TECHNOLOGY IN MATHEMATICS TEACHER EDUCATION

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Graduate mathematics courses for beginning and experienced secondary mathematics teachers should do two things: help students answer the question *What is mathematics?* and focus on multiple ways to represent and communicate mathematical concepts. Based on the core principles of the Interstate New Teacher Assessment and Support Consortium (1NTASC), ideally "teachers responsible for mathematics instruction at any level understand the key concepts and procedures of mathematics and have a broad understanding of the K-12 mathematics curriculum. They approach mathematics and the learning of mathematics as more than procedural knowledge. They understand the structures within the discipline, the past and future of mathematics, and the interaction between technology and the discipline." Understanding what mathematics is requires knowledge of the big *ideas* in mathematics. Shulman (1986) elaborates on that special knowledge as *pedagogical content knowledge,* what teachers need to grasp in order to be able to effectively teach their subject. The experienced teacher with this knowledge base is able to come up with examples, authentic problems, and rich applications that enable students to see the usefulness of mathematics, the links to other disciplines, and the interconnectedness of ideas in mathematics. Once they master the content knowledge, mathematics teachers need strategies for arranging the learning environment so that their students, by doing mathematics, develop an understanding of the patterns in the structure and applications of mathematics. Polya (1965) suggests that the principle of *consecutive phases* should be applied more often in teaching: *exploration, formalization,* and assimilation. However, mathematics classes often spend the majority of time on formally developing a concept, and little time on establishing an intuitive basis for the concept. Seldom do they apply the concept for deeper understanding through the use of non-routine problems. The key is often technology. Technology can be a useful tool in changing the way we *think* about mathematics and in the way we *teach* mathematics to our students.

In a graduate class at SUNY Brockport, we use technology to help teachers think about math and think about teaching math. Teachers in this graduate mathematics course are working towards permanent certification for a Master's degree in secondary mathematics education. Some have not taught school, but most are middle school and high school teachers who have taught mathematics anywhere from 1 to 6 years. These New York State teachers are in mathematics departments that are currently working on implementing new learning standards. They are looking for mathematical activities and strategies to help their students understand, communicate, and apply mathematics. Amazingly, most of the teachers have limited experience in using technology for teaching.

This course addresses many of the topics covered in the secondary mathematics curriculum. The instructor's lessons and activities created by the students in this class reflect the goals of the NCTM Standards and the New York State

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Math, Science, and Technology (MST) Learning Standards. Students discuss and model effective ways of integrating technology into the mathematics curriculum. They observe mathematical models constructed from real data and represent the patterns numerically, graphically, and symbolically. To develop a greater appreciation for mathematics, students read and present mathematical topics from the book *Journey Through Genius* which focuses on the lives and creativity of certain mathematicians and on their great theorems.

Participants in this course do the following:

- Engage in problem-solving tasks, look at the interrelationship between problems and situations, and use a variety of approaches (algebraic and geometric, numerical and visual, inductive and deductive).
- Develop lessons using a conceptual approach (focus on exploring, acquiring knowledge, and extending and applying that knowledge)..
- Use the technology in the design of lessons to enhance the learning of math concepts through exploratory activities to build mathematical intuition, and as tools to solve problems.
- Work on activities that require them to draw upon situations from various content areas and apply a variety of math skills, concepts, and procedures.
- Reason inductively and deductively using the language of mathematics. They make conjectures based on their observations and then use mathematical arguments to validate their mathematical thinking.
- Share ideas about how to teach and think about mathematics from different perspectives and at different levels.

The assumption in this graduate course is that students can easily refresh their memories on procedures for solving systems of equations and finding derivatives of functions, so the focus is on building mathematical intuition and a deeper understanding of concepts in the secondary mathematics curriculum. To that end, the emphasis in the class is on engaging students in solving problems, searching for and representing patterns, and discovering relationships. The graphing calculator, Calculator Based Lab (CBL), and Geometer's Sketchpad are important technology tools for accomplishing these goals. The table below shows the results of a survey given to the students at the end of the course. The question they were responding to was: "to what degree has this course contributed in a *positive* way to ***changing your thinking*** about mathematics or the teaching of mathematics." Based on student responses and my observations, the following are my reflections concerning the role of technology in mathematics education:

- Technology was useful in helping students view mathematics less passively, as a set of procedures, and more actively as reasoning, exploring, solving problems, generating new information, and asking new questions. Students enjoyed i*nteracting with other group members as they shared their observations and solutions to problems. They could compare algebraic and graphical solutions, share conjectures concerning geometric relationships, discuss different models for representing real-world behaviors, and think together about multiple ways of solving problems.

- Students felt the technology not only helped them visualize certain math concepts better, but also added a new dimension to the teaching of mathematics to their students. They felt they were able to offer students alternatives for success and address issues of teaching to students with different learning styles. Some students commented they were taking most of the resources back to their department to share with their colleagues. Many used the activities with their own students and through practice gained confidence in their ability to use technology for teaching mathematics.

Student Responses to Course Survey

Topics	Low				High	mean	S.d.
Mathematics Content	1	2	3	4	5		
1. Lines and linear functions (geometric and algebraic representations, model data)	0	0	1	5	9	4.53	0.64
2. Parabolas and quadratic functions (geometric and algebraic representations, data fitting)	0	1	0	6	8	4.40	0.83
3. Exponential functions (familiar models, nature of growth, model data)	0	1	2	5	7	4.20	0.94
4. Trigonometric functions (unit circle activity, periodic nature, model data)	0	0	2	4	9	4.47	0.74
5. Polar coordinates (rectangular and polar graphs, applications, polar equations)	1	1	0	3	10	4.33	1.23
6. Calculus (representations: graphical, numerical, symbolic; limits, continuity, derivative and applications)	1	1	1	3	9	4.20	1.27
7. Geometry (constructions, investigations, proofs)	1	0	5	3	6	3.87	1.19
Teaching Mathematics Approaches							
1. Use of graphing calculators (regression, problem solutions, graphing, investigations)	0	0	2	2	11	4.60	0.74
2. Use of Geometer's Sketchpad (constructions, investigations of relationships, making conjectures)	0	0	3	2	10	4.47	0.83
3. Study of history of math topics (*Journey Through Genius* readings and presentations)	2	3	3	3	4	3.27	1.44
4. Sharing of individual projects (Presentations of activities used in class reflecting implementation of Standards)	1	1	1	2	10	4.27	1.28

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