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ABSTRACT

An experimental college level course, Functions and Statistics with Computers, was designed using the textbook "Functions, Statistics, and Trigonometry with Computers" developed by the University of Chicago School Mathematics Project. Students in the experimental course were compared with students in the traditional course based on attitude toward and achievement in mathematics. Experimental course students showed a significant gain in confidence about learning and performing well in mathematics. Final grade distributions for the experimental and traditional courses were similar, although experimental course students entered the course with somewhat weaker mathematical backgrounds. On a course evaluation questionnaire, students in the experimental course reported that computer laboratory activities helped them understand course material. Based on an analysis of the attitude, achievement, and course evaluation data, the traditional course was modified to deemphasize algebraic manipulation, emphasize modeling and applications, and include computer laboratory activities. The questionnaire is appended. (Author/DB)

# FUNCTIONS AND STATISTICS WITH COMPUTERS AT THE COLLEGE LEVEL

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**ABSTRACT**

An experimental college level course, Functions and Statistics with Computers, was designed using the textbook Functions Statistics and Trigonometry with Computers developed by the University of Chicago School Mathematics Project. A case study of this course and its influence on a more traditional course is described. Students in the experimental course were compared with students in the traditional course based on attitude toward mathematics and achievement in mathematics. Experimental course students showed a significant gain in confidence about learning and performing well in mathematics. Final grade distributions for the experimental and traditional courses were similar, although experimental course students entered the course with somewhat weaker mathematical backgrounds. On a course evaluation document, students in the experimental course reported that computer laboratory activities helped them understand course material. Based on an analysis of the attitude, achievement and course evaluation data, the traditional course was modified to deemphasize algebraic manipulation, emphasize modeling and applications and to include computer laboratory activities.

In spring 1989, an experimental course, Functions and Statistics with Computers, was offered at the University of Delaware. The textbook chosen for the course was the 1988-89 field trial edition of Functions, Statistics and Trigonometry with Computers (Rubenstein et al., 1988), produced by the University of Chicago School Mathematics Project. The experimental course was offered as an alternative to the traditional course, Elementary Mathematics and Statistics, which satisfied the basic mathematics requirement for most undergraduate majors in the Colleges of Agricultural Sciences, Arts and Science, Nursing, and Physical Education, Athletics and Recreation. This report is a case study of the experimental course and the influence that the experimental course has had on revising the traditional course.

The formal evaluation of the experimental course consisted of comparing it with the traditional course on three measures: student attitude toward mathematics, student achievement in mathematics and student responses to a common course evaluation document. Other less formal but equally important criteria used in the evaluation were the following: mathematics faculty perceptions of the achievement standards of the experimental course, and the feasibility of offering a computer-based course to a large population given hardware constraints.

## THE TRADITIONAL AND EXPERIMENTAL COURSES

The traditional course was originally designed to serve the special needs of its various constituents: statistics for the nursing majors, right triangle trigonometry for the agriculture majors, and a healthy dose of intermediate algebra "skills," with emphasis on manipulating algebraic expressions, for all. Originally, the course was taught by professors in the Department of Mathematical Sciences. However, in 1981 the Mathematical Sciences Teaching and Learning Center was established and by 1984 had taken on the responsibility of teaching all mathematics courses below calculus. A special staff was hired to serve as instructors for these courses and to develop new curricula and innovative and effective teaching strategies. By the fall of 1988, the Center staff had become convinced that the traditional course needed revision. Since the course was the last mathematics course that most of the students enrolled would take, it was unnecessary to teach manipulation of algebraic expressions for the sake of the next sequential course. Rather, instructors believed that the students would benefit more from seeing mathematical applications in a broad variety of content areas and from learning how to use calculators and computers as tools for solving a variety of mathematical problems.

