A Comparative Technology Course for the Prospective Elementary School Teacher

by Gary A. Harris

All students wishing to certify at Texas Tech to teach elementary or middle school must complete a 9 hour sequence of mathematics courses consisting of College Algebra, some Elementary Analysis of the real line including some Coordinate Geometry, some Probability and Statistics, and a course in Elementary Geometry. Those wishing to be declared as "mathematics specialists" must complete an additional 12 hour sequence of courses covering the basic concepts of Calculus, topics from Finite Mathematics, Elementary Number Theory, and finally a course in Computing Literacy. For several years we have been working to modernize this 21 hour sequence, with particular attention being paid to the recommendations coming from the Chicago conference [”On the Mathematical Preparation of Elementary School Teachers,” University of Chicago, 1992], the NCTM Standards [PROFESSIONAL STANDARDS FOR TEACHING MATHEMATICS, NCTM, 1991] and the Garfunkel/Young report [”In the Beginning: Mathematical Preparation for Elementary School Teachers,” COMAP, Inc., 1992]. The purpose of this paper is to report on the development and initial conduct of the last course in the sequence, the computing literacy course (MATH 4371). In doing so we will cover the following topics: the philosophy of the course, the methodology of the course, the student reaction to the course, and the instructor's assessment of the course.

Philosophy

Our philosophy is predicated on our determination that being computing literate does not mean being expert in programing, or for that matter, expert in the use of any particular technology. It does mean being familiar with what technology can do, with its relevance to mathematics instruction, and with the issues involving its use in the classroom. Besides, with the variety of technologies in use, and with the rate they are changing, over dependence on a particular technology might well be viewed as a hindrance. Thus we wish to develop a comparative technology course designed to emphasize the "big picture." That is to say, major emphasis is placed on the general capabilities and pedagogical implications of current technologies, with minimal emphasis placed on particular machine, or program, idiosyncracies.

The three "technologies" we compare are the following:

- The brain with paper and pencil. (P&P)
- The brain with a super graphing calculator. (SGC)
- The brain with a computer algebra system. (CAS)

While concurrently comparing these technologies, the course continuously questions the impact on curriculum, the impact on instruction, and the impact on assessment.

One of the "big picture" issues we wish to emphasize is the ease of use and accessibility of today's technology. The prospective elementary teacher must understand that the ability to "point and click" or choose familiar mathematical words and symbols from on-screen menus makes today's technology accessible to students of mathematics at all levels, and the prospective teacher must be comfortable with this fact of life. Thus it is extremely important that we keep our introduction to, and exploration of, the technology as simple as possible. Our motto is "Keep it Simple Stupid." For example try the following:

Sample exercises from Chapter 1 (Elementary Calculations)

In each of the following perform the indicated computation using each of the three technologies and record the answers in the appropriate places:

	P&P	SGC	CAS
1. 2+3			
2. 4(2+3)			
3. 4(2+3)-5			
4. (2+3)^2			
5. 1/3 + 1/4			
6. (2/3)(6/7)			
7. 10!			
8. 100!			
9. 100! +1			

Another driving force behind our philosophy is the belief that discovery is a better teacher than is instruction, especially when it comes to technology in a lab setting. After all Webster's definition of *laboratory* is "a place equipped for experimental study in a science or for testing and analysis." The omission of some necessary specific technical instruction in the above exercise is intentional. For example simply typing 2+3 and pressing "enter" in a CAS probably causes no reaction, do you know why? In #2 the students discover that our SGC interprets juxtaposition as multiplication, just as we do, but the CAS probably requires use of * to indicate expressions are to be multiplied. In #5 and #6 students will observe a significate difference in the way our SGC does arithmetic and the way our CAS does. What is it? Exercises #8 and #9 demonstrate the same basic differences in the two technologies. Also the students very quickly come to the conclusion that no one in their right mind would use P&P to compute 100! or even write down the answer from the CAS on a piece of paper. They do find the difference in the CAS answers for #8 and #9 to be amusing.

This theme of discovery continues throughout the course and becomes naturally more involved as the mathematical content becomes more sophisticated covering elementary number theory, roots of polynomials, graphing, elementary calculus, matrix algebra, and programing in LOGO. Each chapter also contains questions which are intended to require the students to reflect on the implications of what they are discovering. For example Chapter 1 ends with the following question:

Many educators believe it is no longer necessary for students to master the basic arithmetic skills such as adding, subtracting, multiplying, and dividing fractions. What is you opinion? Explain.

