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Exploring Open Educational Resources for College Algebra

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Abstract

It is estimated that the average student spends around 1200 USD on books and supplies every school year; thus, textbook affordability has become more and more of a challenge for students. Replacing traditionally expensive learning resources with open educational resources (OER) can have a great impact in the reduction of cost for post-secondary education and student learning. With these benefits as a backdrop, this article describes a case study in which one college instructor adopted OER for College Algebra, offered as a hybrid learning model. This paper discusses this experience with adopting such materials and their impact on student success.

Keywords: open education resources, college algebra, math, hybrid course

Introduction

Wiley, Green, & Soares (2012) state, “Education is a matter of sharing and the open educational resources approach is designed specifically to enable extremely efficient and affordable sharing.” (p. 2). The term “OER” was first coined at UNESCO’s 2002 Forum on Open Courseware, and it includes:

teaching, learning and research materials in any medium, digital or otherwise, that reside in the public or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions. Open licensing is built within the existing framework of intellectual property rights as defined by relevant international conventions and respects the authorship of the work. (2012 Paris OER Declaration, 2012, para. 2)

The William and Flora Hewlett Foundation has defined OER as:

Teaching, learning, and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use and re-purposing by others. Open educational resources include full courses, course materials, modules, textbooks, streaming videos,

tests, software, and any other tools, materials, or techniques used to support access to knowledge. (Atkins, Brown, & Hammond, 2007, p. 4)

The main principle behind OER is simple: educational materials should be free and legally available for anyone to reuse, revise, remix, and redistribute. A large number of these materials have already been created; they have the potential to substitute the traditional textbooks and offer a more affordable option for students. According to NBC's review of Bureau of Labor Statistics (BLS) data by Popken (2015), textbook prices have risen over three times the rate of inflation from January 1977 to June 2015, a 1,041% increase. The College Board estimated that at a four-year public college a student spends on average annually \$1200 on textbooks and supplies (College Board, 2015). Wiley & Green (2012) state that students spend an average of \$900 per year on textbooks. For community college students, this amount can approach the total cost of tuition. OER can provide great savings without compromising the quality of education (Hilton & Wiley, 2011).

Allen & Seaman (2016), in their 2015 study on OER in U.S. Higher Education, surveyed over 3,000 faculty members. They reported that awareness of OER among faculty has increased from 20% in 2014-2015 to 25% in 2015-2016. The results of the same survey further indicate that the most cited barrier for faculty to adopt OER is the effort required to find and evaluate these educational resources:

I'd love to be given a redirection towards good catalogs of open-education resources, along with some sort of feedback from users who have successfully (or unsuccessfully!) incorporated them into their courses. (Full-time Natural and Physical Sciences Faculty) (Allen & Seaman, 2016, p. 31);

My biggest hindrance to switching to more open books and OERs is simply the amount of time it takes to find all of these resources on my own. I've gotten to know more common sites to help in these searches, but I've not taken the time to really decide to make the big switch from what I have now (mostly publisher and self-created materials) to the available OERs. (Full-time Social Sciences Faculty) (Allen & Seaman, 2016, p. 31)

The same study notes that compared to the previous report, "there has been a decrease in faculty concerns about permission to use or change OER materials, and an increase in concerns about the quality of OER and that it is timely and up-to-date. There has also been an increase in faculty reporting that OER not being used by other faculty represents a barrier." (Allen & Seaman, 2016, p. 33)

We are looking into adopting OpenStax Precalculus to decrease cost to students. However, we are concerned with the content and its rigor. The book lacks depth in a number of topics. Also, there are some faculty who would like a textbook that has online homework for students. (Full-time Mathematics Faculty) (Allen & Seaman, 2016, p. 34)

A resource that lists available course materials along with cost, list of supplementary materials, and reviews by other faculty members. It would be nice to have an independent website that offered this for materials from multiple publishers/sources. (Full-time Mathematics Faculty) (Allen & Seaman, 2016, p. 39)

This national study indicates that the OER adoption by faculty might increase if there are more empirical research studies on its quality and efficacy. While some research has been done on OER efficacy, it is still preliminary. Particularly within the field of post-secondary mathematics education, very little research has been done. I next review the OER math studies that have been completed.

