

DEVELOPING A COURSE FOR PRESERVICE TEACHERS DEMONSTRATING VALID USES OF TECHNOLOGY FOR SOLVING MATHEMATICAL PROBLEMS

Susan Barton Ph.D.
Brigham Young University-Hawaii
55-220 Kulanui Street #1854 Laie, HI 96762
bartons@byuh.edu

Introduction

Many have noted we are still educating most students in schools that closely resemble those that our parents attended, yet students today must succeed in a economy and culture that has drastically changed from just a generation or two ago. The 21st Century economy demands workers to have a higher level of skills than before. The average worker frequently is placed in situations where the ability to solve non-routine, multi-step problems where analysis, hypothesizing, and creative problem solving are critical to his/her success in the workplace. High quality mathematics education can prepare workers with these skills and intuitions (Stumbo, Circe, and Lusi, 2005).

The use of different technologies in and out of the workplace has also dramatically increased over the past decade. Yet, increase use of appropriate technology in the classroom for teaching and learning has not followed as rapidly. The National Council of Teachers of Mathematics in the *Principles and Standards of School Mathematics* (2000) and in a NCTM position paper entitled *The Use of Technology in the Learning and Teaching of Mathematics*, (2001) stated, "Technology is an essential tool in teaching and learning mathematics effectively; it extends the mathematics that can be taught and enhances students' learning."

De Las Penas and Yang (2005) concluded that the advent of different types of technology would inevitably influence the teaching and learning of mathematics. And, that a major challenge to mathematics educators is how to use these technologies to enhance their competencies, increase their effectiveness as teachers, and to improve the math understanding and ability of the students.

Research and experience have shown there are several key factors that influence when and how technology is use in the mathematics classroom. First, the value and importance the institution (school, college, department, etc.) places on the technology influences the degree to which students are willing to apply themselves in learning the technical skills necessary to work with the technology. Second, the use of multiple representations has been shown to increase students' conceptual understanding and also provides them with alternative methods in solving problems. Finally, it has been found that students need to be guided in judicious use of the technology (Pierce, 2005). This involves teaching students to discriminate in their use of technology, that is, when will a technology tool be of great assistance in working a problem and when would paper and pencil methods be the better approach.

The author believes the most effective way for students to learn to use technology in solving problems would be for them to have hands-on experience with different

technologies within their mathematics courses. However, the type of technologies used in college level mathematics courses often differ from that appropriate for elementary and secondary level students. There are also still some mathematics professors who do not allow students to use technology in their course. Hence, the need to address valid uses of technology in doing mathematics must fall within the realm of teacher education courses.

There are a number of ways to incorporate technology into teacher education. Garofalo, Drier, Harper, Timmerman, & Shockey (2000) categorized the approaches according to the primary user of the technology or controller of the technology: teacher educator, teacher, or student. They also concluded the most direct and effective way to use technology to bring about enhanced student learning of mathematics is to prepare preservice teachers to incorporate into their teaching an array of tasks that engage students in mathematics thinking facilitated by technology tools. Browning and Klespis (2000) stated, "Teacher preparation programs cannot ignore their important role in providing many positive and instructive experiences with using technology in the teaching and learning of mathematics. This role is critically important when research points to the lengthy process of teachers developing competence and confidence in teaching with technology themselves."

Guidelines for Developing A Technology in Mathematics Course

Using results from other researchers (Garofalo et. al., 2000) and personal experience of the author, the following guidelines for development of technology-based mathematics tasks were established for the new course. First, features of a technology ought to be introduced and illustrated within the context of meaningful mathematics-based tasks. Keep in mind, the use of technology in mathematics teaching is not for the purpose of teaching about technology, rather for the purpose of enhancing mathematics teaching and learning through the use of technology.

Second, care must be taken not to use technology to teach the same mathematical topics in fundamentally the same ways that could be taught without technology. This belies the usefulness of the technology and does not strengthen students learning of mathematics. Technology can actually be a hindrance to learning if used to do mathematical tasks that can be done just as easily without the technology. The tasks should take advantage of the capabilities of the technology by extending beyond or significantly enhancing what could be done without the technology (Garofalo et. al., 2000).