Methodology

Of course our methodology is determined by our philosophy as described above. The course is conducted in the department's computer lab, it was first offered during the summer of 1995 when it met for 80 minutes per day, 5 days per week for six weeks. The department furnishes the CAS, the students their P&P and SGC, not to mention their brains. To our knowledge no suitable text exists for such a course, and because of the above mentioned diverse and changeable nature of technology, probably none will ever exist. Hence we are developing our on text in the style of a lab manual from which some sample problems from Chapter 1 were given in Section 1. We consider the text and the course to be inseparable, they are one and the same. (A copy is available from the author upon request.)

Living up to our motto, we never spend more than a very few minutes of any class period discussing matters of syntax. For example on the first day of class we show how to turn on the SGC, the TI-85 calculator in our case, and how to log on to our computer lab server and call up the CAS, MAPLE in our case. With clear instructions written on the board for the students to copy, this takes 5 to 10 minutes, including assigning log-in names and a common password. Then the students immediately begin working on Chapter 1. The instructor and a lab assistant (preferably one who is well versed in the workings of our particular operating and network systems) both act as lab assistants, with the students encouraged to collaborate as much as possible, and ask lots of questions while working through the various exercises. Whenever possible, students are asked to use multiple "technologies" to complete the exercises, as in the above examples this includes P&P whenever appropriate (with determination of appropriateness being part of the exercise). Exercises are chosen to highlight major aspects of the different technologies. Which aspects are involved in the following?

Sample exercises from Chapter 4 (Roots of Polynomials)

In each of the following solve for the roots of the given polynomial in x using each of the three technologies, and record the answers in the appropriate places:

	P&P	SGC	CAS
1. 2x+1	________	________	________
2. sqrt(2)x + 1	________	________	________
3. ax + b	________	________	________
4. x^2 +2x +1	________	________	________
	________	________	________
5. x^2 +2	________	________	________
	________	________	________
6. ax^2+bx+c	________	________	________
	________	________	________

In these exercises the students discover that both SGC and CAS are capable of complex arithmetic, but in addition the CAS is a "symbolic manipulater" as well. We did learn a curious thing from this exercise: the TI-85 polynomial solver will not find the root of a linear polynomial. Of course this chapter continues on to consider higher degree polynomials and rational functions . (Next time you get a chance ask MAPLE to find the roots of the general cubic polynomial.) This chapter also covers the factoring, expanding, and simplifying capabilities of the CAS, and ends with the question

Some people think the skill to factor polynomials and simplify rational expressions (a.k.a. Algebra II) is becoming unnecessary. What is your opinion?

Of course these technologies allow us to do a lot with graphing. We explore properties of graphs of polynomials, rational functions, and transcendental functions and the effects of changes of various parameters on the graphs. Also we give examples to illustrate the difference between the uniform sampling procedure for plotting graphs with a SGC and the adaptive procedure used by a CAS.

We have a chapter called “Sojourn into Calculus” where we do a lot of comparisons between the graphs of functions, their derivatives, and their integrals. This chapter also considers some “real world applications” of the standard concepts of elementary calculus. The Calculus chapter is followed by a brief chapter called Matrix Manipulation. (This was added in response to students’ requests.) The course ends with an introduction to LOGO.

The approach in all these subsequent chapters is the same as that indicated by the example exercises given above; the students are asked to work through a series of exercises designed to demonstrate the mathematical concepts as well as to exhibit the differences in the technologies. The students are constantly asked to explain what they are seeing and to comment on what it all means.

In addition to working through the lab book, the students are also required to matriculate through an extensive reading list containing research and expository articles on the use of SGC and CAS in k-12 mathematics instruction. (Copies of the reading list are available on request from the author.) The students must provide written comments on the articles they read, and occasionally a small amount of class time is used to discuss issues addressed in some of the articles. In the end the students are not only expected to be familiar with the different capabilities of the three technologies, but also to be able to discuss the appropriateness of any one over the others in particular contexts.

Student Reaction

In theory the students taking MATH 4371 have strong backgrounds in mathematics, having already studied all the topics indicated in the first paragraph; however, in practice many take their courses out of sequence, or had major substitutions made in their program. Thus there is a wide diversity in the backgrounds of the students taking this course, but all have studied through the basic concepts of differential and integral calculus. Most have very little previous experience with either computers or graphing calculators. In fact several often claim complete ignorance of both. Also they are used to traditional mathematics classes where they are told exactly what they need to learn, are given explicit examples to mimic, and are tested via “cut and dried” exams, thus some have trouble adjusting to the experimental/discovery approach of a class taught in a laboratory setting. (This is evidenced by many of the comments given below.) However, in the end the student course ratings are uniformly high, with the reactions of several students extremely favorable and very gratifying. (Again see the comments given recorded below.)