A committee was formed to design an experimental course. The committee established the goal of creating a new course that would better serve the needs and interests of liberal arts students. Mathematical topics would be introduced using real-world data. Students would learn to create linear, quadratic and exponential models to describe data and make predictions based on their models. Statistics would be used to organize, display and analyze data. Students would learn to use scientific calculators and computer software as tools to solve mathematical problems. Manipulation of complicated algebraic expressions would be deemphasized.

The committee searched for a textbook that had the appropriate statistics and intermediate algebra content and that would be readable by students, have a modeling and applications approach, and integrate uses of technology throughout. The textbook chosen was Functions, Statistics, and Trigonometry with Computers (Rubenstein et al., 1988).

The one-semester course was designed to have two 50-minute lectures and one 50-minute computer laboratory per week. Three instructors (including the two authors of this report) volunteered to teach the course and collaborated on writing thirteen computer laboratory activities. These activities were designed to reinforce concepts discussed in lectures and to help students make connections among algebraic, tabular and graphic representations. We chose the statistics package TrueSTAT (Kurtz, 1988) and the graphics package Omnifarious Plotter (Dodge, 1986). Our computer laboratory consisted of 20 IBM PS/2 Model 50 Z computers.

The new course was offered on an experimental basis for the first time in spring 1989. The three instructors each had one section of the course. The enrollment limit per section was 40 students. A total of 108 students were actually enrolled. Each section met as a group for lectures and was split into two groups for computer laboratory. Instructors had a portable computer with LCD projection panel available in class for lectures. They used the computer to make abstract algebraic and statistical concepts more concrete and visual through graphing.

The traditional course was also offered in spring 1989. Two textbooks were used: Algebra and Trigonometry: A Problem-Solving Approach (Fleming & Varberg, 1988) and Basic Statistics for Nurses (Knapp, 1985). Instructors taught 17 sections with a total enrollment of 875 students. The enrollment limit per section was 54 students. The traditional course had two lectures per week plus one workshop in which students asked questions about homework problems and took extra-credit quizzes. Each section met as a group for lectures and was split into two groups for workshop. In spring 1989, some workshop groups did six computer laboratory activities (different from those in the experimental course) during workshop time in place of the extra-credit quizzes.

The major differences between the experimental and traditional courses are summarized in Table 1.

It should be noted that the experimental course text strongly influenced both the methodology and uses of technology. The text supported the "data → function → prediction" methodology and emphasized applications. The text also required the use of scientific calculators and statistical and graphing software. In fact, ideas for several of the computer lab activities written by the instructors came directly from the text.

**TABLE 1**

DIFFERENCES BETWEEN THE EXPERIMENTAL AND TRADITIONAL COURSES

| Experimental | Traditional |
| --- | --- |
| **Text** | |
| Functions, Statistics and Trigonometry with Computers (Rubenstein et al., 1988) | Algebra and Trigonometry: A Problem-Solving Approach (Fleming & Varberg, 1988) Basic Statistics for Nurses (Knapp, 1985) |
| **Methodology** | |
| Start with real-world data, create a function, make a prediction | Start with a given mathematical function, analyze it |
| Emphasize applications | Emphasize algebraic manipulation |
| **Uses of Technology** | |
| Computer lab activity each week | No use or biweekly use of computer lab activities |
| Use of a computer in the classroom for lectures | Little or no use of a computer for lectures |
| 3 written projects, 2 requiring use of computers | No projects |
| All students use scientific calculator | No calculator required |
| **Testing** | |
| Primarily free response | Primarily multiple choice |
| Computer component for tests and quizzes done on-line in the computer lab | No computer component for tests and quizzes |

## ANALYSIS OF STUDENT ATTITUDES

### Method

Subjects. We administered two Fennema-Sherman Mathematics Attitude Scales (Fennema & Sherman, 1976) as a pretest and post test to the experimental course population and to a control group of traditional course students. The total population in the experimental course was surveyed as were randomly selected sections of the traditional course. The 53 experimental course students who took both the pre and post mathematics attitude scales comprise the "experimental group," and the 81 students who did so in the traditional course comprise the "control group." Since students self-selected their math course, these were not randomly selected populations.