Hilton III, Gaudet, Clark, Robinson, and Wiley (2013) analyzed the adoption of a collection of open resources across five different mathematics classes by the Scottsdale Community College (SCC) in Arizona, USA. Mathematics faculty adopted open resources in their courses out of concern for their students who use grants, tuitions waivers, and loans to pay for their education. In Fall 2012, 2043 students across five different courses used OER. The withdrawal rates and the grade rates of these courses were compared to the results of two previous years. With the exception of one course, Math 09x, there were no changes in the rates of completion. The negative results obtained for Math 09x might be attributed to different factors other than the adoption of OER. Overall, students who used the OER adopted for these courses saved money and did not have statistically significant changes in their educational outcomes.

In their study, Pawlyshyn, Braddlee, Casper, and Miller (2013) reported on the adoption of OER in a basic math course at Mercy College in New York. In Fall 2012, 695 students used OER in a basic math course. Comparing the results of these students with those who did not utilize OER in Fall 2011, they found an increase in the grade rates from 63.6% in Fall 2011 to 68.9% in Fall 2012.

In one of the largest studies of the impact of OER (Fisher, Hilton, Robinson, & Wiley, 2015) involving nearly 5,000 students using OER and over 11,000 students using commercial textbooks in 10 institutions throughout the U.S. and enrolled in 15 different courses (eight were math courses). Fisher, Hilton, Robinson, and Wiley, chose three important metrics to determine the influence of OER: course completion, final grade of C- or higher, and course grade. They reported that students who utilized OER generally performed the same or better compared to the other who did not use OER.

These three publications suggest that same or better educational outcomes result from adopting OER, in addition to significant savings for students. Hilton III (2016) analyzed 16 research studies involving OER (across a variety of subjects) and noted, “students and faculty members generally find that OER are comparable in quality to traditional learning resources, and that the use of OER does not appear to negatively influence student learning.” (Hilton, 2016, p. 588)

As mentioned above, faculty who are aware of OER are concerned about the quality of OER and feedback regarding the use of these resources. The purpose of this study is to share a case study based on my experience of adopting open educational resources in a hybrid math course, College Algebra, at Georgia College during Spring 2015. After presenting the context of the study I will discuss the results.

Context of the Study

Georgia College (GC), a college town located in Milledgeville, GA, about 100 miles southeast of Atlanta, is Georgia’s designated public liberal arts university. It has approximately 5,900 undergraduate students and

300 graduate students in 37 undergraduate programs and 25 graduate programs. The Department of Mathematics offers a Bachelor of Science in mathematics with an optional teaching concentration. It has about 80 major students instructed by 18 full time faculty. Mathematics, as a cornerstone of a liberal arts education, is required at GC for every student. As part of their core courses, Georgia College's students must complete three hours in the Area A2 Quantitative Skills. The courses that satisfy this requirement are: Quantitative Skills and Reasoning, Introduction to Mathematical Modeling, College Algebra, College Trigonometry, Precalculus, and Calculus I.

College Algebra was introduced in Fall 2011 with the goal to enhance the algebraic knowledge of our students necessary for upper-level math courses and courses in other disciplines. It is one of the courses that "bridge the gap between the ideas emphasized in the high school and in college by treating topics of secondary algebra in the college course more in the light of higher mathematics, and with greater stress on logical considerations" (Rietz, 1910, p. 52). It has been offered using a hybrid learning model, the emporium model, a model of instruction that is based on the principle "Students learn math by doing math not by listening to someone talk about doing math" ("The National Center for Academic Transformation", 2013, p. 3). Many institutions adopted multiple variations of this model. At Georgia College, the characteristics of the Emporium Model are the following:

- Students are required to attend one meeting per week at a fixed time with their instructor;
- Students are required to spend a minimum of three flexible hours in the Emporium Lab, where they work on their assignments having on-demand personalized assistance from instructors and undergraduate learning assistants; and
- All the course materials (syllabus, daily schedule, videos, tutorials, and e-textbook) and assignments (homework, quizzes and tests) are provided through online software.

The course is taught by two instructors (the same instructors who designed the course) every Fall and Spring. Each instructor teaches four sections of this course for a total of about 160 students per semester. The only course material required for students is an access code for the online software MyMathLab. The code provides access to all course materials, including the e-textbook version of the College Algebra & Trigonometry, 5th Edition by Lial, L. M., Hornsby J., Schneider I. D., and Daniels, C. (2012). The online software is a very important course requirement, since the students use it to complete their homework, quizzes, tests, and final exam. Students enrolled in this class must pay \$114 for the access code to this online software.

