standards based lessons and exemplary applets related to them. "Resources for Learning to Teach Mathematics with Technology" at *http://www.mathed.byu.edu/~kleatham/Technology/INDEX.html* is a site as the title suggests, especially for those learning to teach mathematics with technology.

After developing a basic skill level with these tools the undergraduates are required to develop discovery lessons (see Figures 2 and 3 below) for their future math students with the expectation that their students will have graphing calculators and will likely have access to computers containing the types of software identified above. These undergraduate students are also required to develop assessment instruments using this technology.

Students are enrolled in this course a semester or two before their Student Teaching experience, at which time they are required to integrate technology effectively into their teaching.

Comparing Data with Charts and Graphs

For the in-class presentation because I will be teaching at a seventh grade level I will be doing a presentation on different types of data and how they relate to different types of graphs. I would be doing this on a computer with a projector and the students would just be watching for this presentation. First I will ask all of the students in my class (in this example there is twenty students) how old they are, how many pets they have, how many siblings they have, and if they are male or female. While doing this I will be showing them how to create a table and how to enter data into the table. Then from this table I will teach them how to enter certain types of data into a summary table. In this example I will be entering the students' gender into the summary table and explaining the tables attributes to them. Next, we will look at the different types of graphs and what types of graphs are appropriate for what kind of data. For example, for comparing what percentage of the class is male to what percentage of the class is female a ribbon chart is appropriate. This in class lesson is good because not only do the students feel involved because the data is about them, but they are learning how to use fathom and they are learning about what graphs are used in what situations also.

Then after they have heard the presentation on charts and graphs then they will be asked to do this worksheet in class during the next class period.

Figure 2: A description of one student's class presentation on data representations.

By gaining knowledge and experiences in teaching mathematics with technology, and learning how to match an appropriate technology with a mathematics topic before going

into a mathematics classroom as "the" classroom teacher is a real benefit and makes it easier for these future teachers to understand the role of technology in teaching. By beginning their teaching career with knowledge and experience in using technology for instruction, these future teachers look at technology as just another instructional tool, similar to the way many of us considered the overhead projector or chalkboard when we began teaching. They begin to feel that they cannot properly teach without these up-to-date instructional tools. For example, Figure 4 below is part of another student's presentation showing relationships between the measures of the angles, the sides and the coordinates of the vertices of a triangle and those of its reflected image. A third student example (see Figure 5) contains part of an assessment over transforming the sine and cosine functions. The assignment also gave them experience of downloading calculator screens to a computer word processor. A fourth example (see Figure 6) is part of an exploratory investigation using the TI-*n*spire calculator to determine the relationship between the shape of a parent function, f(x) and it's family of functions: $A \cdot f(Bx + C) + D$, by looking at such functions as: $f(x) = x$, $f(x) = x^2$, $f(x) = B^x$, $f(x) = |x|$, and $f(x) = \sin(x)$.

Many fundamental concepts of mathematics, from number and operations at the elementary or middle school level, to learning algebra and geometry at the middle school or high school level, to learning the concepts of calculus at the high school or college level, to developing an abstract algebra at the undergraduate or graduate level of the university, can be acquired and instruction enhanced through technology's offering of dynamic and multiple representations of important mathematics concepts (NCTM, 2008). In this course we focus on topics from pre-algebra, algebra, trigonometry, geometry, statistics, pre-calculus, and some calculus.

Worksheet on Charts and Graphs

1 Look at the table below and based on the information in the table, match each of the different variables with the correct graph.