Materials. To measure students' attitudes towards mathematics, we chose two of the Fennema-Sherman Mathematics Attitude Scales: confidence in learning mathematics and perception of the usefulness of mathematics (see Appendix A). Each scale consisted of 12 questions, 6 positively weighted and 6 negatively weighted.

Procedure. The two Fennema-Sherman Mathematics Attitude Scales were administered to students in the experimental and control groups on the first day of class. The same instrument was administered to these students during the last week of class.

### Results and Conclusions

Before looking at the Fennema-Sherman attitude data, it is informative to look at demographic data of the students in the experimental and control groups. In particular, we looked at scores on the mathematics section of the Scholastic Aptitude Test (MSAT), grade point average (GPA) at the University of Delaware and scores on an algebra placement test (APT) developed at the University of Delaware and administered to incoming freshman. The results are summarized in Table 2.

**TABLE 2**

DEMOGRAPHIC DATA FOR THE EXPERIMENTAL AND CONTROL GROUPS

| | Control | | Experimental | | | |
|---|---|---|---|---|---|---|
| | N | Mean | N | Mean | $\lvert t \rvert$ | P |
| MSAT | 80[a] | 487 | 44 | 471 | 1.1 | .27 |
| APT | 69[a] | 9.78[b] | 27 | 8.85[b] | 0.9 | .35 |
| GPA | 81 | 2.71 | 53 | 2.59 | 1.4 | .17 |

[a]missing data
[b]score indicates number correct out of thirty-six items.

Although there was no statistically significant difference in the means between the two groups for MSAT, GPA and APT, the experimental group was lower on all three measures.

Students in the experimental and control groups were asked about their high school and college mathematics course enrollment (see Table 3). A larger percentage of experimental course students had unsuccessfully attempted the traditional course previously, and a larger percentage of experimental course students had had their last mathematics class three years or more ago. This data suggests that the experimental course population consisted of a fairly large number of students who had either been unable to pass the traditional course or had avoided it until their junior or senior year. In fact, approximately 41% of the experimental group were either juniors or seniors, compared to only 16% of the control group.

**TABLE 3**

MATHEMATICS COURSE ENROLLMENT HISTORY

| | Control N | Control % | Experimental N | Experimental % |
|---|---|---|---|---|
| Never took trad. course | 69 | 85 | 35 | 66 |
| Attempted trad. course unsuccessfully | 12 | 15 | 18 | 34 |
| Total | 81 | 100 | 53 | 100 |
| Years since last mathematics course | | | | |
| < 1 year | 13 | 18 | 10 | 21 |
| 1 year | 30 | 41 | 14 | 30 |
| 2 years | 17 | 23 | 5 | 11 |
| > 3 years | 13 | 18 | 18 | 38 |
| total | 73[a] | 100 | 47[a] | 100 |

[a]Some students did not respond to this question.

Thus, the Fennema-Sherman attitude data should be interpreted in light of the fact that the experimental group was somewhat weaker in MSAT, GPA, algebra placement test score and mathematics course enrollment history.

To analyze the Fennema-Sherman Attitude Scale data, a composite score was calculated for each student in both the confidence and usefulness category by computing a mean confidence score and a mean usefulness score. These composite scores were used to determine the overall means for each group. All responses were coded so that 1 represented a positive attitude and 5 represented a negative attitude. Thus, to interpret Fennema-Sherman data, note that smaller numbers indicate more positive attitudes. t-tests were performed to compare the means between groups (see Table 4).

