*International Journal for the Scholarship of Technology Enhanced Learning* *Volume 1 Issue 2 2017*
*Pages 119-129*

# *The Effect of Project-Based Learning on Student Performance: An Action Research Study*

Josephine Davis, Professor Emeritus, Fort Valley State University
Samuel Cartwright, Associate Professor of Mathematics, Fort Valley State University
Bhavana Burell, Lecturer in Mathematics, Fort Valley State University

## Abstract

The rising cost of college textbooks has become a major factor affecting students' academic success. More research is needed to examine the impact of high textbook costs on minority achievement, especially in mathematics, a major gateway to the sciences. The authors conducted a quasi-experimental study at a public HBCU in Georgia to analyze the effects of an affordable textbook on minority students' achievement in college algebra. The end-of-course grades of 235 students taught by four mathematics professors across 11 sections of college algebra during the 2015 and 2016 spring semesters were compared. The 2015 group of participants in the study paid a $50 laboratory fee and $ 190 for their course textbook and related resources. The 2016 participants only paid the $50 laboratory fee, for a total course saving of $44,650. Both groups were scheduled to attend two days in class alternately with two days in the laboratory. The course syllabus, laboratory assignments, mid-term and final examinations were the same for within group participants. Analyses of the end-of-course grades for the 123 participants (93% African American) in the spring 2016 experimental group compared to the 112 African American participants in the spring 2015 control group showed no statistical differences. However, results of the attitudinal survey completed by the experimental group indicated respondents had an overwhelmingly positive attitude towards using the no-cost course resources. These respondents also indicated that the use of "free" course resources enhanced their class attendance and their interest in engaging the course content. Indicators of high mathematics achievement among minority students using no-cost, college algebra textbook and course resources are their high rates of: class attendance; completion of class assignments and meaningfully engaging the course content.

**Keywords**: Minority Mathematics Achievement, Open Source Mathematics, Affordable Mathematics, Minority in Mathematics, Minority Attitudes in Mathematics, College Algebra, Gate-keeping Mathematics Courses, Minority and Technology Use in Mathematics

## Introduction

Classroom innovations using low-to-no-cost textbooks and open-source materials are inspired and funded within the University System of Georgia (USG) by the Affordable Learning Center (ALC). The ALC represents a response of the USG to the concerns of legislators, parents and other stakeholders over the rising costs of a college education. Prominently situated within the high costs of a college education are the rising costs of college textbooks. Rather than purchase high-cost textbooks, college students, even to their own academic peril, often resort to sharing textbooks with friends, using rentals, downloading outdated digital texts or using mismatched open resource texts.

With increased access to "smart" classrooms, e-textbooks, e-book reader technologies, such as the Kindle and iPad, college and university faculty members now have the capacity to join the movement to reduce the high costs of a college education.

Fort Valley State University (FVSU), a member unit of the USG, is an 1890 historically black institution (HBCU), with a liberal arts and land-grant mission. The institution serves a diverse student body of African Americans, Hispanics, Asians and Caucasian students. First- generation, African Americans constitute the majority of FVSU students. With more than 88% of entering freshmen on financial aid, many students do not have available finances at the start of the semester to purchase required course textbooks and related learning resources.

During the Fall 2014 semester, and more so in the spring 2015 semester, the mathematics faculty began noticing a pattern of increased absences from the laboratory sessions consistent with the ending of the 14-day, free-trial period for accessing the course management system required for the laboratory component of the course. Students cited cost as the major reason for this trend. By the time some students finally accrued enough money to purchase the course management system for the laboratory sessions, it was too late in the semester for them to acquire the requisite background knowledge and skills required for course mastery. It became increasingly clear that students' achievement levels in college algebra and pre-calculus and their retention rates in STEM disciplines, more generally, were being compromised by other than intellectual capabilities.

Responding to the need for a more cost-effective course structure, the team of four mathematics faculty acquired funding from the ALC to implement a "no-cost" instructional design for students enrolled in college algebra and pre-calculus. The Affordable Learning mathematics faculty team, hereafter referenced as ALT, redesigned these courses in the interest of increasing students' class attendance, their laboratory participation rates and ultimately their passing rates in the course. The ALT negotiated reduced costs for course materials with their institutional representative at the Pearson Publishing Company. The FVSU administration subsequently approved the following redesigned course arrangements.

