Comparison of Beginning Algebra Taught Onsite Versus Online

By Gail H. Weems

ABSTRACT: This study compared two sections of beginning algebra: one taught online and the other onsite. The dependent variable of primary interest was mathematical achievement; however, other variables included student attitude toward mathematics, their reasons for selecting an online section, and their critiques of the online format. Although there was not a significant difference between exam averages for the two formats, there was a significant decrease in performance by the online students across the exams, whereas performance by the onsite students remained relatively stable. Significant differences were not found regarding student attitudes toward mathematics. Students indicated an overall satisfaction with taking the course online, and many plan to enroll in online, courses in the future.

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As the exponential growth of the Internet continues, educators are rushing to offer courses online. Alarmingly the push to move courses online is often coming from forces outside academia, such as public pressure to make education available anytime and at any location, which is contrary to the tradition for change to come from research within the academic community (Gibson & Herrera, 1999; Sherritt & Basom, 1997). Many instructors have supplemented traditional lecture courses with online resources, some professors have reduced lecture time and added online activities, and other academicians have transformed traditional courses into distance education courses that harness the increasingly powerful and interactive medium of the World Wide Web, which has reportedly "raised the quality of distance instruction" (Mielke, 1999, p. 3).

Instructors creating Web-based courses must confront pedagogical, technological, organizational, and motivational challenges. Although the number of online courses is rapidly increasing, have instructors successfully conquered the challenges of providing instruction online? Hundreds of studies reviewed by researchers from the Institute for Higher Education cited the merits of distance education over a more traditional format; however, the panel concluded that many studies were flawed and the conclusions were, therefore, suspect (Phipps & Merisotic, 1999).

Of additional concern has been the preference of students; do students prefer to enroll in online or traditional courses? Ward and Newlands (1998) examined three economics courses using online resources to differing degrees and noted the "general satisfaction" of students; however, only 11 of 45 respondents believed that "Web-based teaching materials should be a substitute for face to face lectures" (p. 182). Students who accepted the online format may view Web delivery as a viable textbook substitute instead of a substitute for lecture (Edwards & Harden, 1997). However, students may not take full advantage of the interactive offering as they often print the primary material and compile the "textbook" on their own rather than interacting with various sites and links available online (Ward & Newlands, 1998). Unfortunately, both effectiveness of and student satisfaction with online courses are difficult to ascertain due to the array of experiences offered in online courses (Testone, 1999). At one end of the spectrum of online courses, students encounter a high degree of self-directed learning. In such courses students purchase textbooks, obtain a copy of the course syllabus, are instructed where and when to mail their assignments, and are advised to email questions to the professor. Other courses, however, are highly structured and require frequent computer use. Online courses of this type may have specified meeting times for students to interact online, require frequent group activities, offer interactive notes to accompany the text, and administer exams online. In light of numerous unresolved issues, the search for answers must continue. More research is especially needed in the area of developmental mathematics, for which articles specific to online instruction were not found.

Therefore, the purpose of this pilot study was to compare an online and onsite section of beginning algebra, exploring the issues of achievement, impact on student attitudes, reasons for selecting an online course, and satisfaction with the online format. The results from this pilot study will be used to plan a

larger study, conducted in the Fall of 2002, involving several sections from each level of developmental mathematics.

Method

Participants

Participants in the study were 48 students enrolled in two sections of beginning algebra taught through the Transitional Academic Studies (TRAC) program at an urban university in the mid-South. Through the TRAC program, students enroll in remedial/developmental courses to develop the academic competencies necessary for success in college-level courses. Students admitted to the university as beginning freshmen may be required to take placement tests to determine their readiness for college-level courses. Depending on the results of these tests, students may be required to take TRAC courses in one or more areas. Mathematics placements include prealgebra, beginning algebra, or intermediate algebra. Students receive initial placement in one of three courses and proceed through the sequence to successful completion of intermediate algebra.

A total of 25 students enrolled in the online section, and 23 enrolled in the onsite section. Five students in each section did not complete the course. All students were informed of the study and consented to the use of their scores and responses as required by the Institutional Review Board for Human Subjects Research policies.

