TECHNOLOGY vs. TEXTBOOK
A Study Comparing the Use of Computer Software with the Use of a Textbook as the Primary Vehicle of Instruction in Basic Mathematics at Berea College

Background

The Basic Mathematics Program at Berea College was established almost three decades ago when it was observed that a number of students registered in pre-calculus classes were not prepared to understand the mathematics in that course. The program consists of a pre-algebra course and an elementary/intermediate algebra sequence. For several years, the first course was a college-wide requirement, but the algebra course was required only for students whose chosen major required it. In April 1990, the faculty voted to make the entire basic math sequence required of all students who do not waive the requirement. Since Fall Term 1990, students have been expected to complete the sequence in the first year.

Although the program has undergone some changes in the last 27 years, its basic structure remains the same. The courses are designed to provide students with an opportunity to develop competence in quantitative reasoning and to prepare them for subsequent courses in our curriculum that require quantitative reasoning skills. Three features that are intended to minimize anxiety and maximize learning characterize the courses. These are individual pacing, mastery based learning, and time flexibility. Each student moves at a pace that is appropriate for her or him; no one is expected to keep up with or wait for another. Before leaving a given topic, students are asked to demonstrate a specified level of competence by passing a test on that topic. Because students progress at different rates, they complete the courses in varying lengths of time. There are several other nonstandard features of the courses. "S" and "U" replace traditional end-of-term letter grades. Three scores are used for tests in the courses: Hi

Pass (≥ 85%), Pass (75%-84%), and No Pass (< 75%). Students who score Hi Pass on every chapter or unit test are exempt from the final exam. There are no large group lectures. The focus is on the individual rather than the group.

Materials typically used in these courses include a developmental mathematics textbook with associated tests and ancillary materials. One instructor who is a professional staff member and at least one teaching associate (TA) from the math department's pool of labor students are available during each class to answer student-initiated questions, monitor student progress, provide individual or small group instruction as the need arises, administer tests, and counsel students about such things as time management, math-related anxieties, and test strategies. Average class size is 15. Almost all of the classroom interaction is one-to-one although collaboration among students is encouraged. The content of the first course is a review of topics typically covered in the first eight grades of school – the four basic operations with whole numbers, decimals and fractions; ratio, proportion, percent, descriptive statistics, geometry, and measurement. The algebra courses are roughly equivalent to high school Algebra I and Algebra II. Initial placement is currently accomplished using ACT/SAT scores. Students who are placed according to these scores then take an ACT COMPASS placement/diagnostic test and are given individual assignments based on performance on this test. A typical class includes a mixture of students working in each of the three courses. It is current college policy that students must complete the Basic Mathematics requirement before the beginning of the third regular term of attendance.

Technology vs. Textbook - The Study

Although it is our firm belief that the individualized approach is desirable and worth keeping, we also recognize some inherent difficulties. While time flexibility accommodates differences in background and ability, the absence of strict common deadlines sometimes exacerbates the tendency to procrastinate. Students in an individually paced, time-flexible setting sometimes appear to lack motivation and seem to be less likely to engage the course in a productive way. Another difficulty stems from the fact that individualized instruction requires much careful record keeping by the

instructor. Daily tracking of each student's progress is important because it helps ensure early diagnosis of problems and increases the likelihood that intervention will be helpful. In order to realize the benefits of time flexibility, the instructor must be certain that materials are readily available and be faithful and fast in grading and returning homework and tests.

Interactive Mathematics, a multimedia instructional program developed by Academic Systems, appeared to offer the potential to address these difficulties. It seemed likely that the multimedia format would be a positive motivational factor for many students and that the associated record-keeping features of the program would assist in the organization and maintenance of individual student records. Additionally, the quality and variety of explanations provided for the mathematical ideas appeared, upon review of the materials, to be impressive. For these reasons, the decision was made to try the program on an experimental basis in some sections of basic math.

