College Algebra Redesigned: Opening Doors to Success

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Introduction
College algebra is often a requirement for students pursuing diplomas in science, technology, engineering, and mathematics (STEM) related fields. Algebra may be perceived as a challenge because it involves abstract reasoning, communication with abstract symbols, and the embodiment of mathematical structure (Carraher & Schliemann, 2007; Vogel, 2008). To increase the number of students who are successful in algebra courses, instructional interventions need to be employed. Haas (2005) identified six instructional interventions that can be used to improve students’ performance in algebra, namely: cooperative learning, direct instruction, technology, communication and study skills, multiple representations, and problem-based learning. Rakes, Valentine, McGatha, and Ronau’s (2010), meta-analysis of algebraic instructional improvement strategies, found that the use of technology curriculum and technological tools had a positive effect on the improvement of students’ achievement. Additionally, advancement in online mathematical web-based tools has increased opportunities for self-regulated learning in mathematics courses (Abdulwahed, Jaworski, & Crawford, 2012). Thus, students’ success in algebra is attainable when purposeful interventions are employed.

This article describes a redesigned structure for the delivery of college algebra and discusses research findings of students’ performance achievement for an experimental and a traditional group. We will conclude by considering the implications of the redesigned course structure on students’ success in college algebra and other mathematics courses.

College Algebra: Redesign Initiative
The annual enrollment for college algebra at the University of South Florida (USF) is approximately 2,000. From 2007 to 2010, the average failure rate for this course was 35%. An initiative to improve students’ success began in spring 2011 with the implementation of a redesigned mode of course instruction. The notable change was the requirement of attending the Science Mathematics and Research Technology Lab (SMART Lab)—a university-sponsored initiative.

SMART Lab Design
Students enrolled in college algebra were required to attend the SMART Lab for at least 3 hours each week (outside of class time) to complete assignments and practice mathematical concepts via MyLabsPlus online learning-management system. The learning-management system provided students with practice exercises, interactive tutorials, videos, animated presentations, and an e-book as well as immediate feedback on the correctness of their work. The learning-management system also provided resources to help students learn materials while engaging in mathematical tasks (Abdulwahed et al., 2012; Pearson Education, 2013).

During the operational hours of the SMART Lab, tutors, teaching assistants, and instructors were available to answer students’ questions. Students could request immediate assistance by clicking on a desktop icon that alerted instructional staff of the request through a computer display. The student-to-tutor ratio was 25 to 1.

Efforts were made to limit distractions in the SMART Lab to encourage students to focus on mathematical ideas, practice core concepts, and utilize their time more productively. In addition to non-mathematical and social media being blocked, only students enrolled in SMART Lab classes could log into computers during the SMART Lab hours of operation.

Though tutoring and using the online resources were the primary functions of the SMART Lab, exams were held there as well. In 2011, three weeks in an academic semester were designated as test weeks; during this time students were not required to attend lab except to take their test.

Redesigned Course Model
Traditionally at USF (prior to spring 2011), college algebra was offered with two large lecture classes per week taught by a faculty member and two smaller breakout sessions for questions and answers facilitated by a graduate teaching assistant.
This instructional methodology seldom provided opportunities for students to engage in active learning; hence, the mathematics department sought to redesign the course. During the 2011 spring semester, the redesigned course was piloted in one class, while the remaining classes were traditionally taught. Whereas in the 2011 fall semester, the redesigned structure was piloted in two classes, while the remaining classes continued with the traditional method of instruction. Students were not preselected for the redesigned course; rather their placement was solely due to their course selection in the registration process. The redesigned course had one 75-minute class period and two 75-minute lab periods. Since the redesigned course required less classroom contact and more emphasis on utilizing the resources in the SMART Lab, it was necessary for students to take an active part in the learning process. In short, this put more responsibility for learning on students.