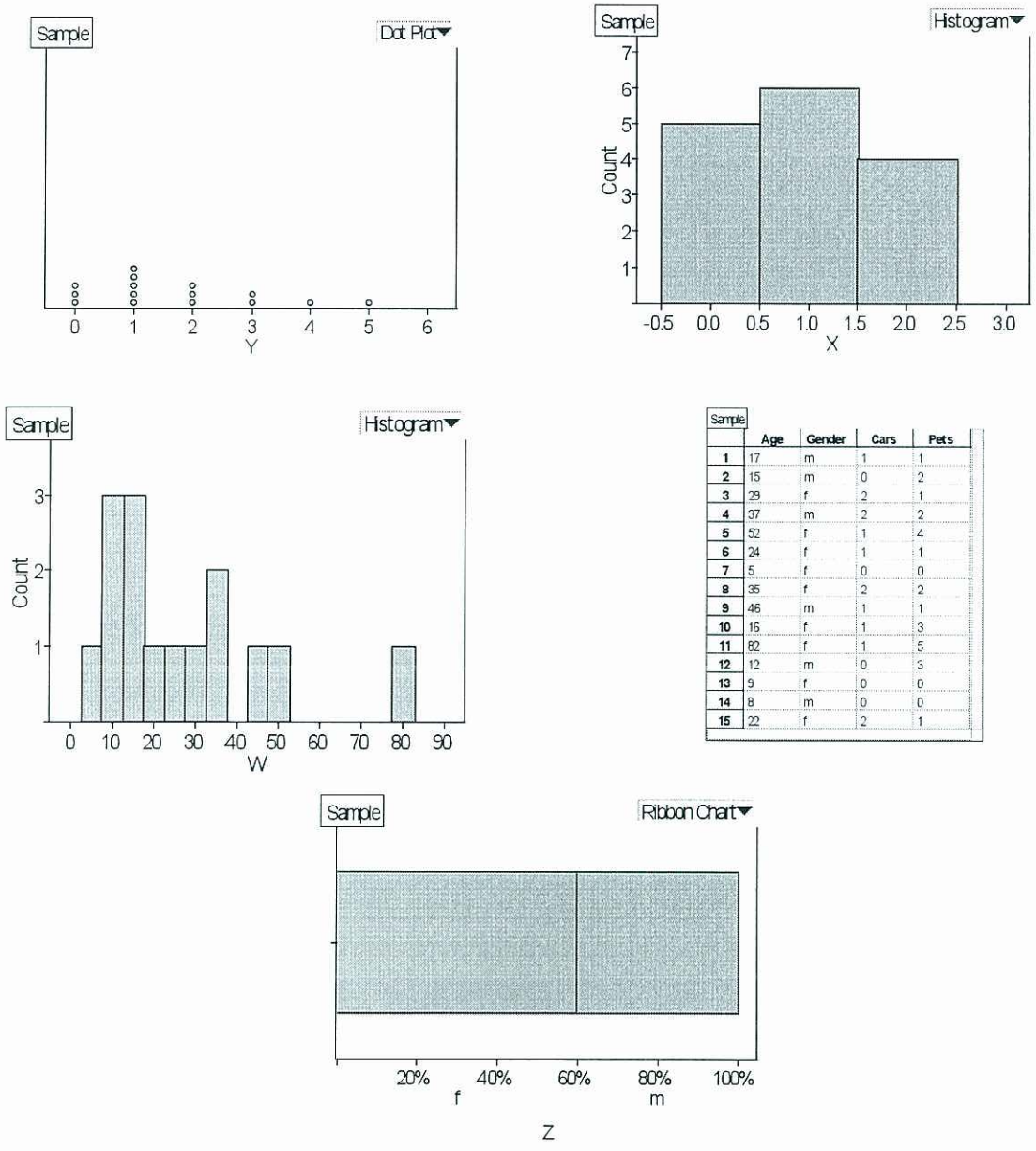
a) Age b) Gender c) Cars d) Pets

2. Find the mean of the number of pets that people have based on the data in the table.

3. Find the median age based on the table.

4. Based on the table, figure out the exact percentage of people that are:

a) Male b) Female



Sample

	Age	Gender	Cars	Pets
1	17	m	1	1
2	15	m	0	2
3	29	f	2	1
4	37	m	2	2
5	52	f	1	4
6	24	f	1	1
7	5	f	0	0
8	35	f	2	2
9	46	m	1	1
10	16	f	1	3
11	82	f	1	5
12	12	m	0	3
13	9	f	0	0
14	8	m	0	0
15	22	f	2	1

Figure 3: Part of a student's class assignment on data representations that is associated with Figure 2.

