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Integrating Calculator Technology in an Elementary and Middle School Preservice Teacher Program: A Personal Journey

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Faced with a group of preservice teachers who had very little training in calculator or technology use in a department where technology had not been a primary focus in mathematics or teacher training, the author implemented the continual use of the Texas Instruments 73 calculator for all elementary and middle school preservice teacher education mathematics courses. After some initial problems and disagreement, the preservice teachers became extremely proficient in the use of the calculator, not only for personal use but also for use in the classroom.

INTRODUCTION OF THE SITUATION

When preparing courses for the first time at a new position at Maryville University, a small liberal arts institution, I discovered that the mathematics department did not mandate calculator use for its courses. Also, the education department had never incorporated calculator or computer technology into any of its courses on a regular basis. Although the mathematics methods course for elementary and middle school teachers did include a segment on technology (for example, one session or class meeting devoted to calculator and computer use), the time spent on examining the technology was not sufficient to provide preservice teachers the experiences needed to integrate technology into their own classroom. Typically, the calculators used for demonstration were either the Texas Instruments (TI)

Explorer or the TI-82 model, and there were not enough calculators for all the prospective teachers. Furthermore, both models seemed "too old," because many schools are using more current models. Also, the TI-82 model seemed "advanced" for the prospective teachers because, at the time, many of the prospective teachers were entering the university with little school experience in using any type of graphing calculator. Most important, although they were exposed to the technology briefly in the mathematics methods course, they were never encouraged to use it or implement it into their own learning or practice teaching. In fact, many of the cooperating teachers in the suburban districts where the preservice teachers are placed rarely used technology in their teaching, and almost no one did so on a regular basis. I strongly felt that the incorporation of technology was important; thus, I became engaged in a personal journey to integrate technology as part of the program.

"The Technology Principle" in the *Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics [NCTM], 2000b) clearly stipulated that all students should be proficient in the use of technology as it is crucial to the teaching and learning of mathematics. NCTM also stated that as calculators reshape mathematics, students (as well as teachers) must reflect those changes (NCTM, 2000a). Teachers have often not learned mathematics with technology in ways that mathematics educators want them to use technology with their own students. Many have come from traditional programs in which calculator use was limited in higher grades or used mainly for "checking" in lower grades. If educators want teachers to be able to teach with technology effectively, modeling this in higher education is essential. Teacher preparation programs must lead in the implementation of technology (Browning & Klespis, 2000; Garofalo, Drier, Harper, Timmerman, & Shockey, 2000). As this was obviously not happening in my new situation, the issue of technology was important to face immediately.

PROGRAM STRUCTURE

Maryville University is a small, private university located in a midwestern city. The student population is approximately 3,100 students, including 1,450 undergraduates, 1,150 weekend college students, and 500 graduate students.

The School of Education is one of the four major schools, with the School of Liberal Arts and Professional Programs being the largest.

The structure of the education program at Maryville University requires all elementary and middle school preservice teachers to take a three-semester mathematics sequence designed for teachers and based in mathematics. The first course focuses on number theory, the second focuses on geometry and measurement, and the third focuses on algebra and data analysis. Furthermore, elementary and middle school preservice teachers take a one semester mathematics methods course which ties what they have learned about number, geometry, measurement, algebra, and data analysis with theory and practice in the classroom. The fact that preservice teachers were required to take several mathematics courses led me to believe that there was ample opportunity to embed the use of technology on a regular basis.

CALCULATOR MODEL

In deciding to incorporate technology, the choice of technology to be used became important. Specifically, I decided to implement the use of the Texas Instruments 73 (TI-73) calculator in the mathematics courses for prospective teachers. The TI-73 calculator was designed for use in the middle grades to support both mathematics and science (Texas Instruments, 2000). Texas Instruments designed this model to facilitate change as students progress from elementary grades and the use of basic calculators to high school grades and the use of more advanced graphing calculators. Texas Instruments describes this calculator as a combination of the Math Explorer model (considered a basic calculator) with graphing calculator capabilities (Texas Instruments, 2002). Its features include extensive use of fractions, statistical plots, graphing, constants, programming, CBL/CBR use, and upgrade-ability (Nast, 1999).