In the 2015 spring semester, students paid a $50 laboratory fee at registration and were required to purchase Algebra and Trigonometry by Rockswold (2014) with MYMATHLAB (MML), a course management system by Pearson, at a cost of $ 190 or more. For the 2016 spring semester, students only paid the $50 laboratory fee during registration; no additional course costs were incurred. This laboratory fee gave students full access to Blitzer's Algebra & Trigonometry 5e (Blitzer, R., 2014), the e-textbook used in the course, as well as to MATHXL(MXL), the Pearson course management system similar in format to Pearson's MYMATHLAB (MML). MXL and MML are adaptive, course-management systems that provide individualized tutorial assistance to students. The mathematics faculty used MML and MXL to assign quizzes, tests, videos, power- point presentations, and homework on topics and problems covered in the college algebra and pre-calculus courses. MML and MXL are accessible on a 24-hour basis using the iPad, cell phones, laptops or desktops. If difficulties are encountered, students are able to send problems to the instructor for feedback or extra assistance as needed. (https://goo.gl/NIvcxa).

Notwithstanding the 24-hour access and phenomenal tutorial support MML provided, the observed patterns of students' high absentee rates, course withdrawals and failing grades provided a mandate for

change. In summary, the ALT , with funding from the ALC conjectured that student pass rates would improve significantly with the elimination of the cost factor for college algebra and pre-calculus textbook and course resources.

This study was undertaken, then, to examine the relative effectiveness of college algebra, as a redesigned, "affordable" course, on students' achievement. This study is important because it expands the knowledge base on the effects of textbook costs on minority students' persistence and achievement in college algebra. Passing the gate-keeping pre-calculus or college algebra course is essential to students' persistence in scientific disciplines as well as their progress to graduation. College algebra or pre-calculus is a core curriculum requirement for graduation. Further, this study provides insights on minority students' willingness to engage and use information technology to learn college-level mathematics.

## Literature Review

Rapid technological advances have encouraged textbook publishers to enter the e-textbook market with encouraging prospects. Carol Twigg (2011), President of the National Center for Academic Transformation (NCAT), stated "…we can say with certainty that technology can be used to address both learning and cost problems simultaneously" (P. 26). The content of textbooks (Afolabi, 2013) and the impact of high textbook costs on student achievement is of research interest globally (Li, Y., 2000; Kajander, A and Lovric, M., 2009; Hsiao, Chun-Hua et al, 2015). Since 2006, textbook costs have increased over 73% (Senack et al, 2016). These researchers also found that nearly one-third of students use financial aid to pay for their textbooks and spend an average $300 per semester. According to the study by Senack (2014), high textbook costs are a deterrent to the number of classes in which students choose to enroll and their interest in passing the courses. Despite their concerns for higher grades, more students risk receiving a lower grade rather than pay for a high-cost textbook.

Over an 11-year period, thirty-seven institutions experimented with course-redesign processes wherein faculty utilized information technology to achieve better learning outcomes at reduced costs. Results showed increased success among minority students, low-income students, and working adults. Projects at the Universities of Alabama and Idaho, demonstrated higher, successful passing rates (grades of C or better) for less-prepared African American and Hispanic students, than their white freshmen peers (Twigg, 2011). Faculty at institutions that attained learning gains at reduced costs indicated a lack of motivation to return to the less successful, more expensive, classroom designs.

With regards to students, no direct relationship has been established between their course performance and their attitudes about using traditional textbooks and pedagogical aids (Landrum et al, 2012). The perceived ease of use of e-textbooks appears to have had the strongest effect on students' attitudes toward their use and subsequent achievement than perceived usefulness (Hsiao et al, 2015). However, other behaviors, such as attending class and having effective study skills are predictors of academic success at the university level (Stelnicki, A., Nordstokke, D., Saklofske, D., 2015). A student's personal belief system has been found to influence how academic decisions are made and responsibilities undertaken (Simpson et al, 2004).