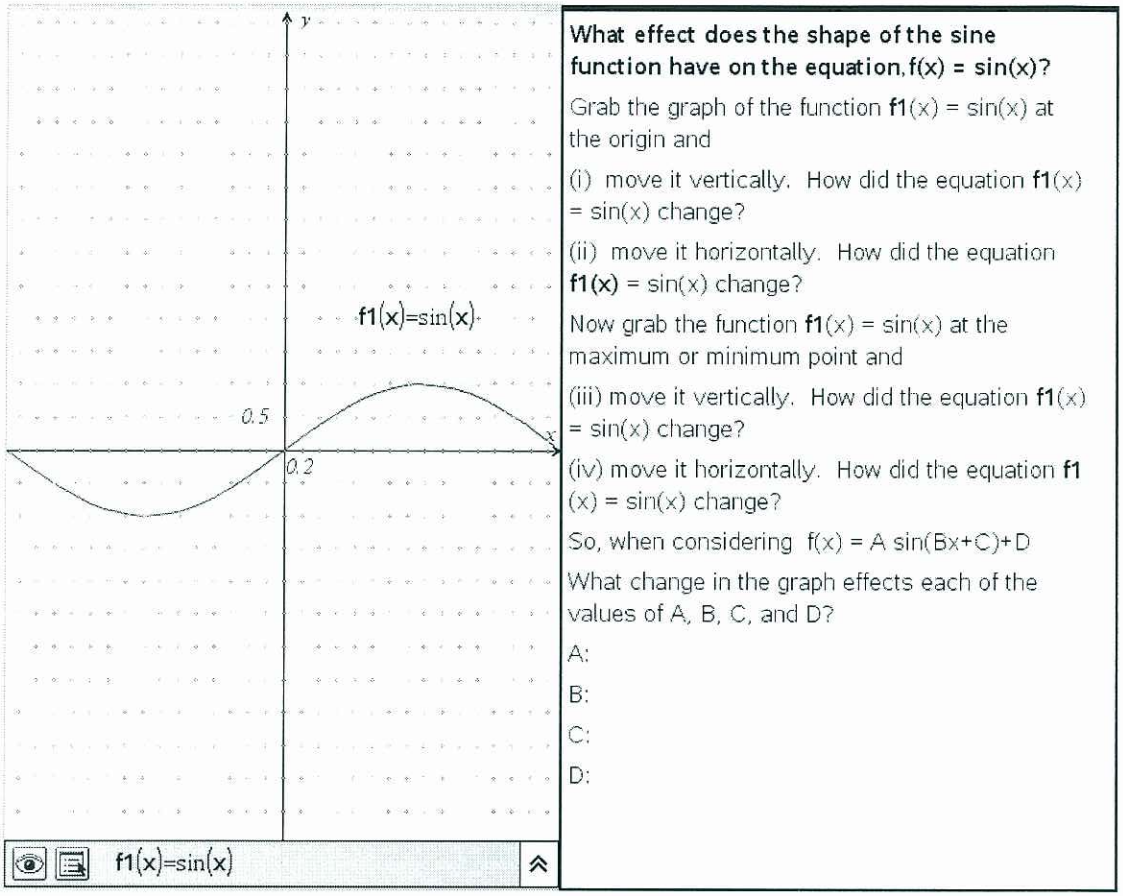


Figure 4: Part of a TI-*n*spire document for student exploration of the relationship between the shape of a sine function and its symbolic representation.

In addition to learning to conduct effective instruction with individual tools such as graphing calculators and computer software, these future mathematics teachers also gain experience with such whole-class instructional tools as the *SMART Board* from SMART Technologies and the *TI-Viewscreen* software from Texas Instruments. As technology is dynamic and changing so does a mathematics technology course change a bit from year-to-year. For example, we recently purchased the *TI-Navigator* System to be used and tested for College Algebra. I include this technology in this methods course but related to the teaching of high school mathematics (see Figure 7). When such tools are used effectively for mathematics instruction, students develop deep and long lasting conceptual understanding of mathematics topics by seeing multiple representations of the concepts in table, symbolic and graphical forms, by dynamically altering a graph to see many variations of the representation and providing opportunities to form conjectures and generalizations concerning the concepts.