The first phase of the project began Fall Term 1999. One section (14 students) of basic math was offered using *Interactive Mathematics* while the remaining seven sections (103 students) used the textbook, Developmental Mathematics (fourth edition), written by Bittinger and Beecher and published by Addison Wesley. Students were placed in the classes by random selection. At the end of the term there were several positive indicators in the experimental section. Test scores suggested students learned the material well. Course progress and completion rates were as good or better than those for students in the "traditional" sections. Student comments about the course (from the Instructor Evaluation Questionnaire) were very positive. On the basis of these positive indicators, it seemed reasonable to expand the experiment to involve more students and instructors.

Design

During Fall Term 2000 *Interactive Mathematics* was used in three sections of basic math. Two instructors and forty-four (44) students were involved in these 3 sections. The remaining 5 sections, including four instructors and fifty-nine (59) students, used the textbook, Developmental Mathematics (fifth edition) by Bittinger and Beecher, as the primary vehicle for instruction. Students were selected at random for placement in a class. In the computer sections class size ranged from 13-17 (average =15). Class

size in the textbook sections ranged from 6-15 (average=12). Each class met four (4) times each week, fifty minutes per class session. One instructor and at least one TA were available during every class. Course content and basic program policies and procedures were the same for all sections. Similar paper-and-pencil tests, designed to determine mastery of each topic, were administered to all students. A common final exam was given to those students who did not waive that requirement.

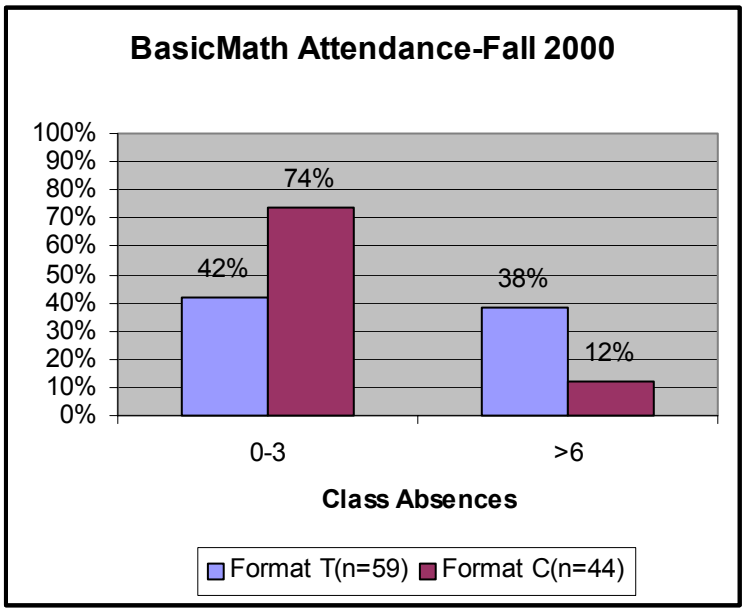
At the beginning of the term, members of the basic math instructional team met to discuss indicators of student motivation. There was general agreement that the most important characteristics of a motivated student were regular class attendance, good preparation for and performance on tests, steady progress leading to timely course completion, and a generally positive attitude toward the course. Conversely, poorly motivated students miss class frequently, require frequent test retakes before demonstrating mastery of a topic, take longer than expected to complete the course, and demonstrate a negative attitude toward the course. On the basis of this information, cognitive, behavioral and attitudinal measures were chosen to indicate student motivation. Cognitive measures included test scores and course completions. Class attendance was the behavioral measure, and responses to survey questions provided attitudinal data.

Results

Data related to class attendance in basic math revealed that students in the computer sections attended class more regularly than did students in the textbook sections. It has been our experience that students who miss class no more than three times during the 14-week term are more likely to be successful in the course. Those who miss class often (i.e., more than six times during the term) are apt to lose touch with the instructor and the material, interrupt the continuity of their study, and experience more difficulty learning. The figures in Table I indicate that 74% of computer students missed class no more than three times during the term while 42% of textbook students exhibited this attendance record. Only 12% of the computer group missed class more than 6 times, but 38% of their counterparts in the textbook group accumulated more than 6 absences.

The average (mean) number of absences in the textbook sections was 7.66 versus 2.84 in the computer sections, a statistically significant difference ($df = 101, t = 3.49, p \leq 0.001$).

