

**Adapting and Adopting Open Educational Resources:
An Analysis of Student Cost Savings, Use, Performance, and Perception**
By Mike T. Springer, Southwestern Oregon Community College, USA



ABSTRACT

OER's are significant in terms of cost-savings to the student, but there are questions surrounding the quality of these resources, as well as whether students prefer OER or traditional textbooks. Many of the OER's available today are often peer-reviewed, but some platforms allow users to alter or customize the content, like OpenStax Connexions (CNX). When open content is altered or rearranged by an instructor, then it becomes essential for the instructor to determine whether those changes are beneficial or detrimental to student learning. Using the OpenStax Connexions (CNX) OER educational content repository and content management system, two customized OER's were developed and used as the only textbooks for two introductory chemistry courses at a community college in rural Oregon. The author of this study examined students' cost savings, performance, use, and perception. Student scores for the OER-only courses were

compared with scores from courses taught with traditional textbooks. The results of a student's *t*-test suggest that there was a significant difference between scores, in favor of those taught with an OER textbook. Because of small sample sizes, Cohen's *d* was also calculated and indicated that, in most cases, the effect size was not large enough to be considered significant. Although it is difficult to say that learning was improved in light of the small effect sizes, it seems reasonable to suggest that learning was not adversely affected by the adoption of customized OERs. Lastly, an analysis of clickstream data from the learning management system and data obtained from an end of course survey seem to indicate that student usage and perception of OER does not differ significantly with traditional textbooks.

Keywords: Student perception, student performance, student usage, custom OER, OpenStax, OpenStax Connexions (CNX)

修改和运用开放教育资源 (OER) :

学生成本节省、使用情况、学习表现和学习感知分析

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摘要

虽然开放教育资源 (OER) 极大地节省了学生上课成本, 但这些资源的质量以及学生倾向 OER 还是传统教学材料都有待考究。如今, 许多 OER 都是经过同行审查的, 但诸如 OpenStax Connexions (CNX) 这类平台允许用户修改或定制内容。因此当教师修改或重新安排开放内容时, 教师必须明确这些改变对学生的学习到底是有益还是有害的。笔者利用 OpenStax Connexions (CNX) OER 教育内容存储库和内容管理系统开发了两种定制 OER, 并将它们作为俄勒冈州农村一所社区学院的两门入门化学课程的唯一教科书。笔者分析了学生的学习表现, 使用情况和学习感知, 并对只接受 OER 授课的学生和接受传统教学的学生成绩进行了比较。学生的 *t* 测试结果表明, 学生的分数之间存在显著差异, OER 教材授课的学生成绩占优势。由于样本数较小, 笔者也通过 Cohen's *d* (均值比较) 计算了效应量, 并指出在大多数情况下, 效应量不大, 称不上显著。鉴于效应量太小, 很难断言学习得到了改善。但似乎有理由认为, 运用定制 OERs 不会对学习产生不利影响。最后, 来自学习管理系统的点击流数据和从课程调查结束时获得的数据分析似乎表明, 学生对 OER 的使用和感知与传统教材并无显著差异。

关□□：学生认知，学生表□，学生使用，定制 OER，OpenStax，OpenStax Connexions(CNX)

Adaptación y adopción de recursos educativos abiertos:

Un análisis del ahorro, el uso, el rendimiento y la percepción de los costos de los estudiantes

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RESUMEN

Los REA son significativos en términos de ahorro de costos para el estudiante, pero hay preguntas sobre la calidad de estos recursos, así como si los estudiantes prefieren REA o libros de texto tradicionales. Muchos de los REA disponibles en la actualidad a menudo son revisados por pares, pero algunas plataformas permiten a los usuarios modificar o personalizar el contenido, como OpenStax Connexions (CNX). Cuando el contenido abierto es alterado o reorganizado por un instructor, entonces es esencial que el instructor determine si esos cambios son beneficiosos o perjudiciales para el aprendizaje del estudiante. Usando el repositorio de contenido educativo y el sistema de gestión de contenido de REA OpenStax Connexions (CNX), se desarrollaron dos REA personalizados y se utilizaron como los únicos libros de texto para dos cursos introductorios de química en un colegio comunitario en el área rural de Oregón. El autor de este estudio examinó el rendimiento, el uso y la percepción de los estudiantes. Los puntajes de los estudiantes para los cursos solo para REA se compararon con los puntajes de los cursos impartidos con libros de texto tradicionales. Los resultados de la prueba t de un estudiante sugieren que hubo una diferencia significativa entre las puntuaciones, a favor de las que se enseñan con un libro de texto REA. Debido a los tamaños de muestra pequeños, la d de Cohen también se calculó e indicó que, en la mayoría de los casos, el tamaño del efecto no era lo suficientemente grande como para ser considerado significativo. Aunque es difícil decir que el aprendizaje se mejoró a la luz de los tamaños de los efectos pequeños, parece razonable sugerir que el aprendizaje no se vio afectado negativamente por la adopción de REA personalizados. Por último, un análisis de los datos del flujo de clics del sistema de gestión de aprendizaje y los datos obtenidos de una encuesta de final de curso parecen indicar que el uso y la percepción de los REA por parte de los estudiantes no difiere significativamente de los libros de texto tradicionales.