The course-redesign movement is the nexus linking the university faculty's response to the rising cost of textbooks, the advent of digital textbooks, open-text resources and improving learning. According to Twigg (2015), course redesign is rethinking the way in which instruction is delivered. Transforming

the classroom to reduce attrition rates has taken on several forms. Learner–Centered models (Blackie, Case & Jawitz, 2010; King, 1993) focus on the active engagement of the learner in the knowledge acquisition process. The higher-order skills development model focuses on the acquisition of cognitive strengths that promote the successful transference of knowledge to novel situations (Arum & Roksa, 2010). Other universities are experimenting with Universal Design for Learning tenets to help all learners (Sturgis, 2016). The John Garner Gateways to Completion (G2C) project is a comprehensive course transformation project that mobilizes faculty to improve student learning and success in historically challenging gateway courses, courses with high rates of failure (Prystowsky, R., Koch, A., Baldwin, C. (2015). Among the best practices identified for success in this project are: minimizing students' time in developmental courses without compromising their success chances in higher level courses and providing timely feedback to students when they get off-track or reach certain benchmarks. The Action Research Paradigm Protocol (ARPP) is centered in a problem-solving modality. The ARPP requires problem identification, the generation of alternatives, an action plan, data collection and analysis, discussion of findings, evaluation of outcomes, followed by recommendations for next steps and the communication of results (Capella University, 2012).

## Method

The ALT taught participants during the two-day lecture/discussion sessions and monitored or assisted them with their MXL homework on two alternating days in the laboratory. Vision Software and personal observations were used to monitor the extent to which participants remained on task while completing MML or MXL exercises. All participants within group were assigned the same MML or MXL laboratory assignments. These assignments consisted of five tests, 20 quizzes and one homework exercise set of 10-15 problems on the 21 topics covered in the course.

The use of the no-cost, e-textbook with MXL, constituted the primary source of pedagogical change(note that as used experimentally with the participants, the terms, "no-cost," "free" and "affordable," are used interchangeably in this study). Participants self-enrolled in the five sections of college algebra during the 2015 semester and six sections during the 2016 spring semesters. All classes were taught in smart classrooms. The ALT developed and disseminated a common course syllabus and pacing guide. The common final examination was administered to all students in the same location at the same time. The MXL homework, quizzes and tests provided in the laboratory exercises were developed by the ALT faculty and commonly administered to all students, in their individual laboratory settings. Students also were free to access the MXL assignments on a 24-hour basis, outside the classroom.

The college algebra course resources also included online content in FVSU's D2L System using power-points, Khan Videos and faculty-produced videos on selected topics. The ALT met on a bi-weekly basis to verify adherence to the course pacing schedule to ensure that participants would be prepared for the commonly administered mid-term and final examinations. The MML and MXL instantly graded participants' assignments. These grades were computed as participants' end-of-course grades using the weighted formula of: 20% of the final examination score, 20% of the combined homework and quiz average and 60% of the test average. Participants' scores on the common sets of MML or MXL quizzes, tests and homework assignments were combined appropriately with three in-class test scores and a limited number of individually administered in-class quizzes and homework assignments by varying by instructor. Students' end-of-course grades in college algebra were compared across the 2015 and 2016 spring semesters so chosen because spring semester populations in college algebra

classes tend to have similar profiles. Approximately, 20% of enrolled students are generally course repeaters. The passing grades for college algebra are A-C grades. A "D" grade may be used as a passing grade in non-scientific disciplines. However, for the purpose of this study, the "D" grade is considered a failing grade in that a C or better grade is required for scientific disciplines. In like manner, the "W" or F" failing grades limit retention opportunities for science-related majors. Collectively, these failing course grades are referenced in this study as the "DWF" rates.

The spring 2016 participants also completed an end-of-course survey. The 100 participants who completed the survey consisted of 53 females and 47 males. Seventy-five respondents were between the ages of 18 and 24 years. There were 80 freshmen, 17 sophomores, one junior and two seniors of whom there were 6 Caucasians and 93 African Americans.

Two questions were posed for this study:

- What difference in A-B-C rates is possible for students using no-cost course resources versus the high-cost traditional textbook?
- What are students' attitudes and perceptions for learning college algebra using no-cost textbook resources?

## Results

The data used in this study consist of participants' end-of-course grades and the participants' responses to a 10-item survey of which 9 items were evaluated using a four-point Likert scale with one item requiring an open-ended response.

### *End-of-Course Grades*

Students' end-of-course grades were determined using a weighted average. The common final examination constituted 20% of the final grade, the average of in-class and MML or MXL tests was weighted at 60% and the combined MXL or MML homework and quiz averages were weighted at 20%.

The A-C Grades earned by students enrolled in college algebra during the Spring 2016 and 2015 Semesters are displayed in Table 1. There was a difference of six more students earning A-C grades in spring 2016 than in spring 2015. Four professors taught six sections of college algebra in the 2016 spring semester, while three professors taught five sections of college algebra during the 2015 spring semester.