A third and related guideline is to incorporate appropriate pedagogy when addressing worthwhile math tasks. These tasks should support sound mathematical curricular goals and not be developed merely because technology makes them possible. The activities developed should facilitate conceptual development, reasoning, explorations, and problem solving within the goals of the mathematics curriculum. Mathematics tasks involving the assistance of technology can be developed to lead students to better comprehend the necessity for mathematical "proof" and "rigor".

The fourth guideline is to utilize technology in connecting mathematical topics that may not have been previously possible or too unwieldy to consider. Technology "blurs" some of the artificial separations among some topics in algebra, geometry, and data analysis by allowing students to use ideas from one area of mathematics to better understand another area of mathematics" (NCTM, 2000, p.26). When the technology-augmented activities were being developed for the new course, it was felt that mathematical connections

should be made in at least two ways, by interconnecting mathematics topics and by connecting mathematics to real-world phenomena.

The final suggested guideline is that whenever possible, the technology-based activities should incorporate multiple representations of mathematical topics. The use of technology can make the inclusion of a number of mathematics applications more practical and allow the user to bring together multiple representations of math topics. Research shows that many students have difficulty connecting the verbal, graphical, numerical, and algebraic representations of mathematical functions (Goldenberg, 1988). Graphing calculators and computer software are capable of providing multiple representations of mathematical concepts.

These recommended guidelines should not be thought of as being independent of one another. Rather, they should be considered as being interconnected when applied in selecting and developing quality mathematical tasks to be completed with the assistance of technological tools.

Creating the Course

Recognizing the importance for pre-service secondary mathematics teachers to develop knowledge and skills in teaching and learning mathematics utilizing technology, the faculty in the Mathematics Department at BYU-Hawaii developed a course to introduce a number of available technologies to the students. The three-fold purpose established for the course was to have students: 1) actively participate in learning how computer software and calculators can be used as authentic tools in solving mathematical problems, 2) be able to work abstract or real world problems that may not be accessible without the use of technology, and 3) review many secondary level and explore tertiary level mathematics concepts within a new technology-based context.

Given the time constraints of a three-credit course, one challenge in creating the curriculum came with deciding which of the many technologies should be included in the course. Another challenge/opportunity came in the fact that a textbook for such a course does not exist. Thus, the technology-based mathematics tasks would either need to be created from scratch or located from various resources. When developing the new course, emphasis was placed on obtaining student engagement with the math task and providing hands-on experience with the technology rather than demonstrating all the “bells and whistles” of the technology.

After reviewing how technology has been successfully used as a teaching and learning tool in doing mathematics, it was determined the minimal types of technology to be included in the course were 1) graphing calculators, 2) spreadsheet software, 3) dynamic geometry software, 4) a software program for writing mathematics symbols and text, 5) Computer Algebra System (CAS) software and 6) the Internet.

As the math tasks for the course were developed, adapted, expanded from existing problems, or borrowed from paper and electronic resources, in regards to technology use, they fell into one of 4 categories. Some of the tasks included "ready to use" tutorials or sketches already created using the technology to assist students in doing the problem. Other activities gave students step-by-step instructions using the technology, to create a visual, numerical, or symbolic representation of the math problem to be explored. Once a particular technology had been used a few times, then math tasks were assigned with

limited guidelines or suggestions on how the technology could assist in solving the math task. For a few assignments, students were given the math problem without receiving guidance on an appropriate technology to use. These problems were challenging enough that students would want use of a technology tool to aid in completing the assignment. These types of assignments helped the students become more discriminating in regards to the features and advantages of the different technologies.

Many of the math problems used in the course were chosen because the concepts have historically been difficult for students to understand. The topics included probability, relationships of polygonal area and perimeter, conic sections, optimization applications with and without calculus, recursion, affects of coefficients on graphs of functions, affects on mean and standard deviation when data are altered, matrix applications, derivative and tangent line relationship, antiderivatives, 3D graphing with applications, and modeling. Since the students were pre-service mathematics teachers, tasks on learning to produce professional looking mathematics documents such as exams and being able to create a grading program were included. The students were also asked to critique each assignment to assist them in processing the learning task more thoroughly. The feedback from the students has been used to refine the course content.

