ENHANCING MATHEMATICS TEACHER EDUCATION COURSES THROUGH THE USE OF TECHNOLOGY

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INTRODUCTION

The focus of this article is on three goals for incorporating technology into mathematics teacher education courses. According to the Association of Mathematics Teacher Educators (AMTE), "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 in the context of teaching and learning mathematics." (2006, p. 1). AMTE recommends that teacher educators:

- Provide opportunities for teacher candidates to explore and learn mathematics using technology, as well as build confidence and skills in using technologies
- Model appropriate use of technologies to enhance and support learning and teaching
- Help teacher candidates to recognize effective uses of technology in the mathematics classroom
- Provide opportunities for teacher candidates to create and implement lessons incorporating various technologies. (p.2)

These recommendations, by AMTE, together with The National Council of Teachers of Mathematics' (NCTM) Technology Principle provide the framework for this article. The Technology Principle states, "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning." Thus, there should be three overarching goals when incorporating technology into mathematics teacher education courses: (a) to support instruction, (b) to enhance learning, and (c) to encourage appropriate technology use in the classroom.

SUPPORTING INSTRUCTION

Technology can support instruction in several ways:

- Technology can help teachers to provide visuals, simulations, and graphs that would otherwise be difficult to create.
- It can be an effective time management tool. With the use of technology, teachers can display tasks, definitions, visuals, graphs, and data quickly that would take significantly more time to write, draw, or create.
- As a result of less down-time (efficient use of instructional time), technology use can also support behavior management.

- Active participation can also be encouraged through technology use. Incorporating a classroom response system (aka clickers) or virtual manipulatives, for example, would require students to actively participate in the lesson.
- Technology can make it easier to assess students' understanding.
- Using technology can allow teachers to go more in-depth into the content. For instance, students can solve more complex problems, or analyze real world data, with the use of calculators because difficult computations can be done more easily.

ENHANCING LEARNING

Technology can facilitate students' learning of mathematical concepts by providing visuals, static or dynamic, that help to elaborate and clarify understandings. Different learning styles can easily be accommodated through the incorporation of technology. For instance, a lecture which may have played to auditory learners could also stimulate visual learners by the addition of textual and pictorial representations of the material. Additionally, virtual manipulatives and dynamic software, like Geometer Sketchpad, can allow students opportunities to perform investigations and interact with the mathematics in a way that is consistent with a constructivist view of learning. Finally, students typically view technology as more engaging and entertaining than instruction without technology.

ENCOURAGE APPROPRIATE USE IN THE CLASSROOM

First, it is widely known that teachers are likely to teach in the way that they were taught (Lortie, 1975; Hansen, 1995). According to Garofalo, Drier, Harper, Timmerman, and Shockey (2000), "Teachers who learn to use technology while exploring relevant mathematics topics are more likely to see its potential benefits and use it in their subsequent teaching." Thus, teacher educators must effectively integrate technology into their instruction, at appropriate times, to meet our first two goals: to enhance and support teaching and learning. Elementary teacher candidates at the author's institution take one or two mathematics content courses with the author prior to enrolling mathematics methods for teaching. Their "technology education" essentially begins in those initial mathematics content courses. Although no formal instruction on how or when to use the technologies occurs at this time, the students are experiencing the very type of learning and teaching enhanced by technology that will be promoted in their methods course.

Second, one of the leading reasons why teachers are reluctant to incorporate technology into their lessons (behind a lack of resources) is that they are not comfortable and confident in their technological skills. Hence it is important for teacher candidates to be provided opportunities to learn about and practice using different technologies in their teacher education courses. To this end, the author encourages, and sometimes requires, students in her methods courses to interact with technologies through various activities in class. Additionally, the students are required to appropriately and effectively integrate some form of technology into their teaching demonstrations, as well as identify instances within their lessons where instruction or learning could have been enhanced or extended

by technology use. Another reason why teachers opt not to utilize technologies where they might be appropriate is because technology is not always dependable. Therefore, teacher educators should demonstrate and emphasize that teachers should always have a backup plan to use incase their technology fails to work.

Some of the technologies the author incorporates into her elementary mathematics teacher education courses, which will be described next, are an interactive whiteboard, a document camera, a classroom response system, videos clips, and Geometer Sketchpad.

