

Impact of OER Materials on Students' Academic Performance in an Undergraduate Astronomy Course

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Abstract

Open Educational Resources (OER) are online teaching and learning resources available for instructors and students to utilize at no cost to them. This case study reports on the impact of OER resources on students' academic performance in an undergraduate introductory astronomy course at a 4-year private university. As part of this study, we compared the students' performance using traditional standard textbook with the newly introduced OER resources while maintaining the same quality of instructional and learning materials. Our findings indicate that the carefully chosen OER resources could serve the need for students and instructors and help to reduce or eliminate the high textbook cost, which is often considered a barrier for many students in higher education. Finally, we discuss the student perceptions about the OER resources and how it could effectively change the higher education in years to come.

Introduction

Textbooks represent a significant portion of the overall cost of higher education in the United States. Students, those who support them, and the taxpayers who fund the grants and student loans which pay for textbooks, typically shoulder the burden of these costs. As shown in Figure 1, the cost of textbooks increased at the highest rate compared to overall college cost (Bureau of Labor Statistics, 2016).

According to the William and Flora Hewlett Foundation, an early leader of the OER movement, open educational resources are "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" (Hewlett, 2013). Additionally, anyone can freely "reuse, revise, remix, and redistribute" these resources (Hilton et al, 2010) under the creative common license.

The effective use of Open Educational Resources (OER) is a potential solution to contain the cost of textbooks and it can help reduce the higher education expenses, which has grown exponentially over the last few decades. The OER materials provide students a way to receive high-quality learning materials at little or no cost (Hilton et al 2014).

The use of OER materials provide much needed flexibility to tailor the instructional materials to fit the need for unique learning communities the academic institu-

tions serve. Colleges and universities are increasingly turning to open educational resources as a solution to the rapidly rising cost of college textbooks. A literature review reveals that not many studies have been reported in assessing the impact of OER materials in higher education. This case study was intended to assess the impact of OER resources without compromising the quality of instruction and see how this approach could effectively contain the textbook cost and in general improve the access to higher education.