In Brown's and Klespis' (2000) critique of Garofalo et. al. (2000) they expressed concern that "students are not prepared to incorporate technology into their teaching after being engaged in such activities [as provided in the article]. [The students] understanding of some mathematical concepts has improved dramatically, but the design of lessons making appropriate use of technology remains a challenge." With this concern in mind, our course included a culminating experience for the students in the form of a project. The preservice teachers were asked to develop their own set of mathematics tasks and determine the appropriate type of technology to be used in working the problems. The project included detailed student worksheets, step by step use of technology, and a teacher's guide including possible non-routine questions. Student also had the opportunity to teach part of their project to the rest of the class and received feedback on their lesson. Either paper or electronic copies of the projects developed in the course were shared with each student.

Conclusion

The student evaluations of the activities were generally positive both in regards to the math assignments and in the use of the technology. All the students felt the course had been beneficial to them and began to recognize how technology can be appropriately used in learning and doing mathematics. Although the students improved in attitude toward technology, some were still concerned of becoming too dependent on technology to do math. It may be difficult to completely eliminate the "crutch" mentality for some pre-service teachers who have had teachers impress this idea upon them. It will take more evidence of authentic uses for technology in working mathematics problems to reverse this preset notion. Browning and Klespis (2000) have suggested. "Preservice teachers need to be engaged in more activities that are designed for *their* level of understanding, present *new* mathematics, and are facilitated by the use of technology in their *initial* constructions, so the preservice teachers can determine the impact of technology on their own "first" learning versus a "revisited" learning."

Some of the activities used in the course were purposely selected because of the good mathematics involved and yet did not do a good job of explaining the problem or lacked

explanation of how to use the technology. These were selected to foster discussion on good pedagogy when working with technology. However, it appears from student comments there needs to be more purposeful dialog on how to make a poorly worded, yet potentially rich mathematical activity, better. The students in general were not very successful with this and some missed the point of intentionally being given a poorly worded problem and then discussing how to rewrite the tasks in a more clear fashion. Although the project helped, more formal practice should be provided. Also, students could use more experience in reviewing math problems, determining if technology could be used as an appropriate tool in solving the problem, and if so what type of technology would be most effective. This will be a critical skill for preservice teachers to have in order to successfully incorporate technology in teaching mathematics concepts and learning of mathematics by their students.

Clearly, one course exposing students to a number of technologies is not sufficient to provide preservice teachers the knowledge to successfully incorporate technology into the teaching and learning of their students. It can become a catalyst for them if they continue to see effective uses of technology in future college level mathematics courses that gives preservice teachers first hand experience with initial mathematical constructions that are facilitated by technology. Learning mathematics in this manner should leave a more lasting impression. Finally, research has shown it is also important for the preservice teachers once they become full time teachers to have follow-up professional development opportunities such as workshops and seminars to refresh their knowledge of previously learned technology applications and to expand on new ways to effectively incorporate technology in their mathematics classroom for the good of their students.

References

- Browning, C.A., & Klespis, M. (2000). A reaction to Garofalo, Drier, Harper, Timmerman and Shockey. *Contemporary Issues in Technology and Teacher Education*, 1(2), 226-228.
- De Las Penas, M.L. & Yang, W.C. (2005). The Use and Influence of Technology in Mathematics Education. *Proceedings of ATCM 2005*.
- Garofalo, J., Drier, H., Harper, S., Timmerman, M.A. & Shockey, T. (2000). Promoting Appropriate Uses of Technology in Mathematics Teacher Preparation. *Contemporary Issues in Technology and Teacher Education*, 1(1), 66-88.
- Goldenberg, E.P. (1988). Mathematics, Metaphors, and Human Factors: Mathematical, Technical and Pedagogical Challenges in the Educational Use of Graphical Representations. *Journal of Mathematical Behavior*, 7, 135-173.
- National Council of Teachers of Mathematics. (2000). *Principles and Standards for School Mathematics*. Reston, VA: Author.
- National Council of Teachers of Mathematics. (2001). *The Use of Technology in the Learning and Teaching of Mathematics*. Reston, VA: Author.
- Pierce, R. (2005). Using CAS to Enrich the Teaching and Learning of Mathematics. *Proceedings of ATCM 2005*.
- President's Committee of Advisors on Science and Technology, Panel on Educational Technology. (1997). *Report to the President on the use of technology to strengthen K-12 education in the United States*.