**TABLE 4**

COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS

| | Mean | | | |
|---|---|---|---|---|
| | Control n=81 | Experimental n=53 | \|t\| | P |
| Pretest | | | | |
| confidence | 3.051 | 3.321 | 1.77 | .08 |
| usefulness | 2.766 | 2.753 | .11 | .91 |
| Post test | | | | |
| confidence | 2.892 | 2.937 | .28 | .78 |
| usefulness | 2.774 | 2.691 | .64 | .52 |

No significant differences were found between the experimental and control groups. However, several points are worth noting. The experimental group was lower on the pretest confidence scale than the control group and, although still lower on the post test, had narrowed the gap. The experimental group was slightly higher on the pretest usefulness scale than the control group and was higher by a wider margin on the post test. The experimental group gained in confidence and perceived usefulness between the pre and post tests. The control group gained in confidence but declined slightly in perceived usefulness.

To obtain a clearer picture of the changes in confidence and perceived usefulness within each group, the differences between pre and post test means were analyzed using t-tests (see Table 5).

**TABLE 5**

WITHIN GROUP PRE - POST COMPARISONS

| Group | Mean Difference (Post-Pre) | \|t\| | P |
|---|---|---|---|
| Control | | | |
| confidence | -.159[a] | 1.92 | .06 |
| usefulness | .008 | .11 | .91 |
| Experimental | | | |
| confidence | -.384[a] | 3.54 | .001 |
| usefulness | -.062[a] | .71 | .48 |

[a]Negative differences indicate a more positive attitude in the post test.

The experimental group showed a significant positive change ($P<.01$) on the confidence in learning mathematics scale.

We next analyzed how this positive change in confidence compared with the positive change in confidence of the control group (see Table 6).

**TABLE 6**

COMPARISON OF CONFIDENCE GAINS

| Confidence Mean Difference | | \|t\| | P |
|---|---|---|---|
| Control | Experimental | | |
| -.159 | -.384 | 1.51 | .098 |

Although the mean of the confidence difference scores for the experimental group is over two times that of the control group, the difference between the means is not significant.

Given a possible testing confound in a pre/post test design, an analysis of convariance with pretest scores as the covariate was also conducted. In this analysis, the post test scores were adjusted based on their relationship to the pretest scores. The homogeniety assumptions for within-group regression coefficients and for variance were met.

**TABLE 7**

CONFIDENCE PRETEST AND POST TEST: ANALYSIS OF COVARIANCE

| | Post Test Confidence | | | |
|---|---|---|---|---|
| | Control | Experimental | \|t\| | P |
| mean | 2.89 | 2.94 | .28 | .78 |
| adjusted mean | 2.96 | 2.83 | 1.07 | .29 |

The actual post test means for the two groups indicate less confidence for the experimental group, whereas the adjusted means indicate more confidence for the experimental group (see Table 7). However, the difference between the adjusted means is not significant.

## ANALYSIS OF STUDENT ACHIEVEMENT

### Method

Subjects. The experimental and control groups for our analysis of achievement are identical to the experimental and control groups for our analysis of attitude.

Materials. Although the two courses were quite different in content, there were several topics in common. Thus, we planned to compare achievement by including some identical or very similar questions on the final examinations for the two courses. After the final examinations were given, by chance we discovered that the final examination for the traditional course was strikingly similar to the previous year's final. Since previous examinations in mathematics courses are on file for student use, control group students had the opportunity to see the questions prior to the examination. Due to this possible testing confound, we abandoned the common item analysis, thereby losing our ability to obtain a valid comparison of mathematics achievement between the two groups.

As an alternative method for evaluating achievement, we chose to look at final course grades for both groups of students. This enabled us to determine the achievement of students relative to the standards set within each course. Since both courses satisfied a graduation requirement for many majors in four different colleges within the university, instructors made every effort to equate the standards. We acknowledge that the final examination scores and therefore the final grades, for the control group may have been inflated due to knowledge about test questions.

The final grades in the experimental course were based on 2 one-hour exams, 3 quizzes, a final exam, 3 projects and 13 computer lab activities, for a total of 1000 points. There were also 15 extra credit points which could be earned for additional lab work. Approximately 38 percent of the total grade was determined from computer lab related activities and tests. The traditional course final grades were based on 3 one-hour exams and a final exam for a total of 525 points. Sixty extra credit points could be earned in quizzes or lab tasks. In both courses, the final grade was solely determined by the number of points earned.