Palabras Clave: percepción del alumno, rendimiento del alumno, uso del alumno, REA personalizado, OpenStax, OpenStax Connexions (CNX)

INTRODUCTION

Open Educational Resources

OERs are freely accessible, openly-licensed documents, images, and multimedia assets that are useful for teaching, learning, and assessing, as well as for research purposes.

OpenStax Connexions

Many authors who create customized OERs use *OpenStax Connexions* (CNX), an educational content repository and content management system. Created in 2012, OpenStax is a nonprofit educational initiative based at Rice University, and is supported by partnerships with [philanthropic foundations](#) and [educational resource companies](#). OpenStax provides peer-reviewed, open textbooks that are contributed freely by authors across the globe, and are also provided free to the end-user. The CNX platform offers users the ability to create, organize, and/or remix learning *modules* into *collections*, which can be offered as open textbooks. A learning module is similar to a section in a textbook; it is smaller than an entire chapter, but it is a complete, stand-alone lesson including content around a topic that can easily be remixed and used in different collections and contexts.

The present study utilized the CNX platform to remix several modules and create two open education resources that were offered as free, open textbooks for two different courses.

Traditional Textbooks vs. OERs

Traditional Textbooks: Pros and Cons

Pros. The content within traditional textbooks is generally thought to be of higher quality than OERs. Traditional textbooks are updated regularly and edited by a team of experts. This regular revision requires resources. Although the cost of this revision is passed on to students in the form of an expensive textbook, many rounds of revision does tend to remove the vast majority of factual errors and inadequacies of early editions that may have been missed initially. Not only are traditional textbooks being reviewed by their authors and editors, but also by the professors that adopt those resources for their classrooms. Although the same could be said of OERs, authors of OERs generally do not receive any type of compensation for their work and thus have little incentive to update or maintain their published materials. Not only do traditional textbook publishers employ authors

and editors, they also employ professional photographers and can pay for copyrighted images. It is often difficult for authors of OERs to find high quality, copyright free images to include in their materials (Perez, 2017). OERs are freely available on the internet, but as such, require a device and an internet connection for access. At the very least, the OER must be initially downloaded (which requires an internet connection) and stored on a device for offline access. There are times when it may be difficult for a student to access the OER, such as when they do not have access to an internet connection or when the battery in their device has died. Traditional textbooks do not suffer from the same accessibility issues.

Cons. The cost of textbooks increased 82% between the years 2002 and 2012. (Student PIRGS, 2014), roughly three times the rate of inflation. Whether they choose to or not, higher educational faculty are often stuck using the latest editions of textbooks due to two primary reasons: 1) on average, a new edition of a textbook is released every 3.5 years (Ozdemir & Ozgur, Hendricks, 2017) and 2) publishers rarely offer previous editions. The National Association of College Stores indicates that 77 cents of every dollar spent on a new textbook goes directly to the publishers and at least 18 cents per dollar is pure profit. Meanwhile, a survey of 156 college instructors across more than 10 public colleges and universities in California and Oregon found that more than half of all faculty respondents indicated that the new editions of textbooks that they used were “rarely-to-never” justified, in terms of the difference in content between editions (Fairchild, 2004). The high cost of textbooks is often an obstacle for low-income students. A survey of 22,000 online students on the Florida Virtual Campus found that as many as 67% did not purchase a textbook at some point in their college career because of its exorbitant cost (Florida Virtual Campus, 2016).