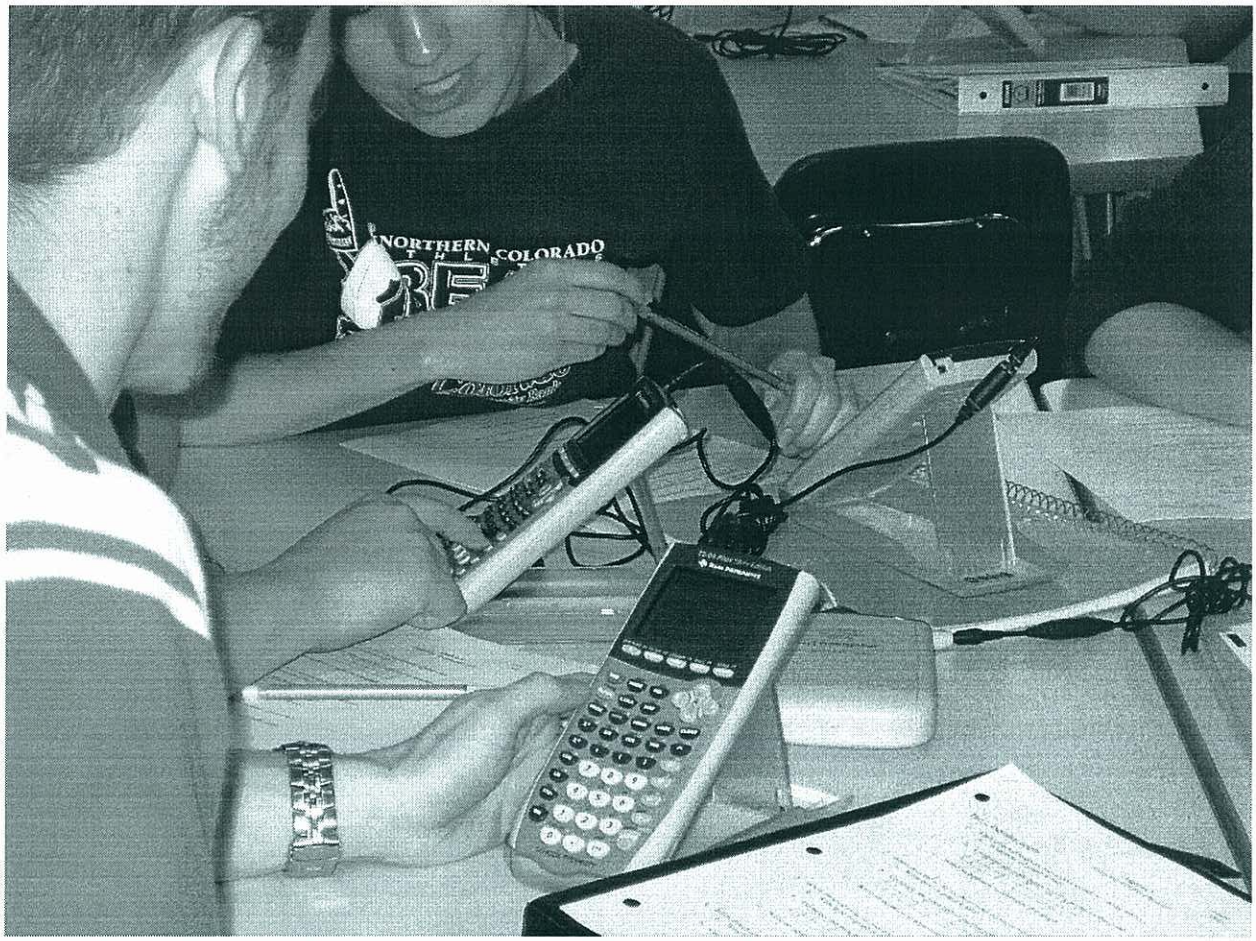


Figure 5: Students working together on a problem through the TI-Navigator system.

Effective use of technology cannot only help in the teaching and learning of such NCTM Content Standards as algebra, geometry, data analysis and probability, but can enhance the development of such NCTM Process Standards as problem solving, reasoning and proof, communication, connections, and representation (NCTM, 2000).