## Results and Conclusions

The final course grades for the experimental and control groups appear in Table 8. Overall, the grade distributions for the two groups were quite similar, and the difference between the means was not significant, $|t|=.50$, $P = .62$. Thus, we concluded that the achievement of students relative to the standards set within each course was similar. Since instructors made every effort to equate the standards, we were satisfied that the mathematics achievement of experimental group students was similar to that of control group students, although the specific mathematics content learned was somewhat different.

TABLE 8

FINAL COURSE GRADES: EXPERIMENTAL AND CONTROL GROUPS

| Grade | Group | | | |
|---|---|---|---|---|
| | Control | | Experimental | |
| | N | % | N | % |
| A | 30 | 37 | 17 | 33 |
| B | 26 | 32 | 15 | 29 |
| C | 17 | 21 | 15 | 29 |
| D | 6 | 7 | 5 | 10 |
| F | 2 | 2 | 0 | 0 |
| Total | 81 | | 52[a] | |
| Mean[b] | 2.938 | | 2.846 | |

[a]One student switched to "Listener" status prior to the end of the semester.
[b]A = 4, B = 3, C = 2, D = 1, F = 0

## ANALYSIS OF COURSE EVALUATION DATA

### Method

Subjects. All students in the experimental and traditional courses had an opportunity to fill out a course evaluation document at the end of the semester. To ensure the anonymity of students responding to this questionnaire, ID numbers were not required. Therefore, we were not able to identify students in the control and experimental groups. Thus, the data reported in this section was taken from the subsets of the total populations of both courses that filled out the evaluation form. In the traditional course approximately 59% of 875 students responded. In the experimental course, approximately 81% of 108 students responded.

Materials. We used a course evaluation document developed at the University of Delaware. Each course had a customized form, with many items common to both, but with special free response questions for the experimental course (see Appendix B).

Results and Conclusions

Four items in common to the two course evaluation documents were useful in comparing the two courses (see Table 9).

**TABLE 9**

QUESTIONS FROM THE COURSE EVALUATION DOCUMENT

| Question | Mean | | | |
|---|---|---|---|---|
| | Traditional | Experimental | \|t\| | P |
| Grade expected at start of course (1=A→5=F) | 2.26 | 2.69 | 3.99 | .0001 |
| Grade expected at end of course (1=A→5=F) | 2.13 | 2.20 | .59 | .55 |
| Personal progress in mathematics (1=good→5=poor) | 2.48 | 2.31 | 1.41 | .16 |
| Textbook's clarity (1=good→5=poor) | 3.23 | 2.89 | 2.65 | .008 |

It is interesting to note that students in the experimental course came into the course expecting a significantly lower final grade than the students in the traditional course. However, at the end of the course, there was no significant difference in the expected final grade between the two groups. This finding is consistent with the increase in overall confidence in learning and performing well in mathematics found in the experimental course group in the Fennema-Sherman survey. Students in the experimental course reported that they had made more progress in mathematics than students in the traditional course, although the difference between the two groups was not significant.

Students in the experimental course rated the clarity of their textbook significantly higher than students in the traditional course.

Students in the experimental course were asked several free response questions about the course, and were asked for their suggestions for improving or changing the course. They were also asked about several aspects of the computer experience and, if they had previously taken the traditional course, they were asked for their impressions of the two courses.

When asked to compare the two courses, students who had experienced both courses were unanimous in the opinion that the experimental course was a better mathematices course. Many students felt amazed by the amount of mathematics that they had learned. Several praised the relevance of the material and felt that the concrete "real-world" problems helped them learn mathematics successfully. Many said they hated and feared mathematics until they took the experimental course.

When asked about the effects of the computer on their learning, many students said that the computer helped them learn by allowing them to "visualize" the mathematics. Most students had a very positive feeling about the computer component of the course. Some said that the computer took the pain out of mathematics.