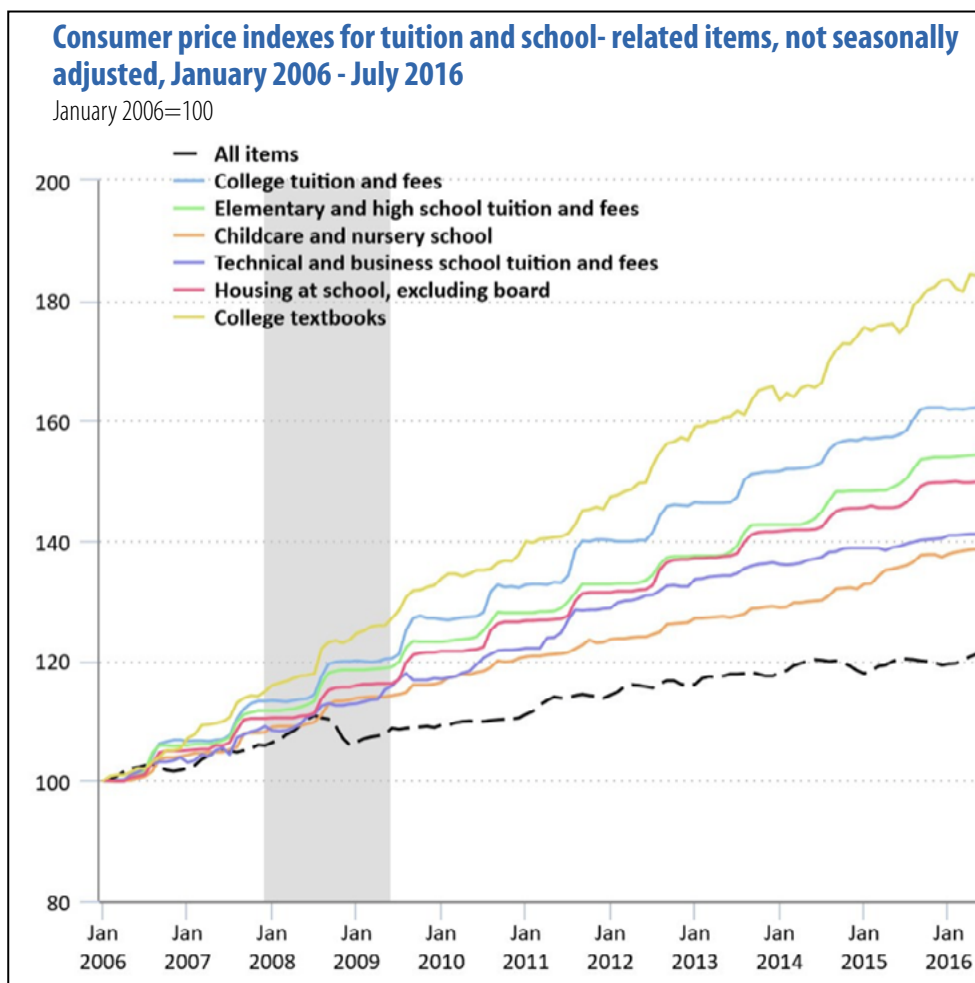


Figure 1. From January 2006 to July 2016, the Consumer Price Index (represents rate of inflation) for college tuition and fees increased 63 percent, compared with an increase of 21 percent for all items. Over that period, consumer prices for college textbooks increased 88 percent and housing at school (excluding board) increased 51 percent and the consumer prices for tuition and fees for private elementary and high schools increased 55 percent.

Background

Despite some recent improvement in textbook market options and transparency, rising prices continue to hinder students who, in the worst scenarios, are turning down classes because the materials are too expensive. A survey of 2,039 students from more than 150 different university campuses showed that 65% of students do not buy textbooks due to the cost (Senack, 2014). These student respondents also felt that access to free textbooks would help them do better in their courses.

Open educational resources have a large potential to save students, as well as the parents and taxpayers who support them through grants and loans with significant amounts of money. The National Center for Education Statistics (2013) study reported that if these savings were realized by only 5% of the 20,994,113 students in the United States who enrolled in college during the 2011 fall semester, the total savings would be approximately one billion dollars per year.

Given Regis College's commitment to increase access to higher education (by reducing cost) and its emphasis on digital pedagogy, we designed an OER eBook (Introductory Astronomy) and made available to our students at no cost to them (Mathew, 2017). The instructor used OER commons platform to design and publish this work. The book has all the contents of a standard textbook available for introductory astronomy course in addition to other features such as embedded videos, quizzes, and other assignments. One of the primary features of the book is that it is self-directed which would enable students to comfortably navigate through multiple layers of information via embedded links, videos and other resources.

Method of Study

Regis is a private liberal arts institution that enrolls approximately 1,000 undergraduates annually with approximately 30% racial/ethnic minority students, approximately 25% first generation college students. Over 95% of Regis students receive some form of financial aid. Higher cost of the textbook prevent many of our students from successfully completing courses and hence their college degree on time. At Regis College, the Introductory Astronomy course is offered in a hybrid format and is a 4-credit course mostly taken by non-science majors as a science core requirement. The class meets online and on campus (two hours/week). The course is conducted using Moodle as the Learning Management System.

For this Introductory Astronomy course the following Student Learning Outcomes (SLOs) are measured to assess the performance of students.

SLO 1: Identify the ideas in several areas of astronomy, including motions in the sky, gravity, electromagnetic radiation, solar system, stars, and galaxies.

SLO 2: Recognize and apply the scientific method to solve problems in Astronomy.

SLO 3: Critically evaluate hypotheses and theories proposed using the scientific method.

SLO 4: Facilitate research, conduct observations, and write science reports.

SLO 5: Measure the properties of stars, galaxies and other heavenly objects from the available data using scientific techniques.