Through the integration of a Computer Algebra System (CAS) and dynamic software, students not only manipulate functions and graphs, looking for patterns and relationships, but have opportunities to organize their thinking and respond to the thought provoking questions presented by the instructor or developed through their own questioning, in coherent and clearly written form where they can open and write in text windows their discoveries and their conclusions.

Assessment takes on many different forms from reading and reporting on how technologies are currently being used by classroom teachers, to grading assigned mathematics problems that requires proficiency at using the technology, to grading their discovery lesson plans and materials that they would provide their students as instructional material, homework, or quizzes.

Students are also required to develop and teach to the class a major project that involves a specific mathematics topic and incorporates technology in its delivery. A lesson plan and assessment are required parts of the project.

Through the integration of writing within the technology, the preservice mathematics teachers respond to NCTM's Communication Standard, by demonstrating the ability to:

1. Organize and consolidate their mathematical thinking through communication;
2. Communicate their mathematical thinking coherently and clearly to others;
3. Analyze and evaluate the mathematical thinking and strategies to others; and
4. Use the language of mathematics to express mathematical ideas precisely.

Through Representational use of technology, our undergraduates are also able to:

1. Create and use representations to organize, record, and communicate mathematical ideas;
2. Select, apply and translate among mathematical representations to solve problems; and
3. Use representations to model and interpret physical, social, and mathematical phenomena.

Students develop a notebook of materials during the semester related to the teaching of mathematics with technology. They are also provided with reference materials so they leave the course with a rich variety of resources that will be of great benefit as they engage in Student Teaching and begin their professional careers.

Concluding Remarks and Challenges

I try to make and keep the focus of this teacher preparation course, as much as possible, on the mathematics and not just on the technology. That is, we address concepts and topics in mathematics that are best learned through a particular technology. However, because of the time required to obtain even a beginners level in using new technology, much time "is" spent on learning the technology, but all in the context of topics of secondary school mathematics. As these college students become reacquainted to some of the mathematics topics of high school mathematics they also develop an overall comfort level with the technology, which is a significant first step.

Because different schools have different technologies, I believe that each student needs to be comfortable and capable at using a variety of tools for mathematics instruction. Also, since the specific tools and their capabilities are continuously changing, the development of a positive attitude toward learning new technology tools is also most important.

Ultimately, mathematics teacher preparation programs must ensure that all mathematics teachers and teacher candidates have opportunities to acquire the knowledge and experiences needed to incorporate technology within the context of teaching and learning mathematics (Niess, 2006). For those college undergraduates who are preparing to teach it is not only necessary that they acquire this knowledge and experiences by observing

effective classroom instruction involving technology, but are provided "hands-on" experiences with the technology and from a teaching perspective is also a necessity.

As students who have completed this course are now beginning their teaching career, I would like to collect data to see if the course is making a difference in the classroom experiences of these teachers. That is, are they making greater and/or better use of technology then they would if they had not taken this course? In either case, I do feel that this course is contributing to their professional growth but data will need to be collected to determine the degree to which this is taking place.

If interested in more information on the course described in this article, please feel free to contact the author for a copy of the course syllabus or to discuss any aspects of the course.

References

Association of Mathematics Teacher Educators (January, 2006). *Preparing to Use Technology to Enhance the Learning of Mathematics*. Retrieved May 21, 2008 from http://www.amte.net/Approved%20AMTE%20Technology%20Position%20Paper.pdf.

Conference Board of the Mathematical Sciences (2001). *The Mathematical Education of Teachers*. Providence, RI and Washington, DC: American Mathematical Society and Mathematical Association of America.

National Council of Teachers of Mathematics (2000). *Principle and Standards of School Mathematics*. Reston, VA: NCTM.

National Council of Teachers of Mathematics (March, 2008). *The Role of Technology in the Teaching and Learning of Mathematics*. Retrieved September 2, 2008 from http://www.nctm.org/about/content.aspx?id=14233.

Niess, M. L. (February, 2006), Guest Editorial: "Preparing Teachers to Teach Mathematics with Technology". *Contemporary Issues in Technology and Teacher Education*, 6, 195-203.

Smith, K. & Shotsberger, P. (2001). Web-Based Teacher Education: Improving Communication and Professional Knowledge in Preservice and Inservice Teacher Training. Available [on-line]. Eric Document #ED459161.