Procedures

The independent variable was method of instruction: online/distance or onsite/lecture. To improve internal validity, the following factors were held constant for both sections: textbook, instructional video, tutorial CD, course schedule, assignments, and exams. Mathematics achievement and attitude toward mathematics were the dependent variables. Descriptive data were also collected from the online students regarding their reasons for selecting an online course and their critique of the instructional format.

The instructor met face-to-face with the online section during the first week of classes to introduce the students to the course and familiarize them with CourseInfo. CourseInfo was the delivery system adopted by the university that allowed instructors to customize their own Web-based course from a generic template. Resources available to students through navigational buttons included announcements, course information, staff information, course documents, assignments, communication, external links, and student tools.

After the first week, students in the online section communicated with the instructor by email, telephone, course discussion board, and visitation in person during office hours. Students in the online section used the textbook, instructional video, CD tutorial, and email with the instructor to learn the material. The online course outline was identical to that of the onsite course; hence, the online students were expected to cover sections in the textbook as if they were enrolled in a course that met twice a week. As a substitute for lecture, online students were instructed to watch the brief instructional video that accompanied their textbook and then work through the corresponding section on the tutorial CD. Following the video and CD tutorial, students were then encouraged to work the assigned homework problems from the textbook. As students encountered problems with the homework, they were instructed to either post their questions to the course bulletin board or email the instructor. To encourage students to use the course bulletin board and promote a sense of community, students were able to earn bonus points for responding to the questions posted by their classmates. The reward, however, was ineffective, and only three students used the bulletin board. Bonus points were not included in test scores for the purposes of comparing achievement between the two sections.

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Students in the onsite section were required to attend lectures twice weekly. Instructional videos and tutorial CDs also accompanied their textbooks, and the functions of the supplements, as well as their merits as a source for additional assistance, were discussed the first day of class. Lectures followed a traditional format. Each lecture was preceded by student homework questions from the previous section, and then the new material was presented. During the lecture students were encouraged to ask questions, and they were given the opportunity to practice working problems with a classmate throughout the lecture.

To discourage procrastination and promote processing of the material prior to exam week, students in both sections were given weekly quizzes. Quizzes were completed online or in class for the respective sections. The quiz questions covered topics beyond basic computations in an effort to stimulate discussion among the students and encourage deeper processing of the content. Sample questions from two quizzes are included in Appendix A. Quiz dates in the onsite section were unannounced and scores could not be made up. The two lowest quiz scores, however, were dropped to avoid penalizing students who had a justification for missing class. Students in the online section were required to complete their quizzes online and submit their responses each Tuesday. To maintain uniform grading procedures, the two lowest quiz scores were also dropped for the online students. Following the traditional policy of the instructor, students in both sections were required to submit homework on exam days. Students were required to show their work for all assigned homework problems and received credit based on the percentage of assigned problems that were attempted.

Measures

Mathematics achievement, the variable of primary interest, was measured four times. On the first day of class, all students took a 20-item teacher-constructed pretest to determine initial mathematical achievement. During the semester, three teacher-constructed exams were administered to both sections on campus at specified times. The exams from the two sections were combined and graded as a single set of exams to prevent grading bias on the part of the instructor.

Attitude toward mathematics was measured pre and post for both sections using the "Scale of Attitudes Toward Mathematics" developed by L. R. Aiken (1974) and selected for this study because of its brevity, simplicity, and usefulness. Although most scales assess either enjoyment with or anxiety toward mathematics, Aiken's scale was designed to measure four separate constructs. The constructs were enjoyment of mathematics, motivation in mathematics, importance of mathematics, and freedom from fear of mathematics. Three of the six items for each scale were worded in the positive direction and three in the negative direction. The response options, however, were extended by the researcher for this study from a 5-point Likert format to 6-points. The extension eliminated the middle category, which is often over-selected and may attenuate scale reliability (Weems & Onwuegbuzie, 2002). A sample of scores, using a 6-point scale, from 300 junior-high students had scale reliabilities ranging from .50 to .86 and total score reliabilities from .81 to .91 (Aiken, 1979). Taylor (1997) verified the factorial validity of scores from a shortened version containing only two scales for college students. The full version, however, was administered in this study; scores on the scales from the first administration had

reliabilities ranging from .83 to .88, and the end of the semester administration's reliability ranged from .69 to .85. Total score reliabilities for the two administrations were .90 and .94 respectively.