When asked "Would you recommend the experimental course to your friends?", 88% of the students responded "Yes."

Overall, the student course evaluation of the experimental course was very positive. When compared with students in the traditional course, students in the experimental course reported that they had made more progress in mathematics. By the end of the course, experimental course students were expecting to earn grades almost as high as traditional course students although their original grade expectations were significantly lower.

## GENERAL DISCUSSION

Our analysis of the demographic data and the attitude data suggests that the experimental group was somewhat weaker mathematically at the beginning of the course, but that their confidence in their ability to learn and perform well on mathematical tasks had improved signficantly by the end of the course. The mean gain score on the confidence scale for the experimental group was higher than that of the control group, but the difference was not statistically significant. Also, the adjusted post test mean on the confidence scale, with pretest as covariate, was higher for the experimental group than the control group, but the difference was not statistically significant. No significant difference between the two group was detected with regard to the perceived usefulness of mathematics. However, the perceived usefulness increased somewhat for the experimental group and decreased slightly for the control group.

The final course grades of the experimental group were comparable to those of the control group in spite of the somewhat weaker mathematical backgrounds of experimental course students and the significantly lower grade expectations of experimental course students at the beginning of the course. The course evaluation data for the experimental course was viewed as a student endorsement of the course.

In August, 1989 a report was sent to the appropriate committee within the Department of Mathematical Sciences describing the experimental course, the results of the attitude and achievement analyses, and the very positive student course evaluation. The report recommended that the course be given permanent status as an alternative to the traditional course. However, concerns were raised as to whether the achievement standards of the experimental course were truly equivalent to those of the traditional course; whether two separate courses were necessary for essentially the same constituency; and whether, given computer hardware constraints, the course could accommodate 1000 students. The recommendation for permanent status was tabled pending further study.

## THE TRANSITION FROM TWO COURSES TO ONE

Both the experimental and traditional courses were offered again in spring 1990. The following changes were made in the experimental course:

- The enrollment limit was increased from 120 to 240 students
- Students were scheduled into the computer laboratory biweekly instead of weekly. This allowed for a biweekly question-and-answer workshop and freed up time in the computer lab so that more students could be enrolled.
- The number of computer lab activities was reduced from 13 (one per week) to 10. Approximately half of these labs were done during regularly scheduled lab times with

instructor supervision and the other half were done on the students' own time without instructor supervision.

- The amount of testing done on-line in the computer laboratory was significantly reduced. In spring 1989, 2 out of 3 quizzes, the two-hour exams and the final exam had lab components. However, in spring 1990, only the two hour exams had computer lab components.

- The number of projects was reduced from 3 to 2.

The traditional course began to take on some of the characteristics of the experimental course: 6 computer laboratory activities for all students, required use of scientific calculators, and use of portable computers for lecture demonstrations by some instructors.

No formal evaluation of the modified experimental course was conducted in spring 1990. However, the course evaluation instrument was used to obtain comparative data for the spring 1989 and spring 1990 experimental courses. Since most of the change between the two semesters related to computer activities, the following question was of particular interest:

> Were the computer lab activities helpful to you in understanding the course material?

**TABLE 10**

HELPFULNESS OF COMPUTER LAB ACTIVITIES

| Mean | | | |
|---|---|---|---|
| Spring 89 N=87 | Spring 90 N=171 | $\|t\|$ | P |
| 1.87 | 2.18 | 2.67 | .008 |

Note: Responses range from 1 to 5 with 1 = very helpful to 5 = not helpful.

Although one might expect the two populations to be the same, in fact, an analysis of the demographic data for the entire populations (with some missing values) shows the following: no significant difference between the means on GPA, but a significant difference at the .05 level on MSAT and Algebra Placement Test, with the 1990 population higher on both tests. Thus, it was the "weaker" 1989 group that found the computer lab activities more helpful. Possibly, the weaker students benefitted more from the computer-generated visual images of abstract algebraic and statistical concepts.