The redesigned course did not change the academic objectives addressed in the college algebra syllabus. In fact, both the traditional and redesigned classes used the same textbook (Ratti & McWaters, 2011). Instead, the redesign changed the manner in which the course was delivered. The model used in the redesigned college algebra was based on the emporium model, which advocates for the use of technology to leverage the learning environment (National Center for Academic Transformation [NCAT], 2011). This model provides a means for students to actively engage in the learning process. Hence, the redesigned course sought to facilitate principles of good practice in undergraduate education, encourage mastery learning, and promote self-regulated learning (Chickering & Ehrmann, 1996; Guskey, 2010; Zimmerman & Schunk, 2008).

According to Rotman (2011), in the emporium model, the faculty serves as a facilitator and students complete assignments for various modules within a learning-management system. This model can potentially affect the mathematical processes and practices students learn, considering that the software credits the correct answer and not necessarily the work students generate to arrive at the answer. Hence, NCAT (2009) cautioned that in redesigning courses, the redesign should attend to the needs of the students rather than the technology. Therefore, in our redesign we adapted the emporium model and required students to attend classes once a week in an effort to attend to students' academic needs and promote Standards for Intellectual Development and Standards for Pedagogy (Etheridge, Monroe-Ellis, & Tankersley, 2014).

In the redesigned college algebra class meetings, the instructor provided examples and an overview of mathematical content that was covered for the week. Students were also provided opportunities to respond to questions via clickers, which increased opportunities for mathematical discourse. It is important to note the use of clickers during classroom meetings promoted higher student attendance and encouraged collaborative participation.

The nature of class assignments and tests varied between traditional and the redesigned classes, however, both groups took the same final exam that accounted for 25% of the course grade. Grading policies for the traditional classes varied among instructors, but the redesigned classes had the same grading policy: tests, 50%; final exam, 25%; quizzes, 10%; homework, 8%; lab attendance, 4%; and class clicker grades, 3%. In the traditional college algebra classes, the instructors created their own assignments (which were primarily paper-and-pencil format), and tests (which were mostly multiple-choice). Whereas, in the redesigned classes, there was uniformity in homework assignments, quizzes, and tests, which were completed using the MyLabsPlus online learning-management system. The homework and quizzes were free-response assessment items. During the three testing weeks in 2011, students in the redesigned course were afforded two opportunities to take each of the three tests for the course. The first test was in a multiple-choice format and the second option was in a free-response format. Generally, students elected to write the free response tests only if they were not satisfied with their initial grade on the multiple-choice tests. In the event the students took both tests, the higher score was used for grading purposes. For the most part, students performed better on multiple-choice than on free-response tests. Additionally, the responses garnered by clickers and students attendance in the SMART Lab was calculated as a small percentage of the course grade in an effort to motivate students to participate in class discussions and to encourage students to utilize the resources available in the SMART Lab.

To promote mastery learning, students were allowed four attempts for homework assignments and three attempts for related quizzes. Students could not access the related quiz if they did not score a minimum of 70% on the homework associated with it. However, it was not required for students to obtain a passing grade of 70% or higher to attempt the next module. This structure gave students the freedom to advance without penalty. Nevertheless, because assignments were deadline sensitive, students generally progressed through the assignments linearly.

**College Algebra Attributes**

The redesigned college algebra format was structured to reflect the seven principles for good practice in undergraduate education; it increased faculty contact time with students, fostered cooperation, encouraged active learning, provided prompt feedback, emphasized time on task, communicated high expectations, and respected diverse talents and ways of learning (Chickering & Ehrmann, 1996). Active learning was
evident when students collaborated on selecting appropriate responses for clicker questions, utilized interactive web-based tutorial tools, and engaged in discourse with instructional staff. With online assignments that provided immediate feedback, students obtained help sooner. The fast feedback time also reduced the number of students who mastered concepts incorrectly as well as built students’ self-confidence (Wiliam, 2007).