Table I



It was mentioned earlier that students are asked to demonstrate competence on a given topic by passing a test (score ≥ 75%) on that topic. Should a student fail a test, he/she and the instructor work together to identify areas of difficulty and decide what needs to be done before the test is taken again. Every effort is made to ensure success on the second attempt, but there is no limit to the number of times a student may retake any given test.

Recall that good preparation for tests was cited as one characteristic of a well-motivated student. Such students should not require frequent test retakes. As a way of measuring the extent to which students were well prepared for the tests, retakes were tallied on each topic. Tables II and III display the data regarding test retakes. For example, on the "Real Numbers" test, six textbook students required one retake, one required two retakes, and one required three retakes. On the same topic, two computer students required one retake and none required more than one retake. Although there is

some variation across topics, students in the textbook sections generally required more retakes than students in the computer sections. The average (mean) number of retakes in the textbook sections was 1.26 versus 1.04 in the computer sections. This difference was statistically significant ($df = 47, t = -2.886, p \leq 0.006$).

The results reported for the "Percents" topic are of particular interest for a number of reasons. The material covered here is typically difficult for many basic math students. It is also exceptionally important because of its widespread application in subsequent courses and postgraduate experience.

Table II

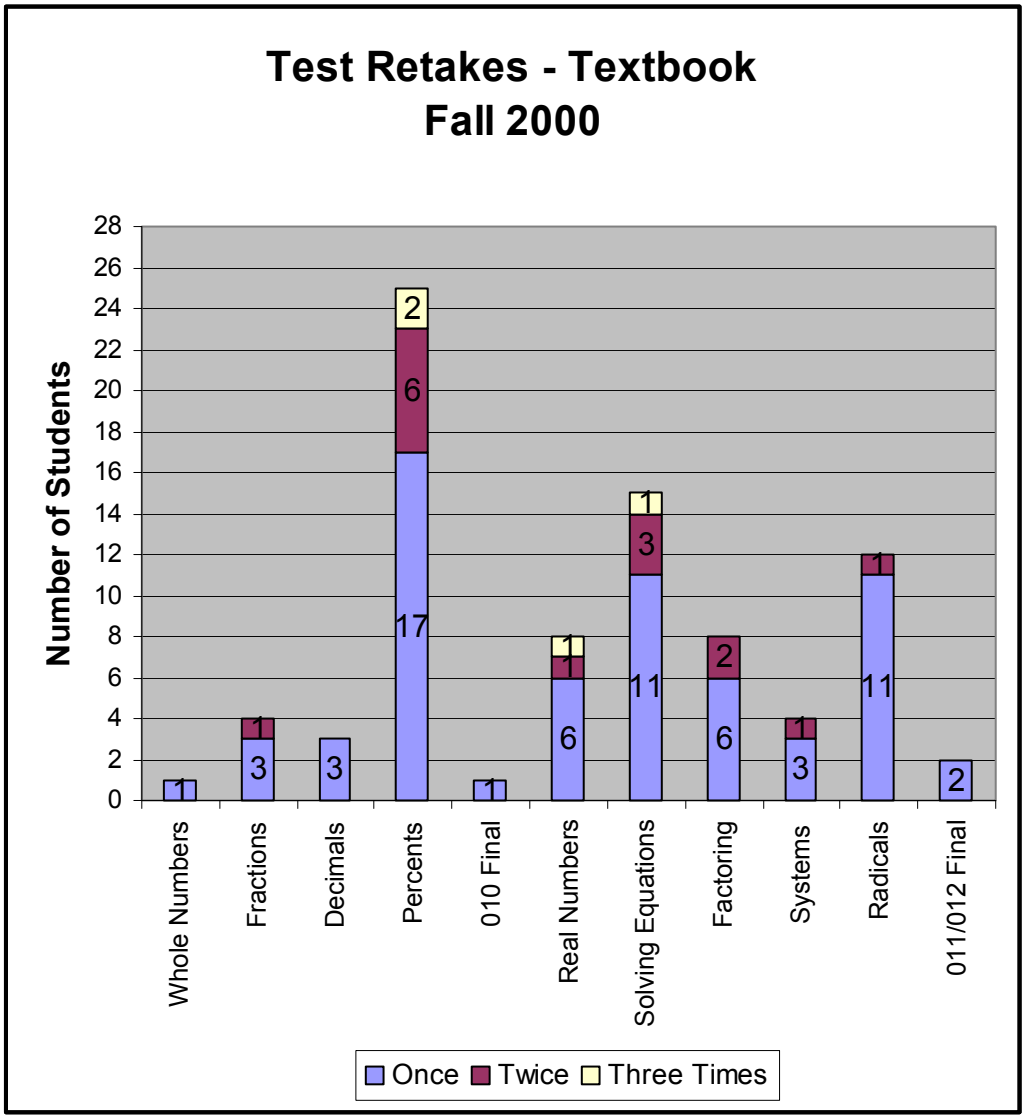
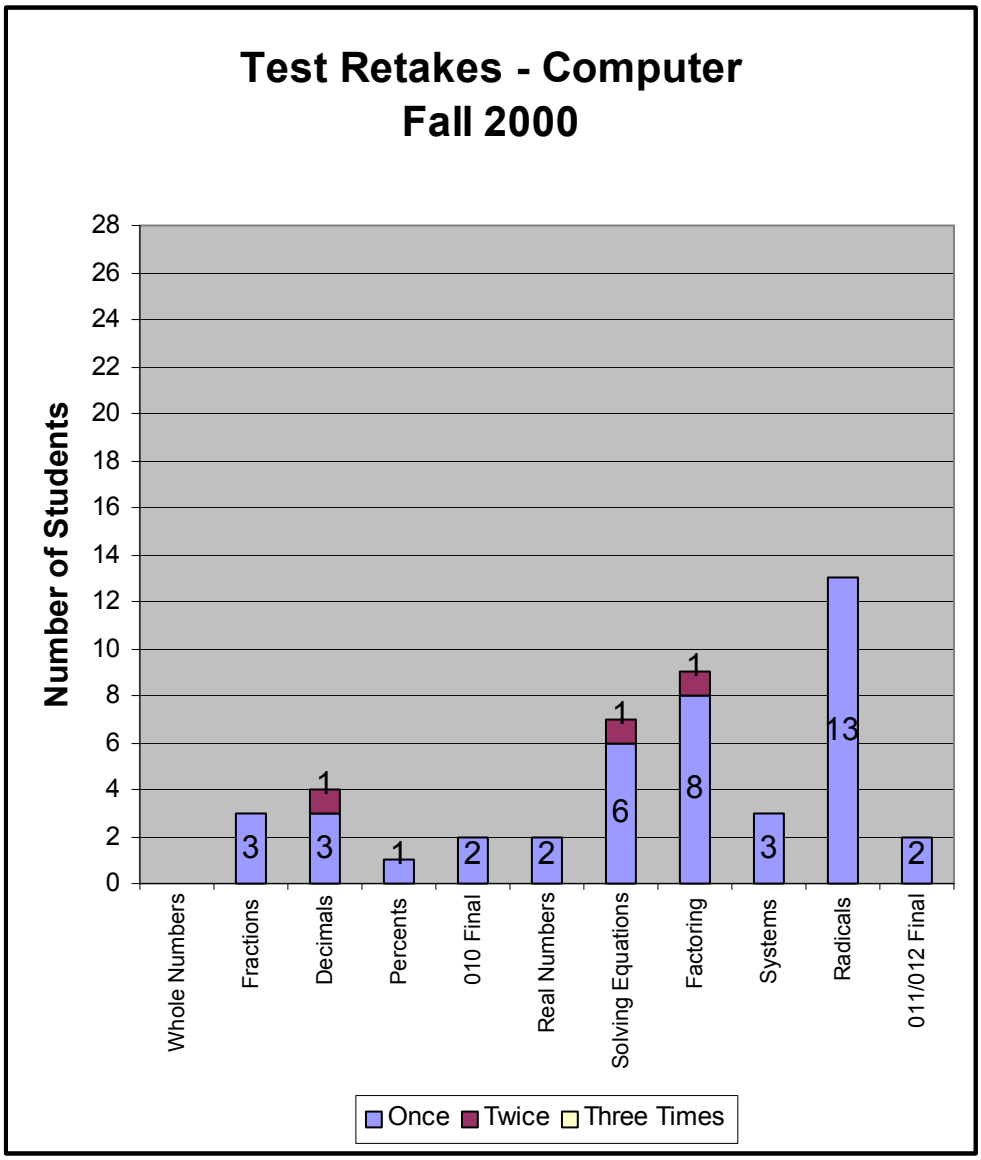