Table 1 End-of-course A-C grades by semester

| *Semester* | *# of Sections* | *# of Students* | *# of Instructors* |
|---|---|---|---|
| Spring 2016 | 6 | 59 | 4 |
| Spring 2015 | 5 | 53 | 3 |

In spring 2016, five more students earned DWF grades than in spring 2015. The number of course sections and course instructors remained the same as shown in Table 2.

Table 2 End-of-course DWF grades by semester

| *Semester* | *# of Sections* | *# of Students* | *# of Instructors* |
|---|---|---|---|
| Spring 2016 | 6 | 64 | 4 |
| Spring 2015 | 5 | 59 | 3 |

Table 3 illustrates the test of proportions. The independent variable is the no-cost resources and the dependent variable for the spring 2016 analysis is the final grade in the course. For the Spring 2015 analysis, the independent variable is the use of high-cost, traditional course resources. The 95% confidence interval was utilized.

Table 3 Statistical analysis of A-C grades by semester

| *Semester* | *# of Sections* | *Mean* | *Std. Dev.* | *95% Conf. Std. Dev. Lower Bound* | *95% Conf. Std. Dev. Upper Bound* | *Variance* |
|---|---|---|---|---|---|---|
| 2016 | 6 | 9.83 | 4.88 | 3.04 | 11.95 | 23.77 |
| 2015 | 5 | 10.6 | 5.13 | 3.07 | 14.74 | 26.3 |

Null Hypothesis: The difference between the proportions of students who earned A-C passing grades in spring 2016 and those who earned A-C passing grades in spring 2015, is less than or equal to zero. Alternative Hypothesis: the difference between the proportions of students who earned A-C passing grades in spring 2016 and those who earned A-C passing grades in spring 2015 is greater than zero.

The one sided test, p value is .9211. At the 5% significance level, we fail to reject the null hypothesis. Therefore, there is not sufficient evidence to support the claim that the proportion of students who attained A-C passing grades in college algebra in spring, 2016 is significantly greater than the proportion of students who earned A-C passing grades in spring, 2015. The results show that approximately 47.32% of the students passed in 2015, while approximately 47.97% passed in 2016. The difference between the two proportions: (prop 1-prop2) = 0.4797 -0.4732 = 0.0065. The 95% confidence interval of the difference between the two proportions is (-0.121387, 0.134308). We are 95% confident that the true difference between the proportion of students who passed in spring 2015 and spring 2016 is between -0.039 and 0.197. Since this interval includes a zero, we cannot conclude that a difference exists between the proportion of students who passed in spring 2015 and those who passed in spring 2016. In like manner, the analysis of data shown in Table 4 indicates no statistical difference was found in the proportion of students earning DWF rates by semesters.

Table 4 Statistical analysis of DWF grades by semester

| *Semester* | *# of Sections* | *Mean* | *Std. Dev.* | *95% Conf. Std. Dev. Lower Bound* | *95% Conf. Std. Dev. Upper Bound* | *Variance* |
|---|---|---|---|---|---|---|
| 2016 | 6 | 10.67 | 4.32 | 2.70 | 10.60 | 18.67 |
| 2015 | 5 | 11.8 | 3.27 | 1.96 | 9.40 | 10.7 |

The histograms shown in Figures 1 and 2 illustrate the A-C grades earned by students during spring 2016 (Figure 1) and spring 2015 (Figure 2). Each displays a normal distribution. The number of students earning A-C grades is displayed on the x-axis and the frequency count per section is shown on the y-axis. There are no outliers shown in the boxplots. More A-C grades were earned in spring 2016 compared to 2015. However, the DWF rate was slightly higher.