Because elementary teachers at my institution are certified through Grade 6, they and middle school teachers would benefit from a thorough understanding of this calculator. Hence, I required all prospective elementary and middle school mathematics teachers to purchase the calculator for the mathematics and mathematics education courses beginning the fall 2000 semester. All elementary preservice teachers should have the ability to teach with a graphing calculator if given the opportunity in an upper grade

elementary classroom, so I chose this graphing calculator instead of a more basic calculator. Furthermore, preservice teachers who are competent in using the TI-73 would be able to transfer their learning to a more basic model like the Explorer if necessary in their own classroom. The extensive publications by Texas Instruments and their online information (www.ti.com/calc/) and support made this an appropriate tool for the preservice teachers, because they would have additional support to continue to implement this technology as appropriate in their own classrooms.

ASSESSING THE IMPLEMENTATION OF THE CALCULATOR

During the initial introduction of the calculators, I conducted an informal analysis of this calculator requirement to determine the effectiveness of its use and to improve my teaching. Because I was starting with a group of preservice teachers who had never used technology in a university where it was not implemented regularly, I wanted to document the process. This documentation was also essential in reporting to the dean of the School of Education about the implementation of technology — an issue the dean was especially concerned about in reference to accreditation requirements. I gathered data by informal observations and kept a journal of course experiences, as preservice teachers commented about calculator use throughout the entire 2000/2001 academic year. I intended to focus mainly on technology use in the three-sequence mathematics courses. However, its use was implemented in the mathematics methods course, as well, and insights from this course are also reported.

IMPLEMENTATION OF CALCULATOR TECHNOLOGY IN THE MATHEMATICS CONTENT COURSES

I began the fall 2000 semester teaching the first required mathematics content course with calculator instruction on the TI-73. This not only allowed for the introduction of a calculator into the program, but also allowed me to model for the preservice teachers how a calculator can be used effectively without dominating the curriculum or detracting students from learning basic skills. As a result, the prospective teachers were expected to bring their calculator each day and use it when pertinent to the topic.

In these classes, the preservice teachers were allowed to use their calculators whenever they wanted. However, I stressed appropriate calculator activities as opportunities arose in the course. An "appropriate" calculator activity was often an activity in which preservice teachers investigated a mathematical topic with aspects of the calculator and without using the calculator for basic operations or as a type of "crutch" for solving problems. For example, in the first mathematics course, which stressed number theory, the use of the calculator in studying functions was essential. The class used the idea of a "function machine," a common way to introduce functions in elementary and middle school. With a "function machine," a value is input, and the machine (after correctly performing the function) produces an output. Hence, the user develops tables to see a pattern of numbers. After doing this on paper, the class used the "List" function of the TI-73 to record *x* and *y* values.

By plotting points using the "Plots" function, the prospective teachers graphed their functions on the screen. The "Plots" function plots points and then connects those points with a line. When pressing the "GRAPH" key, the graph is displayed. The powerful part of using the calculator came when the class entered the function using the "graph" feature. Using the "Y=" button, the user can type the actual function. To the left of the function is an area where the user can change how the function is drawn. The line can be drawn or it can be traced using dots, a heavy line, or a bubble. By changing the drawing of the graph from a line to a tracing bubble, the prospective teachers could see that the equation of the function traced over the same picture from using the plots (because the calculator always plots the points and creates a graph when the "plots" function is left on). This aspect was very helpful when the prospective teachers began comparing two functions at the same time.

Another example of calculator use in number theory came when the class studied prime factorization and greatest common factor (GCF) (and least common multiple) topics. By changing the "MODE" of the calculator to "Mansimp" and "b/c" the prospective teachers could find the prime factorization of a number such as 18. They had to modify the value by entering it in the calculator as 18/18. By using the "SIMP" function they could see the fraction simplify step by step (factor 2 leaves 9/9; factor 3 leaves 3/3; another factor 3 leaves 1/1). The factors show the prime factorization of the number 18 (2x3x3).

This same idea was used to demonstrate finding a GCF of two numbers. Prospective teachers placed the two numbers in fraction form (such as 18/24). By using the "Simp" key the prospective teacher could see the factors of both numbers. Using the "Simp" function to see the fraction simplify step by step, factor 2 leaves 9/12, and factor 3 leaves 3/4. The calculator then shows that the fraction is in simplest form, and the two common factors of 18 and 24 are 2 and 3; so the GCF is (2x3=6). This activity is also considered an "appropriate" calculator activity because the user investigated the patterns of simplification of two numbers in order to understand how factors and prime factors are used in calculating the GCF. Therefore, rather than using the actual GCF function built into the calculator, the preservice teachers were able to investigate the concept of GCF using the calculator as a tool.