Questionnaires were administered on both the first and last day of classes to students enrolled in the online section only. The first questionnaire addressed issues of computer access, technical expertise, and reasons for selecting the online section. The last questionnaire addressed satisfaction with the online format.

Results

Achievement

The final sample size for students completing all scheduled exams was 16 in the online section and 18 in the onsite section. One student in the onsite section did not grant permission for her data to be used in the study, so the sample size was further adjusted to 16 and 17 students respectively. The total sample size of 33 was smaller than the initial 48 due to 5 students from each section dropping the course and other students not taking all exams at the scheduled times. Although the sample size was extremely small, exclusion of students who took make-up exams seemed necessary as those students took a different exam and had additional time to learn the material before testing. The number of students dropping the course and requiring make-up exams, however, was consistent with patterns from previous sections of beginning algebra.

The exam scores were analyzed using a repeated measures design. Testing occasion was the within-subjects factor with three levels and treatment; either online or onsite, was the between subjects factor. Pretest scores were not included in the repeated measures design due to failure to meet the sphericity assumption which is necessary for proper interpretation of the F ratios in repeated measures designs (Mauchley's $W = 0.421$, $p < .001$). An independent measures t-test, however, did not find a significant difference between the means for the two groups, $t(31) = 1.036$, $p = 0.308$. The cell means and standard deviations are presented in Table 1.

Without the pretest scores in the model, the sphericity assumption seemed reasonable (Mauchley's $W = 0.948$, $p = .443$). The main effect of treatment was not significant, $F(1, 31) = 0.168$, $p = 0.684$; however, due to the small sample size of the pilot study the power was only 6.8%. The main effect of testing occasion was significant, $F(2, 62) = 7.100$, $p = .002$, with 18.6% of the variability in test scores explained by testing occasion. However, the interaction between treatment and testing occasion was also significant, $F(2, 62) = 3.257$, $p = .045$, with a small effect size ($\eta^2 = .095$).

Table 1
Exam Means and Standard Deviations

Treatment	Pre-Test Mean (*SD*)	Exam 1 Mean (*SD*)	Exam 2 Mean (*SD*)	Exam 3 Mean (*SD*)
Online	11.56 (5.03)	84.94 (12.47)	72.00 (21.07)	65.06 (22.47)
Onsite	9.08 (4.27)	77.41 (12.24)	74.24 (20.14)	74.29 (19.90)

Analysis of within-subjects simple effects revealed a significant difference for the online students for testing occasion, $F(2, 30) = 6.0907$, $p < .010$, with a moderate effect size ($\eta^2 = .315$). A Tukey post-hoc analysis uncovered a significant difference between the first and last test, $Q(30) = 5.23$, $p < .010$, with a large effect size ($d = 1.31$). Although the differences between the other pairs of test scores were not significant, in light of the small sample size it may be of interest to note that the effect sizes for the two comparisons were $d = 0.77$ and $d = 0.54$. The within-subjects simple effects for the onsite students were not significant, $F(2, 32) = 0.741$, $p > .05$.

The most frequent reason given for selecting the online section was...that students were unaware that the section was online.

Attitude Toward Mathematics

At the conclusion of the study, 16 students in the online section, and 17 students from the onsite section had completed both the pre- and postattitude scales. Scales were formed by summing across the six items for each scale-measuring the constructs enjoyment, motivation, importance, and freedom from fear of mathematics–with higher scores indicating more positive attitudes toward mathematics. Means and standard deviations for the scales and total scores appear in Table 2.