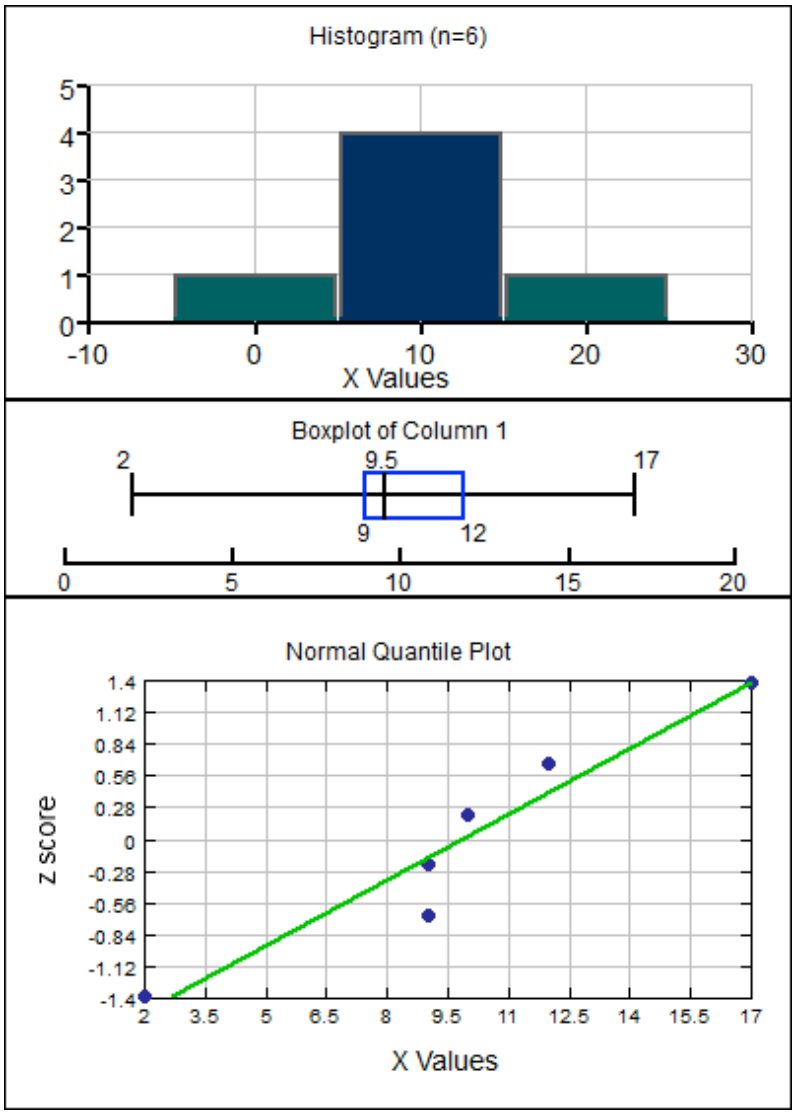


*Figure 1 Grades A-C for Spring 2016*

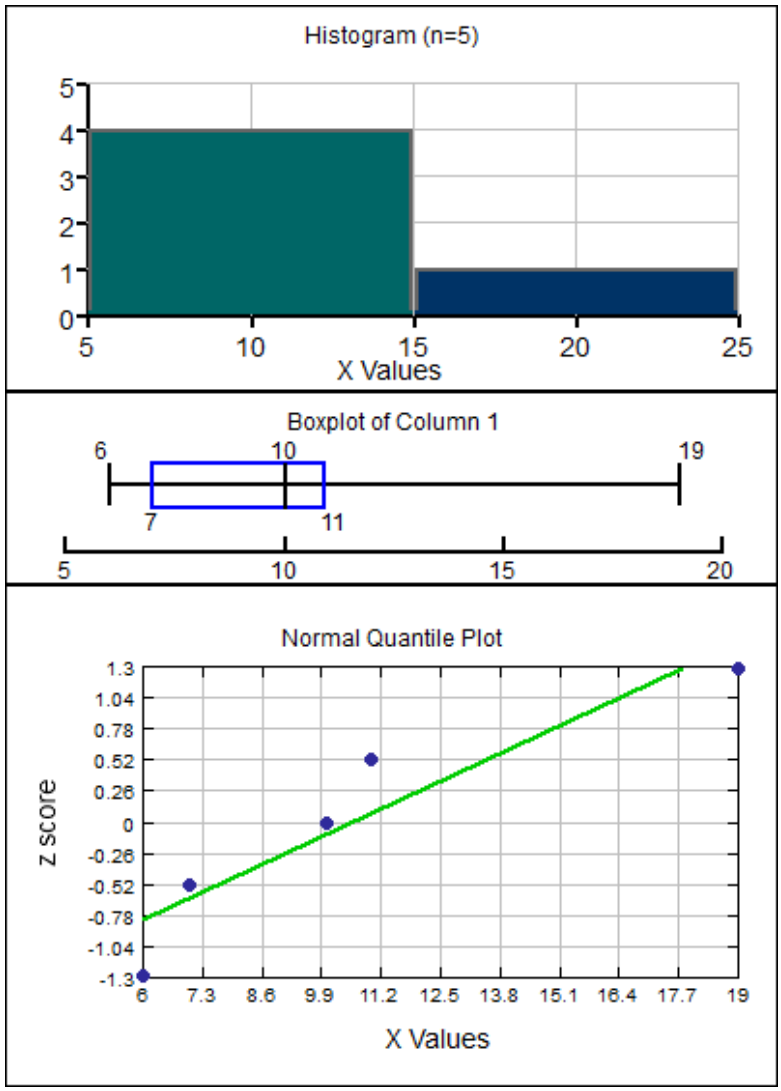


*Figure 2 Grades A-C for Spring 2015*

***Student Attitudinal Survey***

Students responded to a 10-item survey that assessed their attitudes towards using the no-cost course resources. Nine items required respondents to select a rating using a four-part Likert scale. One open-ended response item concluded the survey. A total of 123 students responded to the survey of which only 100 surveys were completed fully and capable of being used in this analysis. Overall, respondents indicated having very positive attitudes and highly favored the opportunity to have and use no-cost resources in college algebra versus the traditional high-cost course resources. The following are among the responses displayed in Table 5 as rated by the 100 participants:

- 90% of respondents indicated that the affordable or free resources motivated them to complete the work required in the laboratory.
- 90% of respondents were highly motivated by the free resources to attend the laboratory sessions.
- Only 2% of respondents indicated that they would have preferred to pay for their textbook for the course.

- 5% of respondents expressed preference for using a traditional textbook over the e-textbook. The rating for this item (#3) is a direct reflection of the rating respondents made indicating a 95% agreement with the statement that the e-book was easy to use (#6).
- All participants disagreed with the statement that using the e-textbook negatively affected their attitude towards the course.
- 93% of respondents stated that the free courses resources encouraged them to honor the class attendance policy. This policy permits 3 unexcused absences with a one-point deduction from the final grade for each absence over the allowed 3.

Some typical open-ended responses received to Item 10 were:

- "I think it's great that we don't have to pay for our college algebra book considering that we have other books to buy."
- "I wouldn't like carrying a book (hard copy) to class everyday; also, purchasing a book does not mean the student will learn more."
- " The free book gave us very easy access to materials instead of our having to wait for financial aid refunds to buy our textbook - then we are so far behind in the class."