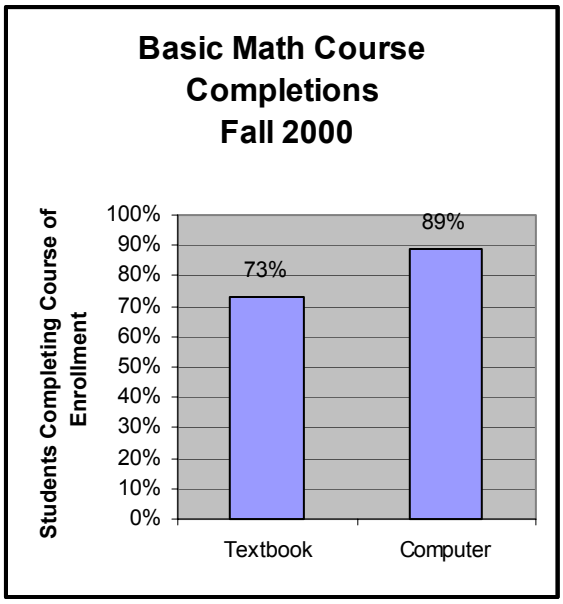
Table III



The third characteristic of motivated students, as identified by the basic math instructional team, was steady progress leading to timely course completion. The instructional team believes that students who engage the material in a conscientious and constructive way will complete the basic math course in which they are enrolled in a given term. At the beginning of Fall Term 2000, each student in the study was enrolled in one of two courses: pre-algebra (MAT 010) or algebra (MAT 011). Table IV shows course completion data for the computer and textbook sections. As indicated, 89% of

students in the computer sections and 73% of students in the textbook sections completed the course for which they were registered. The difference between course completion rates for the two formats was statistically significant ($df = 101, t = 1.98, p \leq 0.05$).

Table IV



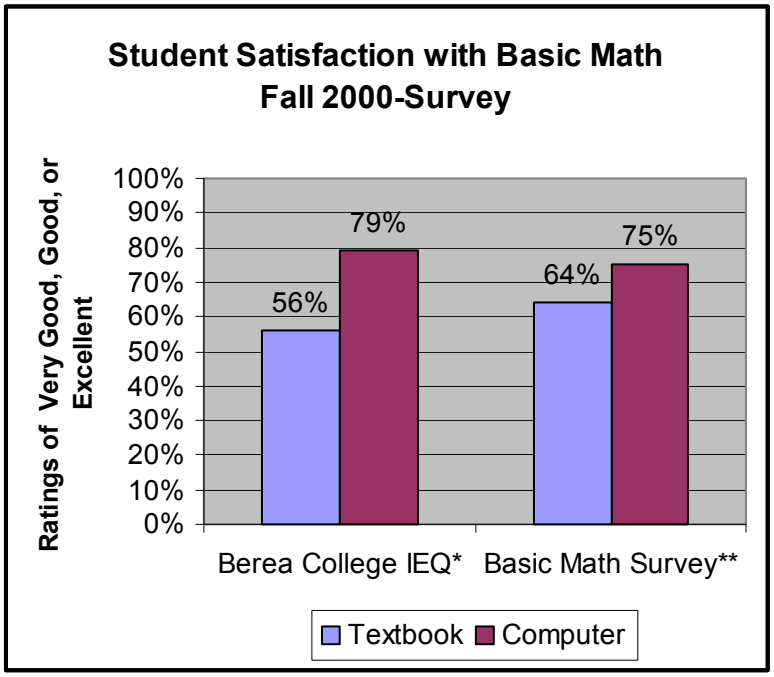
A generally positive attitude toward the course was specified as the fourth measure of motivation. Student satisfaction with the course was measured using response to one relevant question on each of two questionnaires administered together near the end of the term. On the Berea College Instructor Evaluation Questionnaire (IEQ), students were asked to use a rating scale to respond to the question, "How would you rate this course overall?" (very poor=1, poor=2, average=3, very good=4, excellent=5). The average (mean) rating for the textbook sections was 3.71 and the mean rating for the computer sections was 3.94. Both are between average and very good. The difference between the means is not statistically significant.