When compared to students in traditionally taught classes, students in classes incorporating mastery learning strategies obtain higher levels of performance, and develop more confidence in their ability to learn (Guskey, 2010). The technological features of the lab and multiple attempts to complete assignments, gave students an opportunity to engage in mastery learning.

The redesigned college algebra provided students the opportunity to manage and regulate their learning. According to Zimmerman (1986), students are self-regulated to the extent that they are actively involved metacognitively, motivationally, and behaviorally in their own learning process. The assignment deadlines were stated in the syllabus, which students were required to peruse at the beginning of the semester. Considering that students had deadlines to complete assignments, they had to plan their time accordingly. Students had to consider which tasks they needed to place greater attention on, and the extent to which they engaged in the conceptualization of mathematical ideas in order to complete all assignments by the stipulated deadlines.

**Methods**

We employed a mixed method research design to examine the influence the redesigned course had on students’ learning. For the quantitative component, we compared the departmental-wide common final exam performance and the course failure rate of students in the experimental group (students who were enrolled in the redesigned course), to the controlled group (students taught via traditional methods) during the 2011 spring and fall semesters. Considering that the final exam was 25% of the course grade for both groups, students still had the potential to pass the course even if they were not successful on the final exam. Nevertheless, the final exam grade provided an opportunity to compare students’ academic attainment on a common assessment measure. We also compared failure rate between the experimental group and controlled group. It is important to note that at the University of South Florida, the failure rates reported by administration encompasses grades D and F, as well as the number of students that withdraw from the course (W).

The qualitative data were collected using interviews and course evaluation comments. A tutor in the SMART Lab assisted with interviewing students in spring 2011 about their perspectives (Maher, 2012). Although all students in the redesigned course were invited to participate in the interview, only a few students volunteered. Hence, 21 students enrolled in the redesigned course were interviewed about their perspectives of the learning environment and resources made available to them, and the influence they may have had on their learning of college algebra. Additionally, we asked students to reflect on their overall perspectives of the course and their SMART Lab experience. Admittedly, the small sample for the qualitative component, limits the extent the findings can be generalizable. Nevertheless, the data provides insight into students’ perspectives and can be used to improve the learning experiences of students within college algebra.

Data from the quantitative component were analyzed using descriptive statistics (percentages of frequency). Data from the qualitative component were analyzed using a thematic analysis (Creswell, 2012) and emergent themes were identified.

**Results**

In general, students enrolled in the redesigned college algebra performed notably better than their counterparts, and demonstrated a positive disposition towards the SMART Lab. Quantitative data suggests that the failure rate of students enrolled in the redesigned college algebra was lower than students enrolled in traditional classes. Furthermore, students enrolled in the redesigned course performed better on the departmental-wide common final exam when compared to their traditional counterparts. As evidenced by Tables 1 and 2, students in the redesigned college algebra classes were more likely to be successful in the course. Considering that a passing grade is 70% or higher, it is inferred that students who passed the final exam would have exhibited basic competency on the identified course objectives.

The qualitative results suggested that students generally welcomed the redesigned algebra course. Interview data revealed that students exhibited a positive disposition towards the revised structure of the course and their attitude towards mathematics improved. An emergent theme indicated that, although students were initially opposed the required lab hours, they recognized that the time spent in the SMART Lab reduced their procrastination. Also, students reported that attending the SMART Lab assisted in mastering course materials. For example, one student stated, “I know if I didn’t have the labs I’d wait until the last minute and just take the quiz or take the homework real quick and then not actually learn it.”
<table>
<thead>
<tr>
<th>Course</th>
<th>Spring 2011 Failure rate</th>
<th>Students with grades of D, F, W</th>
<th>Number of students enrolled</th>
<th>Fall 2011 Failure rate</th>
<th>Students with grades of D, F, W</th>
<th>Number of students enrolled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>30.3%</td>
<td>162</td>
<td>534</td>
<td>23.1%</td>
<td>184</td>
<td>798</td>
</tr>
<tr>
<td>Redesigned</td>
<td>21.4%</td>
<td>40</td>
<td>187</td>
<td>14.6%</td>
<td>48</td>
<td>329</td>
</tr>
</tbody>
</table>