- "I felt as if I could focus on my studies more without having to worry about money. This way, no one can use the excuse that they don't have a textbook or they have to wait until their refunds drop to buy a book."
- "I enjoy the free-cost, but prefer the ease of using a physical textbook."

Table 5 Survey of students' attitudes toward affordable learning

| *Statements* *N = 100* | *Strongly Agee (%)* | *Agree (%)* | *Disagree (%)* | *Strongly Disagree (%)* | *No Opinion (%)* |
|---|---|---|---|---|---|
| 1. With free access to MATHXL, I was motivated to complete the laboratory homework. | 15 | 75 | 5 | 3 | 2 |
| 2. I prefer to have paid for my college algebra textbook for this course. | 0 | 2 | 5 | 93 | 0 |
| 3. I prefer using the e-textbook for this course rather than a traditional hard-copy math textbook. | 1 | 94 | 3 | 2 | 0 |
| 4. Using an e-textbook negatively affected my attitude towards this course. | 0 | 0 | 88 | 12 | 0 |
| 5. Having free course materials motivated me to attend the labs for this course. | 18 | 80 | 2 | 0 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| 6. The e-textbook was easy to use. | 1 | 94 | 3 | 2 | 0 |
| 7. Since I did not have to purchase a textbook, I have a more positive attitude towards this course. | 89 | 10 | 1 | 0 | 0 |
| 8. The free textbook and lab resources encouraged me to honor the class attendance policy. | 6 | 87 | 3 | 0 | 4 |
| 9. Overall, I have a favorable attitude towards using technology to study college algebra. | 8 | 88 | 0 | 2 | 2 |
| 10. Free Response Item<br>What are your final thoughts about having free textbook and laboratory resources for this course? | | | | | |

### *Summary*

The findings of this study suggest that rather than cost, students' robust engagement with the course resources is a major factor affecting achievement. Robustness is reflected in students' attitude. Those who made significant efforts to complete the assigned homework and quizzes in the laboratory and maintained favorable attendance records were found to have attained A – C grades at a higher rate than students who were less engaged. While 99% of the participants in the experimental group indicated a positive attitude towards the course for not having to purchase a textbook, their 48% level of A to C passing rate appears to be inconsistent with the extremely positive attitudes expressed