The detailed examples show two ways to teach concepts using the calculator. Other mathematical topics taught with the help of the calculator included using the fraction buttons to add, subtract, multiply, or divide fractions without changing to decimal form first. These functions also allow someone to move between a mixed number and improper fraction or fraction and decimal.

Some topics in probability and statistics were easier to teach with the aid of the calculator. The calculator has the ability to "roll dice" or "flip a coin" to offer random outcomes, as well as supplying random numbers and determining permutations and combinations. The prospective teachers found the "List" and "Plot" functions essential when working with statistics. Multiple sets of data could be used to produce all kinds of graphs (e.g., box and whisker plot, pie chart, bar chart, line graph, and pictograph). Many of the preservice teachers noted here that the TI-73 was a powerful and extremely useful tool, especially in elementary school where pictographs and bar charts are being taught much more than in the past. For example, many elementary students begin bar graphs by sorting something like toy bears into colors. They often do this as a group actually lining up bears into spaces on the chalkboard. A preservice teacher noted that, in an upper grade elementary classroom, students could go back to this type of problem and extend it; students could reproduce the board bar graph in the calculator using the "plots" function and choose the bar graph (or pictograph) with the data placed in a list.

Thus, in addition to learning with the help of the calculator and some of the powerful, built-in functions it offers, the preservice teachers became

proficient at graphing in a variety of ways. Although what I have described above may seem elementary to many of us in the mathematical community, the prospective teachers at our university took a huge step for the first time with incorporation of the calculator on a regular basis.

The requirement to purchase a calculator allowed continual exposure to the calculator throughout the course and helped the preservice teachers develop proficiency and confidence with the calculator in personal use, as well as in practice teaching. Consequently, prospective teachers began to use their calculator appropriately without specific instruction in class. As an example, once preservice teachers were familiar with graphing, they automatically used their calculators to aid in graphing when beginning a function problem.

OBSERVATIONS IN THE MATHEMATICS CONTENT COURSE

During the implementation of the mathematics classes for elementary and middle school teachers, prospective teachers showed frustration as they began to learn the calculator and asked why the class was using it, because "most elementary schools don't use graphing calculators." Additionally, given our location, it was difficult to find and purchase the necessary calculator; most students had to purchase it online or through the bookstore at a highly inflated price. These "negative" comments lasted for approximately one month. As the class persevered through the course, the students shared comments such as, "This thing is great…I love the way it does fractions," and "Now I can really see the different ways to graph data." Initially, I specifically had to tell the class to get calculators out. Eventually, prospective teachers would reach for their calculators when appropriate, and regular use was evident during the second semester of this three-course sequence.

USE OF THE CALCULATOR IN THE MATHEMATICS METHODS COURSE

A transition was also evident when preservice teachers were working with practicing teachers in local schools. The impact of the use of technology implementation became apparent halfway through the second semester, when the preservice teachers were using their calculator on a regular basis in the mathematics

content courses and when many students were implementing technology into their lesson plans. For the first time, the preservice teachers were required to implement technology into at least one of the four lessons they were going to teach throughout the semester (their first semester practice teaching). Resistance occurred at the beginning of the methods course as the preservice teachers began discussing with their cooperating teachers ways to incorporate technology. Many of the cooperating teachers could not provide typical guidance in this area—causing many of the preservice teachers to develop a lesson themselves using (often limited) technology. As the first preservice teacher who had completed her lesson with technology reported back to the class about her experience, she described it with enthusiasm. She was very excited about the fact that, "While I have been learning a lot from my cooperating teacher, she really learned from me this time. She told me that she loved the way I incorporated technology and would do the same lesson next year."

Another preservice teacher commented that her school had a class set of TI-73s that no one had used. She found them and used them in her lesson using the "plot" feature for some data the class collected. This preservice teacher's class collected data by taking a poll of the number of siblings each student had in the class. Then, using the pictograph function in "plots," they showed the number of students who had 0, 1, 2, 3, 4, and more than 5 siblings. She also explained that her cooperating teacher planned on using the calculators more often now that she had introduced the students and other teachers to them.