In Fall 2014 with the support of an Affordable Learning Georgia Textbook Transformation Grant from University System of Georgia (USG) and with collaboration with one of GC's librarians, I decided to explore the adoption of OER for College Algebra for Spring 2015. Affordable Learning Georgia is a USG's initiative to support reducing the cost of textbooks and the enhancement of GALILEO, Georgia's Virtual Library. The Textbook Transformation Grants are intended to lower the cost of course materials for students by supporting institutions to pilot different textbook approaches, including adoption, adaptation, and creation of OER.

In addition to saving students money, another key reason for piloting open education resources was to personalize my course, namely to rearrange the topics of the course to fit with my teaching style. I was unsatisfied with how some of the topics were treated in the commercial textbooks, especially the textbook we were using prior to Spring 2015.

After extensive research, I decided to replace the old textbook with the free open source e-book, *College Algebra*, 3rd edition by Stitz C. and Zeager, J. (2013). The advantage of this e-textbook is that it can be packaged with access to the online instructional software, WebAssign, which provides access to online assignments generated from the exercises of this book. Because *College Algebra* is offered as a hybrid course, the option of having the textbook bundled with online instructional software is a must. This requirement made the adoption of a low-cost textbook for this class a challenge, since there were few reliable low-cost online math software available. Compared with MyMathLab, WebAssign has a limited amount of supplemental course materials. To compensate for the lack of resources, in collaboration with my librarian colleague, I decided to create a LibGuide (Library-Specific Springshare Product) with supplemental materials on GC library's website. I arranged the topics of the course in five modules, very similar to the chapters in a book (<http://libguides.gcsu.edu/math1111>). In each section, every module contains learning objectives, links to the sections of the e-book that align with the particular content, and a collection of links to videos and tutorials. I did not create the videos or tutorials due to time constraints, but I asked for permission to use tutorials or videos I found online and were copyrighted. The LibGuide gave me the opportunity to arrange the topics of the course in the order that I prefer and to include the examples and tutorials that I think help the student the most.

Due to technical problems, which will be described in the discussion section, in Fall 2015 I returned to the traditional resources that I used before Spring 2015.

Results

My main research questions for this study were:

- How much money did the students save because of my adoption of open and affordable course materials?
- Did students achieve different levels of academic success as a result of the new curriculum?

In Spring 2015, my four sections of *College Algebra*, 159 students in total, used the low-cost course materials. The free open textbook packaged with the online software WebAssign was priced at \$27.95. Compared to \$114 required the previous semester, this price was a 75% (\$86.05) savings for every student and a total of \$13,681.95 savings for all students registered.

The Spring 2015 students had the same number of proctored tests (including the final exam) taken online as in the previous semesters and in the next semester. The test questions were not the same (although they were of equivalent difficulty) as in the previous semesters or the following semester, since I used a different,

although very similar, online software package. To determine the academic impact of the new textbook, I analyzed the grade distribution during Spring 2015 compared to previous two semesters: Spring 2014 and Fall 2014, and the following semester Fall 2015. These results are shown in Table 1. The percentage of students who earned C or better was slightly higher in Spring 2015 than in Spring 2014, Fall 2014 or Fall 2015. A z-test of proportions shows that this change is significant at $p < 0.05$ when comparing Spring 2015 (OER) versus Spring 2014 and Fall 2015 (traditional textbook). There was no significant difference between Spring 2015 (OER) and Fall 2014 (traditional textbook).

Table 1

Percentage of Students Who Earned C or Better

College Algebra	Spring 2014	Fall 2014	Spring 2015	Fall 2015
Percentage of students who earned C or better	78.2%	80.9%	84.3%	77.2%

Examining Table 2 we observe that 37.1% of the students received A in Spring 2015, a statistically significant change at $p < 0.05$ compared with Spring 2014, Fall 2014 and Fall 2015. This seems to suggest that students performed better when they used OER. The same table indicates that only 5% of the students withdrew from the course in Spring 2015 compared with 9.9% in Spring 2014, 8.8% in Fall 2014 and 10% in Fall 2015. The z-test of proportions shows that this change is significant at $p < 0.05$, indicating that students were statistically *less* likely to withdraw from the course when the lower cost materials were utilized.