## Conclusion

The findings of this study confirm findings in the literature that students do make academic decisions on the basis of cost, even to their own academic peril. That is, students will persist in classes without purchasing the required textbook resources or they will use rental books that are not necessarily aligned with the edition required for the course. This study does expand the literature revealing that the provision of no-cost textbook and course resources does not significantly enhance minority students' achievement in college algebra. To the contrary, surveyed students indicate being more engaged with the course content and having a very positive attitude towards college algebra when no-cost course resources are provided. Finally, the end-of-course grade is not necessarily an accurate measure of students' optimism about having affordable learning opportunities in college algebra. Overwhelmingly, students expressed appreciation for having this affordable learning opportunity.

## References

Afolabi, S. (2013). Textual material variables as correlate of students' achievement in mathematics. In *Proceedings of the 1st Annual International Disciplinary Conference* (pp. 24–26). Azures, Portugal: AHC.

Arum, R., & Roska, J. (2010). *Academically adrift: limited learning on college campuses.* Chicago, IL: University of Chicago Press.

Blackie, M., Case, J., & Jawitz, J. (2010). Student-centeredness: the link between transforming students and transforming ourselves. *Teaching in Higher Education, 15*, 637–646.

Blitzer, R. (2014). *Algebra and trigonometry*. Boston, MA, Pearson Publishing Company.

Capella University. (2012). *Action research paradigm protocol*. Retrieved from https://media.capella.edu/CourseMedia/ELMS8102/actionResearchModel/actionResearchwrapper.asp

Hsiao, C., Tang, K., & Lin, C. (2015). Exploring college students' intention to adopt e-textbooks: a modified technology acceptance model. *LIBRI, 65*(2), 119–128.

Kajander, A., & Louvric, M. (2009). Mathematics textbooks and their potential role in supporting misconceptions. *International Journal of Mathematics Education in Science and Technology, 40*(2), 173–181. http://dx.doi.org/10.1080/00207390701691558

King, A. (1993). From sage on the stage to guide on the side. *College Teaching, 41*, 30–35.

Landrum, E. R. (2012). Assessment of textbook usage and the relationship to student course performance. *College Teaching, 60*, 17–24.

Li, Y. (2000). A comparison of problems that follow selected content presentations in American and Chinese mathematics textbooks. *Journal for Research in Mathematics Education, 31*(2), 234–241.

MathXL by Pearson. Retrieved November 29, 2016, from http://www.pearsonmylabandmastering.com/northamerica/mathxl/

MyMathLab by Pearson. Retrieved November 29, 2016, from http://www.pearsonmylabandmastering.com/northamerica/mymathlab/

Prystowsky, R., Koch, A., & Baldwin, C. (2015). Operation 100%, or, completion by redesign. *Peer Review AAC&U*, 19–22.

Rockswold, G. K., Krieger, T. A., & Rockswold, J. C. (2014). *Algebra and trigonometry with modeling & visualization*. Boston: Pearson.

Senack, E. (2014). *Fixing the broken textbook market: how students respond to high textbook costs and demand alternatives.* Retrieved from http://www.uspirg.org/sites/pirg/files/reports/NATIONAL Fixing Broken Textbooks Report1.pdf

Senack, E., & Donoghue, R. (2016). *Covering the cost: why we can no longer afford to ignore high textbook prices*. Retrieved from http://uspirg.org/sites/pirg/files/reports/National - COVERING THE COST.pdf

Simpson, M. L., Stahl, N., & Francis, M. (2004). Reading and learning strategies: recommendations for the 21st century. *Journal of Developmental Education, 28*(2), 2–32.

Stelnicki, A., Nordstokke, D. Saklofske, D. (2015). Who is the successful university student? An analysis of personal resources. *Canadian Journal of Higher Education, 45*(2), 214–228.

Sturgis, I. (2016, March). Access for all. *The Chronicle of Higher Education: Diverse Issues in Higher Education*, 28–32.

Twigg, C. (2011, May/June). The math emporium: a silver bullet for higher education. *Change*, 25–34.

Wood, D. F. (2003). Problem based learning. *British Medical Journal*, *236(7384)*, 328-330.