The computer lab activities themselves may partially explain the difference in their perceived helpfulness in understanding course material. Of the 10 labs used in 1990, five were essentially identical, with minor editorial changes, to labs used in 1989, and one lab was a consolidation of two 1989 labs. However, three 1990 labs were created by adding real-world applications to their 1989 editions, and one 1990 lab was completely new. Possibly, the added applications made the labs seem more difficult to students and thus less helpful in understanding course material.

The 1989 students were in the computer lab every week with their instructors, whereas the 1990 students were supervised in the lab every other week and had to do approximately half of the labs on their own. Thus, 1989 students had the benefit of an instructor present during each lab to give immediate feedback. We hypothesize that supervision of lab activities is a factor influencing students' perception of the helpfulness of lab activities. We estimate that the total time needed in the lab to complete computer lab activities in 1990 was approximately the same as in 1989, and thus was not a factor in perceived helpfulness.

Spring 1989 students were tested on-line in the computer laboratory five times during the semester, whereas 1990 students were tested on-line only two times. Possibly, 1989 students viewed the computer lab activities as a more important part of the course because they were tested so frequently on the computer, and made a greater effort to learn how t use the computers in order to improve their grades. Then, having spent more time studying lab activities, they found the activities more helpful in understanding the course material.

During the spring 1990 semester while both the traditional and experimental courses were being offered, the Director of the Mathematical Sciences Teaching and Learning Center formed a joint committee of instructors from both the traditional and experimental courses. The charge to the committee was to create a single course that incorporated the best mathematical content and methodologies from the two courses and that could accommodate 1000 students in one semester.

The new course, referred to by the traditional course name of Elementary Mathematics and Statistics, was offered for the first time in fall 1990 with a limited enrollment of 240. The text chosen by the joint committee was Applied Mathematics for Life and Social Sciences (Harshbarger & Reynolds, 1989). The traditional course text was rejected on the grounds that it did not have sufficient emphasis on modeling and applications. The experimental course text was rejected on the grounds that it was not a college level text, having been written for high school students, and that the Scott, Foresman edition would not be ready in time for spring 1991. However, the "data → function → prediction" theme from the experimental course text was deemed sufficiently important that instructors wrote worksheets incorporating this theme to supplement the new textbook.

By fall 1990, partially due to the positive experience of experimental course students with computer lab activities, all mathematics courses below calculus incorporated computer labs. This limited the number of labs per course to six due to hardware constraints. Instructors wrote six new lab activities to accompany the new text.

The new course resembles the traditional course in that no testing is done on-line. When 240 students were tested on-line in the experimental course in spring 1990, instructors wrote five different versions of the on-line tests. To scale the course up to accommodate 1000 students would have required a minimum of ten different versions. This was deemed too costly in terms of instructor time. Also, no projects are required in the new course in part because of instructor time required to grade them.

The testing policy for the new course represents a compromise between the traditional and experimental courses: between 50% and 60% of tests and quizzes are multiple choice and between 40% and

50% are free-response. However, the final examination is primarily multiple choice. The calculator policy is consistent with that of the experimental course: scientific calculators are required for homework and on tests.

The new course is being offered in spring 1991 to the full enrollment of 1000 students. The six new lab activities written for fall 1990 were revised based on feedback from students in the fall semester. The Fennema-Sherman Mathematics Attitude Scales for confidence and usefulness have been administered to 240 students, and a post test will be given at the end of the semester. In addition, the course evaluation document will be administered to the entire population. We will be particularly interested in the question about computer lab usefulness. Since students in the new course have biweekly instead of weekly lab activities, we are concerned that they will spend more time relearning software and less time making connections between the lab activities and course material.

Since this is the last mathematics course that most enrolled students will take in their academic careers, our goal is to constantly strive to make the course more relevant, interesting and informative for all students.

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## APPENDIX A
### Fennema-Sherman Attitude Scales

Note: Your responses to these items should begin with <u>number 3</u> of your scan sheet.