INTERACTIVE WHITEBOARD

Many of the K-12 classrooms are now equipped with either an interactive whiteboard or a document camera. An interactive whiteboard is an exceptional instructional tool which enables the instructor to have all the capabilities of a computer, while still having all the functionalities of a whiteboard, at their fingertips. For instance, when projecting a document, the teacher can highlight or annotate that document on a whim, based off of what a student says or does. One way the author uses the interactive board is to lecture. Presentation software (e.g. PowerPoint, Smart Notebook, Easiteach) is used to create slides which serve as a template for the notes. Within the template, any complex visuals, detailed/lengthy definitions, problems, and instructions for tasks are included to save time during instruction. The students are then provided with copies of the slides to serve as a "note-taking guide." This allows the students to fully attend to the teacher's explanations and elaboration of the concepts. The instructor can draw on, highlight, or add to the slides by simply writing on the screen with a special stylus.

Additionally, this technology enables individuals to manipulate objects on the screen. Objects can be rotated, reflected, dragged, or resized with the touch of a finger. Thus, the process of adding three digit numbers with a base-ten block representation can be demonstrated on the interactive whiteboard for the whole class to see. Or, a right triangle can be copied, rotated, and translated to illustrate that (a) a rectangle is composed of two congruent right triangles or (b) the area of a right triangle is half of the area of the rectangle with the same base and height.

DOCUMENT CAMERA

A document camera (e.g Elmo, Mimio) operates much like an overhead projector. Although the latter will only project transparencies (which limits the instructor to documents copied onto transparencies prior to class or things that can be handwritten onto a transparency), a document camera will project anything (e.g. pages in a book, images in color, objects in 3-D). One of the benefits of having a document camera is the ability to display students' work easily and quickly. For instance, if students are creating composite shapes using manipulatives (e.g. tangrams), individuals can share their composite shapes by placing the manipulatives under the camera. Or, if students are graphing functions to find their intersection point, they can show their graphs to the class without having to redraw it on the board.

CLASSROOM RESPONSE SYSTEM

Classroom response systems, also known as clickers, are best used to engage and assess a large number of students (i.e. a whole class). Each student is provided with a device (a clicker) which enables them to respond to a question with a letter, number, or short answer. Their response is wirelessly sent to the teacher's computer and tabulated into the corresponding program. Once everyone has responded, the teacher can choose how to view the results: table, graph, percentages, etc. It is relatively easy for the instructor to incorporate the clickers into his/her instruction. For instance, a classroom poll can be added to an existing PowerPoint presentation with one click, followed by selecting which type of responses (e.g. multiple choice, short answer) and response reporting (e.g. bar graph, table) is desired. This form of technology is most useful for middle and secondary teacher candidates, as it is less frequently found in an elementary classroom.

VIDEO CLIPS

Classroom videos provide opportunities for teachers to make judgments about what is worthwhile, to develop critical analyses of teaching and learning that is student centered, to analyze situations and weight the effectiveness of various alternatives, to exchange perspectives with peers, and to reflect on their own practice. From watching these videos, students are able to determine effective and ineffective instructional strategies.

Similarly, one of the most powerful tools for educating future teachers about how children think is to view video clips of real children solving problems. Not only is the strategy seen more believable, but students also tend to remember it better. Often at the end of the semester, my teacher candidates identify the video clips we watched as the aspect of the class from which they learned the most.

GEOMETER SKETCHPAD

Geometer sketchpad facilitates geometric investigations that would be otherwise difficult. In this program, students can construct different geometric shapes and analyze their invariant properties as they manipulate each shape (e.g. resize, drag, rotate). It also enables the savvy high school teacher to create animations and coefficient sliders. For example, an animation can be created to illustrate the connection between the unit circle and the cosine graph so that as the unit circle is traced, the graph of the cosine function is created. There are also excellent existing files that help students to understand, and play with, the complex definitions of limit of a sequence, limit of a function, and derivative of a function, to name a few.

CONCLUDING REMARKS AND CHALLENGES

It is essential for teacher educators to integrate technology effectively into their instruction and to provide students with experiences using and interacting with various technologies. When students learn relevant mathematics through the use of technology (e.g. sketchpad investigations) or through instruction that is enhanced by technology, they are more willing and eager to incorporate those technologies into their future instruction.

In addition to effective use of technology in their classrooms, teacher educators face the challenge of incorporating technologies that are relevant to K-12 teachers. Hence,

teacher educators need to maintain awareness of the technologies that are generally available to teachers. And, because new technologies are continually being developed, educators will need to be flexible and willing to learn new skills.

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