Many preservice teachers in kindergarten and first-grade classrooms used the lesson plan assignment to introduce the calculator and initial keystrokes. Some of these preservice teachers allowed the students to explore and "discover" what happened when buttons were pushed. Some other mathematics topics that were taught included skip counting on the calculator, the brain vs. the calculator, and place value games. Skip counting included starting at 0 and then adding a number such as 2. By pressing Enter the students could see the answer increase by two continually. In the brain vs. the calculator activity, the teacher placed students into groups of three. One student did problems on the calculator, one student did the same problems without a calculator, and one student was a scorekeeper. The place value game included using a list of numbers which students had to subtract or add correctly to obtain the correct next number in the list — the ability to do so was always based on understanding place value. Again, incorporation of

technology in these ways may seem trivial to some. However, the inclusion of technology in participating school districts in any way was a tremendous accomplishment.

CONCLUSIONS

The preservice teachers experienced a transformation from frustration over the calculator's introduction to acceptance and excitement at using it regularly in mathematics class, as well as in elementary and middle school classrooms. The most common complaint noted from the preservice teachers was that the schools in which they were placed did not have the TI-73 calculators, and many did not have adequate supplies of basic calculators or technology to allow them to implement the technological principles they were learning. The most common negative response about the calculator in our classes was the expense of having to purchase this specific model and the difficulty of finding the calculator.

Overall, the major benefits from incorporating the TI-73 calculators were (a) the preservice teachers used graphing calculators regularly in their own learning and (b) the preservice teachers became more confident in teaching mathematics with the use of technology. One way to encourage the continual implementation of current technology for teaching mathematics is by educating preservice teachers, who can eventually influence technology purchases and implementation of technology in their schools.

TECHNOLOGY IN THE COURSES SINCE MY FIRST YEAR

Since the initial semesters, I have continued to include technology as described at my university. However, I do not teach all sections of the mathematics and mathematics methods classes each time they are offered; thus, a major problem for our university has been finding other instructors who will require and use the TI-73s regularly in all four of these classes. Because I always teach a section of the first course, the purchase requirement of the calculator and obvious use in this course exists. However, if preservice teachers are in a different section of this first course (the number of students taking the course has increased over the past 3 years and two

sections are offered now) or they have taken the course elsewhere, many do not purchase the calculator in the subsequent courses if the instructor does not require it. Many instructors are willing to let prospective teachers use various models of calculators, in general, if the preservice teachers desire, but they do not themselves understand how to teach using the technology as more than an answer or checking tool. Because this is difficult to monitor, it is my understanding that other instructors are not using the technology as much as possible.

Although finding adjunct instructors who will include the TI-73 has continued to be difficult, my dean and I have continued to try to hire instructors who will agree to the technology component. The dean is in the process of hiring an adjunct who is interested in working each semester; she will team teach with me in the fall 2003 semester to see how to incorporate technology effectively. After this initial team teaching semester, she may teach more sections individually. Hiring a "long term" adjunct is a new idea in our department, and currently the dean hires various instructors. Some of these instructors have offered to attend workshops or attend my class on particular days to learn how to use the calculator in teaching more effectively. With the aid of Texas Instruments, the School of Education has offered a few short workshops over the past year for our preservice teachers as well as any faculty and adjunct faculty who are interested. The Dean has also offered some funding for training in calculator use for some instructors as requested. A Texas Instruments' summer weeklong workshop is offered locally, and the School of Education funds some adjunct faculty to attend if they desire.

The School of Education does feel it is making progress towards the implementation of technology in teaching through the increased use of software and calculator resources in its mathematics and methods courses, as well as in the preservice teachers' classrooms. However, I am continually trying to monitor and offer suggestions to implement and increase more technology use in all four courses. I hope to continue in this endeavor with various computer programs and classroom sets of different models of calculators; however, funding is always an issue, causing change in this direction to be slow. Because the preservice teachers purchase the calculators individually, the cost to the institution is high only when trying to incorporate other types of technology or different calculator models. However, I would also like to introduce other models of calculators, and having class sets of these would be beneficial. Furthermore, since my first

year, I have noticed a greater number of preservice teachers coming to the program with a graphing calculator, most often the TI-83 model. Thus, if this trend continues, our program may eventually switch to requiring this particular model so that students do not have to buy the TI-73 (which is somewhat similar to the TI-83) when they already own the TI-83.

In conclusion, progress has been made successfully in implementing calculator use in mathematics courses and classrooms since coming to this university where little technology existed previously. However, in order to continue to implement "appropriate" calculator use in these courses, challenges and changes that must be faced include hiring and training of adjunct faculty, obtaining other technology resources, and possibly, changing the calculator model to fit the needs of our changing preservice teachers.

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