A - strongly agree
B - agree
C - undecided
D - disagree
E - strongly disagree

3. Generally I have felt secure about attempting mathematics.
4. I am sure I could do advanced work in mathematics.
5. I am sure that I can learn mathematics.
6. I think I could handle more difficult mathematics.
7. I can get good grades in mathematics.
8. I have a lot of self-confidence when it comes to math.
9. I'm no good in math.
10. I don't think I could do advanced mathematics.
11. I'm not the type to do well in math.
12. For some reason even though I study, math seems unusually hard for me.
13. Most subjects I can handle O.K., but I have a knack for flubbing up math.
14. Math has been my worst subject.
15. I'll need mathematics for my future work.
16. I study mathematics because I know how useful it is.
17. Knowing mathematics will help me earn a living.
18. Mathematics is a worthwhile and necessary subject.
19. I'll need a firm mastery of mathematics for my future work.
20. I will use mathematics in many ways as an adult.
21. Mathematics is of no relevance to my life.
22. Mathematics will not be important to me in my life's work.
23. I see mathematics as a subject I will rarely use in my daily life as an adult.
24. Taking mathematics is a waste of time.
25. In terms of my adult life it is not important for me to do well in mathematics in college.*
26. I expect to have little use for mathematics when I get out of school.

*The original document used "high school" instead of "college."

APPENDIX B
Course Evaluation
Experimental Course

The purpose of this questionnaire is to give you the opportunity to express your opinions about this course and your instructor. Please select one of the five responses for each question. Choice A corresponds to the word on the left, and Choice E to the word on the right, while Choices B, C, and D are between the two extremes. Use only a No. 2 pencil. Please do not put extraneous marks on the front of the scan sheet. INSTRUCTORS VALUE YOUR WRITTEN SUGGESTIONS AND COMMENTS. Please write them on the reverse side of this form. Thank you.

1. Hours a week spent on this course beyond the three class hours?
   A. 0-2 B. 2-4 C. 4-6 D. 6-8 E. Over 8
2. Before I started this course, I expected to earn a grade of:
   A. A B. B C. C D. D E. F
3. What grade do you now expect in this course?
   A. A B. B C. C D. D E. F
4. As a result of this course, my personal progress in mathematics has been: excellent A B C D E poor
5. Textbook's clarity in explaining course material?
   excellent A B C D E poor
6. Instructor's preparation for lecture?
   excellent A B C D E poor
7. Instructor's clarity in explaining course material?
   excellent A B C D E poor
8. Instructor's knowledge of when students were lost during a lecture? excellent A B C D E poor
9. Did the instructor encourage participation of questions from students? always A B C D E never
10. Did examinations seem appropriate to the materials covered in class? always A B C D E never
11. Did the instructor appear to enjoy teaching?
    always A B C D E never
12. Instructor concern and respect for student interests and welfare? excellent A B C D E poor
13. If possible, would you take another course with this instructor? definitely yes A B C D E definitely no
14. Overall, I would rate the instructor: excellent A B C D E poor
15. Was the one hour computer lab session effective?
    always A B C D E never
16. Were the computer lab activities helpful to you in understanding the course material? very helpful A B C D E not helpful
17. Were the three projects helpful to you in understanding the course material? very helpful B C D E not helpful

Please answer these questions as thoroughly as possible to help us in evaluating this experimental course. We also need your feedback in order to make changes and improvements in this course.

1. Can you think of a situation or question in your own life or the "real world" that can be best answered by mathematics?

2. Can you think of any way that you could use math in your other course work. Describe how you have used math in any of your other course work this semester.

3. How would you change this course to improve it?

4. If you have taken or attempted to take the regular M114 course, how would you compare M167 to M114?

5. Would you recommend this course to your friends?

6. Describe ways that the computer has or has not affected your learning.

7. Describe ways that the computer usage during lecture has or has not affected your learning.

8. Please describe your overall feelings about this course. Also, use this space to make any other comments you would like to make about the course.