Total attitude measures were also analyzed using a repeated measures design. Survey occasion was the within-subjects factor with two levels and treatment; either online or onsite was the between subjects factor. The sphericity assumption appeared reasonable (Mauchley's $W = 1.00$, $p = .001$). The main effect of treatment was not significant, $F(1, 31) = 1.791$, $p = 0.191$; the main effect of survey occasion was not significant, $F(1, 31) = 0.365$, $p = .550$; nor was the interaction significant, $F(1, 31) = 0.202$, $p = .656$. Although the attitude scores appeared to be unaffected by the treatment, the power for the tests ranged from only 7% to 25%.

Table 2
Attitude Toward Mathematics Scale Means and Standard Deviations

Scale	Treatment	Preattitude Mean (*SD*)	Postattitude Mean (*SD*)
Enjoy:	Online	20.63 (8.34)	21.50 (6.44)
	Onsite	23.12 (5.63)	23.65 (5.65)
Motivation:	Online	21.50 (8.21)	22.25 (6.68)
	Onsite	23.82 (5.70)	23.71 (6.56)
Importance:	Online	26.31 (7.99)	27.25 (4.84)
	Onsite	29.12 (3.92)	27.59 (5.09)
Free of Fear:	Online	17.50 (7.60)	18.94 (5.11)
	Onsite	20.06 (6.33)	21.76 (5.96)
Total:	Online	85.94 (29.39)	89.94 (20.28)
	Onsite	96.12 (15.32)	96.71 (17.65)

Online Prequestionnaire

The first item on the five-item prequestionnaire administered to students in the online section, "Why did you choose to enroll in an online section instead of a traditional lecture section," was open-ended, and the responses were analyzed inductively, in that the categories emerged from the data. The most frequent reason given for selecting the online section was the acknowledgment by the students that they were unaware that the section was online (41%). However, the section was marked in the schedule of classes as an online section, and letters were mailed to enrolled students one month prior to the first day of classes indicating that they had selected an online section. Possible explanations for the failed communication include incorrect student addresses and students registering after the information letters were mailed. Flexibility of time and/or location was the primary reason given by students for intentionally selecting the online section (30%), followed by the opportunity to learn on their own (29%), and to have a new learning experience (18%).

In response to the second item, "Have you taken an online class before," only 1 of the 15 students completing the questionnaire reported affirmatively. The final three items concerned computer comfort, access, and planned usage. Most of the students indicated

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that they were "very comfortable" using a computer (80%) and had Internet access in their home or at work (74%). The instructional option that students planned to use the most was the textbook (80%) followed by CD and online tutorials (20%). None of the students planned to use the tutorial videos.

Online Postquestionnaire

Students were asked to rate the "course in having met their learning needs." The majority of the respondents rated the online course as "good, very good, or excellent" (94%) and planned to take an online course in the future (84%). The last items on the questionnaire were open-ended, and the responses were analyzed inductively. Table 3 presents the items and categories along with frequencies and percentages.

Discussion

Achievement

Offering beginning algebra online appears to be a workable option for several students, and many students enjoyed the new experience. In interpreting the results, however, it should be emphasized that students were not randomly assigned to the online section, and the results are based on students who, for the most part, selected that particular format. The repeated measures analysis was particularly enlightening in this situation. Although the main effect for treatment was not significant, which might lead instructors to infer that the method of course delivery had no impact, the interaction between test occasion and treatment was significant. An interesting, though troubling, finding was the significant decline in performance by the online group while the performance by the onsite group remained relatively stable.

Students in the online section scored significantly lower on average on the last exam ($M = 65.06$, $sd = 22.47$) than on the first exam ($M = 81.94$, $sd = 12.47$), and scores on the second exam fell between the two ($M = 72.00$, $sd = 21.07$). Although the average for the second exam did not differ significantly from the other exams, the effect sizes for the differences were moderate. A larger sample was needed to ascertain whether the linear decline in performance existed.

For this sample, however, explanations for the significant decline between the first and last exams must be considered. The last exam was not comprehensive and, as a result, two plausible explanations for the descending scores exist. The difference could be the result of the specific topics covered on the last exam or the impact of less effective instructional techniques throughout the course. Beginning algebra students have often been known to struggle with factoring polynomials, which comprised the majority of the last exam. However, performance by the onsite students remained relatively stable on the last exam.