One solution for addressing this financial barrier is for faculty to adopt, adapt, and / or develop OERs. However, in terms of quality and efficacy between traditional textbooks and OER textbooks (as perceived by faculty and students), OERs have been questioned in these categories. This has been an important issue, with many variables that the larger OER community continues to address with research.

OERs: Pros and Cons

Pros. One of the greatest advantages of OER textbooks is that they are free and/or can be printed cheaply at the college bookstore or at an office supply store, like FedEx or Staples. OERs can be used to supplement traditional textbooks to explore a content area that is tangential to the main content for little or no cost. OERs are more easily transported than traditional textbooks. Another decisive advantage that OERs offer over

traditional textbooks is the capacity for multi-media components: it is relatively straightforward to add a video, song, or other animation into an OER that exists as a webpage or a PDF file. Further, active links to external websites and resources can easily be embedded in an OER for students to delve deeper into certain topics than the main text allows. Because OERs can easily be accessed with any device and internet connection, students have access to the learning materials at the very beginning of a course, rather than having to wait for financial aid to purchase expensive textbooks.

Cons. An important issue surrounding OER is in regard to the quality of the content. Certainly, students are excited about cheap or free course materials, but likely not at the cost of their own academic performance due to inferior textbooks. Some of the OER resources that are available have been authored and reviewed in processes that are similar to those of traditional publishers; *OpenStax* textbooks are a good example of this model. However, even resources from *OpenStax* can be altered or “customized” by adding, changing, or removing content. These “customized” OER textbooks do not require peer-review before they are used in the classroom. There are certainly advantages to using a customized OER textbook, like reordering topics or adding an example for context, but if the customizations are associated with lower scores than a traditional textbook, then the customized OER is a disservice to students.

This study seeks to investigate the amount of tuition costs that community college students save by enrolling in a course offering an OER versus a traditional textbook, whether using a customized OER textbook affects student scores by comparing student scores from courses taught with traditional textbooks to those taught with customized OER textbooks, and whether students prefer to use OERs or traditional textbooks.

LITERATURE REVIEW

Student Learning Outcomes

Several studies have investigated the extent to which student learning is affected by the use of an OER versus a traditional textbook. Robinson, et al (2014) investigated OER use in high school science courses in the Nebo School District in Utah and compared standardized exam scores between students that used an OER versus those that used a traditional textbook. They found that students in a chemistry course that utilized an OER scored significantly higher than those that utilized a traditional textbook, but they found no difference in student scores for earth science or physics courses that utilized an OER. These results suggest that OER use does not negatively affect student learning and, in some cases, might even improve student learning. The authors of this study compared the scores of 4,183 students taught by 43 teachers and even though the study controlled for possible differences due to individual teacher effects, it is possible

that the effect observed was due to differences in teaching style, especially since teachers independently chose whether to use the open textbooks.

Another study compared 478 students using OERs to 448 students using traditional textbooks in a chemistry course at UC Davis (Allen, Guzman-Alvarez, Molinaro, Larsen, 2015). This study did not suffer from the possible confounding effects of individual teachers since both courses were taught by the same teacher and TA, and used the same exams. Regardless, these researchers found no significant difference in student scores.

Hilton (2016) examined the results of 9 studies that pertained to student learning outcomes in courses taught with an OER versus those taught with a traditional textbook. Eight of these studies conclude that students perform as well or better in courses taught with an OER and the one study that connected OER use to lower student scores showed that these differences were not statistically significant.

Hendricks, et al (2017) published a study investigating the use of OER in an introductory physics course at the University of British Columbia that enrolls between 800-900 students per year. There was no statistical difference in student scores on final exams between the section that utilized an OER in fall of 2016 and the previous three years of sections that utilized a traditional textbook.

The general conclusion in all of these studies is that student learning does not seem to be negatively affected by use of an OER versus a traditional textbook.