The original enrollment in the summer 1995 class was 24 students, all of whom completed the course successfully. Repeating, there was zero attrition. Near the end of the course the students were asked to rate the course via a 20 question questionnaire, the first 19 questions of which address specific aspects of the course with the last question being an overall rating of the course. The students were asked to respond to statements on a scale of 1 to 4, with 1 meaning "strongly disagree," 2 meaning "disagree," 3 meaning "agree,' and 4 meaning "strongly agree." Statement 20 reads as follows:

The overall quality of instruction in this course is satisfactory.

Of the 24 students in the class, 22 responded to the questionnaire. Of these none responded to this statement with a 1 or 2, eight responded with 3, and the remaining 14 responded with 4.Thus on a scale of 1-4 the rating was 3.64. This is considered very high, especially for a course in this sequence. The prospective elementary teachers at Texas Tech have historically given very low ratings to the courses in the mathematics sequence. The questionnaire was designed to address the instruction in the class more than the course itself; however, it seems reasonable to conclude that such a favorable rating reflected well on the student's perception of the course. In the Spring of 1996 we will solicit responses about the course content and delivery as well as about the teaching effectiveness.

Excerpts from comments of student on the course evaluations

Students were asked to comment on what they liked best, what the liked least, and what suggestion they had for improvement. Some responses were the following:

Slightly more structure would have kept me more interested.

The readings were too repetitive.

Showed students how to put emphasis in real life situations.

It was a great course.

The summer session is too short.

Don't turn the students loose on their own so quickly.

..some of us had no clue beforehand how to work the computer. Didn't give very clear explanations on some of the work we were to do.

Showed how the material related to and could be used in teaching. ..At times I was frustrated, because I would attempt to do a program and think I was on the right track and get an error. .. He could take more class time to explain things on the board.

..a very open and self paced classroom...I didn't always know what I was supposed to be doing.

Occasional it would have been nice to have a little more instruction...

No tests, just the workbook. It is too hard to have a test in this particular course.

One of the best course ideas for a teacher.

An interesting side note, every student indicated at least one of the readings to be of sufficient interest to make personal copies for future reference.

Instructor's Assessment

As for the instructor's assessment of the course, the methodology and content appear on target. The students accept the technology as if it comes naturally. Most of them are eager to discover the many mysteries hidden in the various menus and the catalog of the SGC, and the on-line help of the CAS. Of course this is partially due to the fact, as indicated previously, that many latter exercises are given with minimal instructions, and students have to use these features to complete these exercises. The amount of material covered in the six week course was very impressive, considerably more than initially expected.

As for the instructor's assessment of the students for the purpose of assigning grades, a lot remains to be done. Students received 500 points for completing the lab book exercises and 200 points for completing the reading list. There was a 100 point midterm exam and a 200 point final. Since all students ended up receiving the full 700 points for doing the work, the system did not adequately differentiate between "A", "B", or "C" students. Everyone received a grade of "A". However, based on the exam performance 2 or 3 students should have been assigned "C" and several should have been assigned "B". When the course is to be offered again in Spring 1996 the method of assigning final grades will be changed. The new plan is to guarantee a grade of "C" to every student who completes the lab book exercises and the reading list, but to require an average of "B" or "A" on the midterm and final in order to receive the grade "B" or "A" respectively for the course.

Summary

We believe there should be no question about the significance of the impact of the new technologies, specifically the super graphing calculators and computer algebra systems, on mathematics instruction at all levels, including k-12. We believe that prospective k-12 instructors must be familiar with the technology, familiar with the issues surrounding its use in the classroom, and comfortable with their abilities to deal with it now and in the future. Further we believe that much of this goal can be achieved via our one semester, senior level course designed to compare the relevant technologies.

The important feature of the course is its emphasis on the "big picture." It must not emphasis esoteric machine idiosyncracies, and must emphasis the ease of use of the modern technologies. It must be kept as simple as possible. It must emphasize discovery, and allow the students to place their discoveries in the context of their expected teaching environments. All evidence gathered from the "first run" of our course suggests that it reaches this goal with a surprisingly high degree of success. Finally, a pleasant and not necessarily anticipated aspect of the course is its natural "capstone" quality. The students seemed to benefit greatly from the review of 3+ years of mathematical studies contained in this one "technology" course.