Therefore, it is possible that factoring polynomials might be better taught traditionally or that the instructional materials used for factoring in this study need revision. Because topics in algebra are often hierarchical, the decline between exams might instead be a trend in the overall inadequacy of the online instruction emerging. This study, however, with a duration of only one semester, cannot determine the existence or nonexistence of such a trend.

Furthermore, even if such a trend had been confirmed in this single study, it could certainly not be generalized without many comparable studies uncovering similar findings. This studied examined online instruction developed and delivered by a single instructor, and instruction developed by other professionals might have resulted differently. Additionally, most professionals probably are interested in ascertaining the effectiveness of online instruction for students who choose to enroll in that format; however, for this sample 41% of the participants did not intend to enroll in an online course.

Attitude Toward Mathematics

Virtually all studies exploring the effectiveness of online instruction have used achievement as the dependent variable. However, the method of instruction for a course would likely impact students in a variety of ways and, therefore, other measures should be explored. Attitude toward mathematics was one such measure included in this study. Although the methods of instruction possibly did have a differential impact on the students, none was detected by the questionnaire used in this pilot study.

Online Prequestionnaire

The study was conducted at a large urban university, and many students had work and family responsibilities in addition to their studies. Therefore, it was not surprising that many students selected the online section because of the freedom offered in both time and location for learning. Another common reason for online selection was a desire by students to have more control over their learning. The lecture section, although an approach often effective in mathematics, placed the instructor in control of learning. Online students, however, could more easily select from a variety of instructional formats and could select different options for different topics.

Online Postquestionnaire

It was disappointing that the instructional method most often utilized by the students, as indicated by responses to the postquestionnaire, was the textbook. Students were not required to watch the videos, use the tutorial CD, read instructor materials posted online, or interact with their peers. Students could earn additional points for responding to peer inquiries posted to the course bulletin board; however, only 7 students participated in the activity.

At the conclusion, student attitudes toward the online format were generally positive, and the majority expressed the possibility of enrolling in online courses in the future. One student reported overall dissatisfaction with the format; however, it should be mentioned that the student was not aware that the section was online when he enrolled; he did not complete any homework assignments, take any quizzes, or participate in any manner. Although students such as that enroll in all sections, instructors may have found it more difficult to motivate those students with-

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Table 3
Responses to Open-Ended Items

Item/Category	Frequency	Percent
Please list 2 or 3 things that you liked about taking the course online.		
Not attending class	7	21.21
Working at own pace	6	18.18
Working on own time	5	16.13
Working at home	4	12.12
Working with computers	4	12.12
Accessories offered online	4	12.12
Learning on own	3	9.09
Please list 2 or 3 things that you did not like about taking the course online.		
Getting behind	8	30.77
Missed having teacher "show me"	7	26.92
Discussion/class participation	5	19.23
Computer problems	4	15.38
Other	2	7.69

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out the regular personal interaction that transpires in the traditional classroom.

Positive features of the online format from student lists at the course's conclusion mirror their initial reasons for selecting the online section. The contradiction between "working at own pace" and "getting behind" as respective strengths and weaknesses of the format is interesting. However, college is a time when many students struggle to balance newfound freedom with meeting necessary obligations. Computer hardware and software have developed to the point that offering courses online has become easier and more reliable; however, the students can encounter problems of both types. Finally, students may miss participating in class discussions and interacting with their peers.

Suggestions for Developing an Online Course

Developing an online course, especially for the first time, requires a great deal of planning with important decisions to be made months in advance. Therefore, ideally, instructors should begin preparing approximately 1 year in advance. Two steps that must be completed in the early planning stages are textbook selection and securing an available technical advisor.

Textbook selection may be the most important decision in the entire process. Because online instruction is rapidly expanding, many publishers are offering supplements designed specifically to assist online students. The textbook selected for this pilot study, for example, included instructional videos so the students could watch someone explain the material to them, and an interactive CD allowed them to practice the material. Newer incentives offered by publishers include textbook Websites and tutoring services. Securing a technical advisor may be a tip that is overlooked by instructors who are comfortable with technology; however, technical innovations are occurring rapidly, and discussing new delivery options with an expert in the field can prove invaluable.