SLO 6: Apply important physical laws, including Newton's Laws of Motion, and Kepler's Laws of Orbital Motion to explain certain astronomical events, including eclipses and tides.

SLO 7: Describe some of the missions undertaken by the world's space agencies.

SLO 8: Analyze the current theories of the origin of the universe

The final course grade for each student was calculated at the end of the semester. This was calculated using weighted average formula comprising test/quizzes (20 percent), student presentation (10 percent), space mission paper (20 percent), homework (15 percent), online discussion (15 percent) and lab activities and report (20 percent). We also used an assessment rubric that reported scores for each of the SLOs mentioned above. Using this information, we calculated percentage of students who achieved a total score of 60% or more on problems linked to various SLOs.

The data for this study was collected from two sections of Introductory Astronomy classes- one offered in fall 2017 and other offered in spring 2018. Each of these sections had 14 students. The same instructor with same syllabus and assignments taught both of these classes. The only difference was that the fall section was taught using standard textbook and associated course materials provided by the publisher. The textbook used for fall course was Explorations: Introduction to Astronomy by McGraw-Hill publishers (Arny & Schneider, 2013). The spring section was taught using OER course materials that replaced the standard textbook and other course materials provided by the publisher. The textbook used for spring 2018 course was adapted materials from various OER resources and made available to the students authored by the instructor (Mathew, 2017).

In this course, each week students had to complete an online discussion on a given topic, homework and a lab report. All these assignments were completed and posted on our Learning Management System (Moodle) for grading. Prior to completing any of these assignments students were asked to read the specific chapter associated with the assignment from the textbook (fall 2017) but for the spring 2018 the relevant readings were shared using multiple OER materials. For example, in fall 2017 to complete the online discussion on force of gravity students were required to read chapter 3 of the standard textbook, while in spring 2018 to do the same assignment the following freely available reading sources were assigned.

<https://www.oercommons.org/authoring/23762-introductory-astronomy-for-undergraduates/4/view>

<https://spaceplace.nasa.gov/what-is-gravity/en/>

<https://phys.org/news/2016-12-strong-gravity-earth.html>

The following is an example of a lab assignment provided as part of the OER course materials in spring 2018. The Regis College is an all iPad institution and as such, we decided to integrate technology to use freely available activities.

Download a free Astronomical observation app on your iPad (examples: SkyView(r) Free - Explore the Universe, Go SkyWatch Planetarium, Starch art, Sky View, StarMap etc.). Observe the motion of any astronomical object using this application on your iPad for a week. Create a one-page report on what you observed and post it here (on Moodle).

This activity is followed the questions:

- What did you learn from this activity?
- Include appropriate supporting details such as scientific information, technical details of observation and knowledge gained through this activity?
- Finally summarize the results, what you observed and learned. Reports MUST be typewritten.

Discussion

We compared the academic performances of these two groups of students (fall 2017 and spring 2018), each group had 14 students. It is to be emphasized here that both group of students had similar academic profile (business, communication and liberal arts majors) as this course was taken by non-science majors to fulfill their general core education requirement in natural science. As mentioned above, one group used traditional textbook (fall 2017) and the other group used OER textbook (spring 2018). All the assignments and the performance measures including the students learning outcomes were the same for both groups. We gathered both qualitative and quantitative data from students to assess their performance and experiences in these courses. We analyzed our data using the statistical software SPSS.

We used independent sample t-test to compare the means of the final course grade for both courses.

Null hypothesis stated that both means are same and alternate hypothesis stated that they are different. Our Test result: t- test statistic $t = 1.08$, $p\text{-value} = 0.29$. Because $p\text{-value} > 0.05$, we failed to reject null hypothesis. Based on this test, we concluded that there is not statistical significant difference between two means of the final course grades of both courses.