Student Perceptions of the Quality of OER

Illowsky, et al (2016) examined student perceptions of OERs in a mathematics course at De Anza College, a community college in California. These researchers designed a multimedia textbook, *Collaborative Statistics* (first written in the mid-1990s), and the collaboration with Rice University that ensued was the beginning of what would later become the OpenStax Connexions (CNX) platform. After many revisions, *Collaborative Statistics* was renamed *Introductory Statistics* and it became the prototype for OpenStax College's open textbook model. Their analysis showed that students saved money and viewed the OER as a useful resource. Whether students purchased a hard copy of text or printed the pages, most students experienced significant cost savings. The study reported that 66% of the students said they used the textbook at least twice a week, similar to their use of other traditional textbooks. Survey results also revealed that students perceived OER favorably: 62% said the quality of the OER was equal to traditional textbooks, 25% said the quality of the OER was better, and 13% said the quality of the OER was worse.

Bliss et al. (2013) investigated student and faculty perceptions of OER used in 8 community colleges across the United States. In all, 490 students and 58 faculty from 8 colleges responded to an online survey about OER in their classrooms. The majority of students and faculty had a

positive experience using the open textbooks, appreciated lower costs, and thought quality was equal.

Jhangiani, et al (2018) examined student perception of OERs at a large research university in Canada, Kwantlen Polytechnic University. This study revealed that the print format of the open textbook was rated significantly higher in quality than the commercial textbook and that the digital version of the open textbook was not significantly different than either. Their results showed that there was no dimension of the commercial textbook that was rated higher than either format of the open textbook.

Whether in a small community college or a large research university, most studies involving student perceptions of OER seem to indicate that students perceive the quality of OERs to be at least as good as traditional textbooks, and even better, in some cases.

Purpose of the Study

The average college student in the United States spends \$900 a year on textbooks (Allen, 2010). For students at some community colleges, this is nearly the same amount that they pay for tuition every year. It is important to examine ways to reduce this cost, and OERs are a viable, potential solution. However, the quality of the OER, in terms of whether it helps or hinders student learning, is paramount to this discussion. To examine this issue, this study compares student scores between courses taught with OERs versus those taught with traditional textbooks. It is also important to measure the students' perception of quality of OER textbooks offered in their college courses. Though students often cannot comment on the *accuracy* of the content, they can provide information about how often they used the material, whether they prefer the online format of the textbook, etc. Data regarding students' perception of OER materials can add a valuable perspective to the conversation.

Research Questions

In the present study, to examine any differences between courses taught with a traditional textbook and those taught with a customized OER textbook, the courses will be compared in terms of students' cost savings, performance on course assignments, use of course resources, and perceptions of the quality of open educational resources. The following research questions were addressed in the study:

RQ1: What are the cost savings to students when an OER is used in place of a traditional textbook?

RQ2: Do students use OER differently than they use traditional textbooks, in terms of their study habits?

RQ3: Do students using an OER perform differently on course exams from students that use a traditional textbook?

RQ4: Do students perceive OERs to be of similar quality to traditional textbooks?

METHODS

This study was performed at a small, rural community college on the Oregon coast. This college utilizes the quarter system. Two courses were examined in this study during the 2016 and 2017 winter quarter (Table 1). CHEM 110 is a 1-quarter introduction to general, organic, and biological chemistry primarily for undergraduate health and nursing majors and GS 105 (General Science) is a 1-quarter introduction to general chemistry for undergraduate, non-science majors. In winter 2016, a traditional textbook was used, and in winter 2017, a customized OER textbook, created on the CNX platform, was used.

Table 1. A Comparison of Traditional and a Customized OER Textbooks in Chemistry 110 and GS 105 During 2016 and 2017 Winter Quarters

	Traditional Textbook	Customized OER Textbook
CHEM 110	Winter 2016	Winter 2017
GS 105	Winter 2016	Winter 2017

OER Organization & Development

Creating a customized open textbook from the CNX platform (<https://legacy.cnx.org/>) begins with identifying which modules to use, how many modules to use, and in what order to place them. A module is a short lesson on one specific topic. Modules can be added together to create a “collection” or a “book”. It is possible for authors to edit existing modules or to create their own. To limit the number of any unintentionally added errors in the development of the custom OER textbook, the present study did not add any original content or materials. The customized textbooks were created by selecting modules from two peer-reviewed collections from the *OpenStax* library: *Chemistry (OpenStax College, 2016)* and *Biology (OpenStax College, 2016)*. A customized OER textbook was created for each course and was made available as a link on the LMS course portal, as well as in print through the bookstore. A course outline was created to align with the content of each course, then appropriate modules were chosen and arranged to support the course outline.