Responses to a similar question ("How would you rate your overall satisfaction with this course?") on the Basic Math Survey were also examined with similar results. Again the

ratings were very poor=1, poor=2, average=3, very good=4, excellent=5. The average (mean) rating for the textbook sections was 3.95 (between average and very good) versus 4.09 (between very good and excellent) for the computer sections. The difference was not statistically significant.

The results shown in Table V show that 79% of the computer students versus 56% of the textbook students chose one of the top two categories (very good/excellent) on the IEQ question. On the Basic Math Survey question, 75% of computer students versus 64% of textbook students chose one of the top two categories (good/excellent).

Table V



* Responses to "How would you rate this course overall?"
** Responses to "How would you rate your overall satisfaction in this course?"

Anecdotal records provided by the instructors in the three computer sections, though informal, seem worthy of note. Two instructors were involved in teaching the three sections using *Interactive Mathematics.* Both had several years of experience teaching basic math at Berea College - 18 years for one instructor and 11 years for the other. Both had strong positive reactions to the new approach and expressed preference for teaching future sections using the software rather than returning to the textbook.

Among the benefits cited by the instructors was that tracking individual student progress on a daily basis was easier. The Instructional Support System (ISS) allowed the instructor to monitor each student's activity in class and outside of class, thus increasing the potential for early intervention and effective remediation. Also, because TA's could be assigned to use the ISS to monitor student progress, they could become more active participants in the record-keeping aspects of the course.

Other benefits observed and noted by the instructors included:

- Students attended class more regularly.
- Students were more engaged in the course work during class time. They began work each day more promptly, used class time more productively, and more often left class with a feeling of accomplishment.
- Students seemed to be better prepared for tests. In general, there was less need for retakes.
- The overall quality of the multimedia lessons was impressive.

Some disadvantages were also noted:

- One or two topics seemed inordinately difficult for students.
- Technical difficulties occasionally interrupted student progress.
- A few topics were not covered adequately.

Summary

This study was conducted to compare the use of *Interactive Mathematics*, a multimedia instructional approach, with the use of a developmental mathematics textbook in basic math classes at Berea College. More specifically, the study sought to examine the comparative effects of the two approaches on student motivation and instructor record-keeping. Several measures were used as indicators of student motivation: test scores and course completions (cognitive measures), class attendance (behavioral measure), and responses to survey questions (attitudinal measure). Statistically significant differences were noted between the two formats on most measures and in every case the difference favored the computer-mediated format. Students using *Interactive*

Mathematics attended class more regularly, completed the course at higher rates, and demonstrated better preparation for tests. The difference between the two groups with regard to attitude was less obvious; no statistical significance was apparent on this measure. However, students using *Interactive Mathematics* exhibited a slightly more positive attitude toward the course.

Less formal measures were used to indicate the effect on instructor record-keeping. Anecdotal records from the two instructors involved in teaching the three computer-mediated sections indicate the Instructional Support System provided a relatively easy way to track student progress on a daily basis and effect early identification of difficulties.

These results confirm the positive indicators noted in the first phase of the project. The early perception that *Interactive Mathematics* offered the potential to enhance learning and improve teaching by increasing student motivation and assisting in the organization and maintenance of individual student records was strengthened in a very convincing way. On the basis of these positive results, the use of *Interactive Mathematics* in basic math classes at Berea College was increased for Fall Term 2001. The possibility of further study and additional expansion in future years is currently under consideration by the basic math instructional team.

Patricia J. Boyce, Co-Director
Basic Mathematics Program
and
Judith Weckman, Director
Office of Institutional Research and Assessment
Berea College
Berea, Kentucky

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