As higher education struggles to contain the cost, it should be a priority to select course materials that are

Course Type	Sample size	Percentage of students who achieved a total score of 60% or more on all SLOs	Mean of final grades	Standard Deviation of Final Grades	p-value
With OER	14	85.71	88.71	5.46	0.29
Without OER	14	85.71	86.38	5.83	

Table 1. Grade comparison of students with and without OER textbook

pedagogically most appropriate and affordable to our students whenever possible. Each student who took in Introductory Astronomy course with OER materials at Regis College saved about \$200 during the semester. This amount includes cost for the textbook and lab manual that are offered in electronic or print format to students at no cost as part of the OER initiative. Additionally, these resources increased multi modal learning opportunities and flexibility within choosing course content and delivery methods for instructors.

In addition to the savings, Open educational resources allow instructors to mix-and-match content for a more personalized and engaging learning experience for their students. In addition to cost savings, these resources increase the quality of pedagogy and instructional materials and offer instructors innovative ways to engage students and exchange best practices in teaching and learning. These resources can be customized to the needs of students and it provides immense flexibility for the instructor to design a course that will serve the need of unique learning communities at various institutions.

Students Perceptions

We conducted a survey to rate the student's perceptions about the textbook and other materials. Students were asked to provide feedback on the textbook quality based upon the content, the organization and the level of comprehension and the overall effectiveness of the pedagogical support in each chapter. While 50% of the students who used standard textbook reported overall satisfaction about 85% percent of the students expressed same level of satisfaction with OER materials that include selected texts, videos etc. The main point of contention was that the standard textbook could not provide a level of ease with which they could comprehend the materials. Additionally, when small amount of OER materials were shared every week students' enthusiasm was high to explore and comprehend those materials.

In open-ended responses, students reported ease of understanding, organizational features, the online nature of the books, and visual appeal of the book as reasons to prefer the open textbooks. In this study, we took the extra effort in customizing the readily available OER materials to make it more relevant to our student population majoring in business, communication and liberal arts disciplines. For the initial implementation, this amounts to at least an additional hour of work per week from the faculty member compared to the traditional model. We would like to emphasize here that customization OER materials may not be necessary for many institutions and can be used "as is" for simplicity of implementation. We list some of the feedbacks received from the survey (spring 2018 using OER resources) below:

1. The fact that the class was a hybrid was new for me and I liked that different forums of teaching were used for the class. Discussion posts, videos, and homeworks, along with a weekly meeting made me feel confident and knowledgeable about the material
2. Online textbook (OER commons) was great and supplemented course topics very well.
3. In many other courses, I had to buy the textbook and I never used them but this free book much more than what I could ask for.
4. Every week the instructor shared some new readings form different sources (ex;NASA) and those sources were much easy to understand than regular science textbooks.

We would like to acknowledge that this study has a number of limitations. First, the sample size is limited to one section from each semester and students could not be expected to evaluate the accuracy of textbook content.

Conclusion

Although there is no significant differences between the performances of students in both courses, the students'

enthusiasm as reflected in the above feedbacks reveal that OER resources could be a valuable asset in higher education. The fact that students were able to save considerable amount of money without compromising their performance or quality learning is a huge advantage for considering the OER resources. Additionally, the instructor had much more flexibility in engaging the students pedagogically due to the ownership of materials and its customization. To facilitate the effective use of OER materials, the instructors should invest a considerable amount of time in customizing these materials for individual institutional needs. The customization involves revise and remix the original material from multiple sources to generate new custom materials. However, customizations are not necessary especially if the students taking the course are from similar disciplines or with similar backgrounds. Furthermore, in order to ensure the quality of the materials a careful evaluation is needed from multiple instructors in the field. As such, this study would encourage further research associated with open textbooks to assess the veracity of OER resources, but carefully chosen materials have the potential to make huge changes in higher education.

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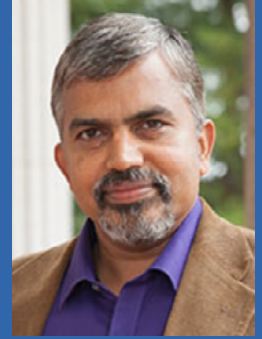
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