Table 2

Grade Distribution

	A	B	C	D	F	W
Spring 2014 (151 students)	29.8%	35.8%	12.6%	5.3%	6.6%	9.9%
Fall 2014 (147 students)	27.9%	34%	19.1%	6.8%	3.4%	8.8%
Spring 2015 (159 students)	37.1%	34%	13.2%	5.7%	5%	5%
Fall 2015 (149 students)	29.5%	32.9%	14.8%	4.7%	8.1%	10%

At the end of the semester, I also surveyed the students to learn a bit about their perception for the free e-textbook, the WebAssign software, and the LibGuide. There were 159 students surveyed and 125 of them responded for a response rate of 83%. Since most of the students who enrolled in this course are placed in this course by their advisors, it was unsurprising that only 25% of the students answered “Yes” to the

question: “Did the cost of the course materials influence your decision to enroll in this course?” Some of them commented: “I did not know this when I enrolled but the price difference made me very happy and it relieved a lot of stress to know I was paying so little,” “Needed elective, but the low cost was awesome,” and,

I was enrolled by my adviser because freshmen do not make their own schedules. However, I am very thankful that the course materials were offered at such a great price! It definitely encourages me to take and continue with the course!

Among the students who answered the survey, 51% thought that the e-book was adequate for the course. Forty percent felt like this electronic version of the textbook was more difficult to handle, stating that it was not adequate. The other 9% of the students did not express an opinion about the e-book as they chose to rely heavily on the class notes and the tutorials provided by WebAssign and LibGuide.

Regarding the LibGuide, 70% of students said that it was easy to navigate and contain all the resources needed to successfully complete the course. Twenty five percent did not find it easy to navigate; 5% did not use it.

Although the online software WebAssign was found adequate by 75% of the students who answered the survey, students complained about many technical problems the software had during the semester, specifically that the software did not allow randomly chosen students to enter answers to some questions during homework and tests, it did not specify the format of the answer to be entered, and in addition to it lacking many tutorials, they complained of the software running very slow. \

Discussion and Conclusion

One of the key findings from this study was that there were statistically significant fewer students who dropped the course after OER was implemented. It is interesting to note that in Fall 2015, when I returned to using the traditional textbook, the withdraw rate went up again to a rate comparable to the other semesters where traditional textbooks were primarily used. It is also important to note that student grades were higher when the OER course was used, comparing Spring 2015 with Spring 2014. Thus although fewer students withdrew from the course (and we might suppose that students who withdraw are most likely to receive low grades) student performance actually improved with the open textbooks.

Looking back at these results from (Hilton III, 2016; Hilton III, Gaudet, Clark, Robinson, & Wiley, 2013; Pawlyshyn, Braddlee, Casper, & Miller, 2013) and comparing them with the results of this study, I noticed the same trend. When adopting OER in a hybrid course, students also perform the same or better compared to the case when traditional textbook is used.

Although only 25% of the students registered in this course in Spring 2015 because of the low-cost of the course requirements, all students benefited from the use of the free open textbook and reduced cost of the online software.

Students found the open textbook supplemented by the LibGuide adequate for this course. From my point of view, the use of these materials provided me the opportunity to personalize the course materials to align with my teaching style. There are many topics that I like to approach differently and in a varied order than in the commercial textbook; this pilot gave me the opportunity to modify resources to fit my teaching needs.

Although the textbook and the LibGuide were adequate for the course, the online software WebAssign was not. WebAssign had many technical problems, especially during the tests. Besides the fact that the program was very slow (a challenge during quizzes and tests), there were many times where the program gave random errors (it would not allow the student to type an answer for some exercises or for all students, making it hard to identify the problem) and many exercises would not specify the format of the answer. It was very frustrating for me and for my students. Being a hybrid course with all the assignments (homework, quizzes, tests, and final exam) taken online, this course needs reliable software.

Overall, OER have the potential to save money to our students with almost no significant effect on learning outcomes. Furthermore, OER also allow teachers to engage with the course materials. They can now change and rewrite the content of the course to fit with their teaching style, can implement new pedagogies, and can personalize their educational materials in a manner that was not previously possible.

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