Table 1. Course Failure Rate for Redesigned and Traditional Students, 2011

<table>
<thead>
<tr>
<th>Course</th>
<th>Spring 2011 Failure rate</th>
<th>Failed exam count (grades of D, F)</th>
<th>Exam count</th>
<th>Fall 2011 Failure rate</th>
<th>Failed exam count (grades of D, F)</th>
<th>Exam Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>44.0%</td>
<td>197</td>
<td>448</td>
<td>42.5%</td>
<td>305</td>
<td>717</td>
</tr>
<tr>
<td>Redesigned</td>
<td>31.1%</td>
<td>51</td>
<td>164</td>
<td>31.7%</td>
<td>95</td>
<td>300</td>
</tr>
</tbody>
</table>

Table 2. Common Final Exam Failure Rate for Redesigned and Traditional Students, 2011

Additionally, it was deduced that students welcomed opportunities to attempt assignments multiple times to increase their overall score. For example, a student responded, “I thought there was plenty of opportunities to improve your grade and you can get a better grade if you put in the time. … Overall it was better than I expected.”

Even though students were generally receptive to the structure of the redesigned course, several students noted areas that could be refined. It was suggested that the amount of class time for lectures should increase. For example, a student noted, “Good trial run! Awesome lecture modules, maybe one lecture is not enough. Other math classes should definitely emulate!” Another suggestion was to provide opportunities to opt out of the lab requirement. For instance a student wrote, “… The only thing I would change would be making lab attendance mandatory as I never needed help from the TA and work better from home.” Thus, there were a few students that might not have been receptive to the reduced class time or the required lab hours.

**Implications**

The implementation of the redesigned course positively influenced students’ performance and has implications on modes of instructional delivery. The change in the structure of the course provided more opportunities for students to spend time doing mathematics in the SMART Lab setting, which might have positively affected students’ performance. Since time is needed for mastery, efforts are needed to increase the amount of time students devote to learning core algebraic ideas and reasoning abstractly. Having students engage in algebraic activities in a controlled and supportive environment may have increased the likelihood that students completed assignments accurately and before the due date. Based upon the success of students in the redesigned college algebra classes, the inclusion of a learning resource center (such as the SMART Lab) should be considered for other mathematics courses.

Due to the fact that we did not track the students beyond the course, we cannot provide insight into their success in future mathematics courses. Hence, future studies should examine the effect of a redesigned model on students’ performance for other mathematics courses, as well as track students’ performance as they transition from college algebra (taught via an adapted emporium model) through other courses.

Additionally, the redesigned course has implication on the role of the teacher when technology is integrated in the classroom setting. The results suggest that using mainly lecture-style practices may not necessarily be the most effective means of delivering instruction for college algebra, thus our university adopted the redesigned course structure for all college algebra classes in fall 2012. In the redesigned course, the role of the teacher shifted from a lecturer to mostly being a facilitator and coach. The shift in teacher role provided students with increased autonomy in learning mathematics. Having students work independently and seek help as needed, changed the nature of the questions posed and allowed students to take ownership of what was learned.

We are mindful that change comes with resistance. Students’ receptiveness to a reform initiative cannot be
ignored when considering the sustainability of the initiative. Although students initially did not like being required to attend the SMART Lab, over time they noted it was beneficial to their success in the course. Therefore, students’ positive disposition towards the redesigned course at the end of the semester suggests this initiative ought to be encouraged.

**Conclusion**

Utilizing the adapted emporium model for college algebra increased opportunities for students to take more ownership of their learning and regulate their time more efficiently. Furthermore, results on students’ performance suggest that students taught via the redesigned course performed better than their counterparts. Hence, the redesigned course can be viewed as a vehicle to improve students’ performance in college algebra.

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