Other issues to consider when developing an online developmental course include student procrastination, lack of peer interactions, and absence of lecture. Although student procrastination is not unique to online students, it is of heightened concern due to the greater self-initiative online courses require. The significance of this problem is clear from our review of student responses to the postquestionnaire where one-third of the responses list "getting behind" as a limitation of taking the course online. Therefore, instructors should consider requiring regular interaction by the student. In this pilot study, weekly quizzes have been required for this reason, and although they may not entirely eliminate student procrastination, the quizzes force at least some regular interaction with the material. Some online courses require attendance at weekly online meetings. However, this requirement may negate one of the greatest benefits of offering a course online: the freedom to learn on your own time.

Students also list the lack of student interactions (19%) as a limitation of learning online. A suggestion for enhancing student interactions and further disallowing procrastination is assigning weekly group work. Instructors may structure such activities in a variety of ways, but a model that will be implemented in an upcoming online course involves the use of assigned groups. At the beginning of the semester, students will be assigned to groups, and each group will be assigned a bulletin board. All group work must be done on the bulletin board to allow the instructor to check for individual participation. Each week the instructor will assign a group leader who will be responsible for summarizing the group's work and emailing their solution to the instructor.

The contradiction between "working at own pace" and "getting behind" as respective strengths and weaknesses of the format is interesting.

To assist the 27% of students who "missed having the teacher show-me the steps," instructors can consider constructing supplements of their own or forcing students to try the textbook supplements. Instructors may not feel responsible for monitoring activities from all resources for the entire semester; however, it is important to consider initial activities to encourage students to reach beyond the textbook and, thereby, familiarize themselves with the instructional options available to them. In many instances, the auditory component of instruction is lacking in online courses. Although technical limitations still make auditory files difficult for all students to utilize online, instructors can consider options such as constructing an audio and/or video CD. Using this process, each student can obtain a CD at the beginning of the semester, and icons embedded in the online notes can be designed to activate the appropriate track on the CD to provide the student with a brief explanation by the instructor.

Conclusion

Online courses are quickly becoming commonplace at colleges and universities across the nation. Educators must proceed with caution, however, to ensure such adaptations are in the students' best interest and remember that such formats may not suit all students. Student evaluations of the online instruction from this study have been generally positive; still, this researcher advises moving forward with caution. A specific concern uncovered in this quasi-experimental pilot study is the significant decrease in performance by the online students across the three exams while the performance of the onsite students remained relatively stable. More research is needed in this area to determine if offering beginning algebra entirely online is a suitable option for all students. Specifically, are all students suited for online instruction, and do all mathematical topics lend themselves to the distance-learning format? If particular topics do prove more difficult for students to master without classroom interaction, would a combination of online and onsite instruction better serve the students?

Suggestions emerging from the study that instructors planning an online mathematics course might consider include: starting early, selecting a textbook with available supplements, locating an available technical advisor, requiring regular activities, requiring student interactions, forcing students to explore the available instructional options, and providing supplements to assist auditory learners.

Although this pilot study provided an initial look at delivering beginning algebra online, all findings should be interpreted as directions for further research rather than conclusions due to the numerous limitations of the study. Major limitations included the use of only two sections, the nonrandom assignment of students to treatment groups, the fact that 41% of students who enrolled in the online section did not intend to enroll in an online course, and the inexperience of the instructor in offering a course online. Therefore, more research is needed to determine the most effective way to adapt this new delivery method to better meet student needs.

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Appendix A

Sample Questions From Two Quizzes

1. Explain why the point (-3,3) is not the same as the point (3, -3).
2. Explain how to plot the point (-2, 5).
3. What does it mean to say an equation in two variables has infinitely many solutions?

1. Explain how you use substitution to solve a system of equations.
2. When solving a system of equations, what advantages and disadvantages are there with the graphing method? With the substitution method?
3. Explain how you check the results after solving a system using the substitution method.

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