Two guiding principles were followed when organizing content for customized OERs: 1) to make each textbook no longer than eight chapters and 2) to craft a coherent narrative that is woven throughout the text to connect stand-alone chapters and topics. The OERs were designed for use in a 10-week quarter-system course. As such, it was decided that the maximum number of chapters should be kept to 8. Many traditional textbooks for these chemistry courses are designed

for the semester system and, as such, have upwards of 15 chapters, which is unrealistic for a 10-week course. To reduce the number of chapters in the OER, similar chapters were combined into a single chapter, thereby retaining all of the content from the original course, simply packaged into more manageable chunks.

Modules are generally stand-alone units that can be reshuffled in many different ways depending on the curriculum. To adhere to guiding principle #2, an overarching theme of “*how molecular structure affects function*” was followed when determining which modules and topics to include, as well as how to organize them. This is a typical theme in chemistry and helps non-experts approach and understand chemical reactivity. To the greatest extent possible, it was decided that the book should tell a compelling story about nature that is connected throughout by the idea that chemical function is based on chemical structure. If a topic did not fit this story narrative, it was removed from the course outline. Because both courses are one-term, terminal courses (not part of a sequence), there was some freedom to modify the curriculum in this way.

For example, Unit 2 of the OER created for CHEM 110 contains the chapters: Cell Structure (Chapter 5, *Figure 1*), Structure and Function of the Plasma Membrane (Chapter 6), and Metabolism (Chapter 7).

5 | CELL STRUCTURE

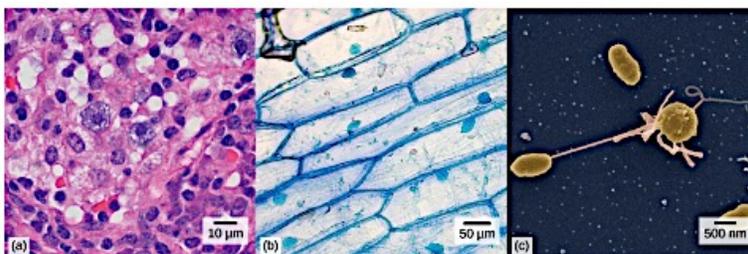


Figure 5.1 (a) Nasal sinus cells (viewed with a light microscope), (b) onion cells (viewed with a light microscope), and (c) *Vibrio tasmaniensis* bacterial cells (seen through a scanning electron microscope) are from very different organisms, yet all share certain characteristics of basic cell structure. (credit a: modification of work by Ed Uthman, MD; credit b: modification of work by Umberto Salvagnin; credit c: modification of work by Anthony D’Onofrio, William H. Fowle, Eric J. Stewart, and Kim Lewis of the Lewis Lab at Northeastern University; scale-bar data from Matt Russell)

Chapter Outline

- 5.1: Studying Cells
- 5.2: Eukaryotic Cells

Introduction

Close your eyes and picture a brick wall. What is the basic building block of that wall? A single brick, of course. Like a brick wall, your body is composed of basic building blocks, and the building blocks of your body are cells.

Your body has many kinds of cells, each specialized for a specific purpose. Just as a home is made from a variety of building materials, the human body is constructed from many cell types. For example, epithelial cells protect the surface of the body and cover the organs and body cavities within. Bone cells help to support and protect the body. Cells of the immune system fight invading bacteria. Additionally, blood and blood cells carry nutrients and oxygen throughout the body while removing carbon dioxide. Each of these cell types plays a vital role during the growth, development, and day-to-day maintenance of the body. In spite of their enormous variety, however, cells from all organisms—even ones as diverse as bacteria, onion, and human—share certain fundamental characteristics.

Figure 1. An example of a page from Chapter 5 of the CHEM 110 OER: General, Organic, and Biological Chemistry: A Cellular Perspective.

Analysis

The *student cost savings* of traditional textbooks versus OER textbooks used for courses CHEM 110 and GS 105 was measured by determining the cost of each traditional textbook as charged by the campus bookstore and comparing that to the cost of the OER textbooks.

To examine any differences between *students' usage* of course materials between the two types of textbooks, clickstream data collected automatically by the LMS were analyzed to compare the number of times each student clicked on each link on the LMS course page.

Differences in *student performance* were measured by comparing scores on different types of assignments (homework, exams), as well as final course grade, in a course taught with a traditional textbook versus a course taught with a customized OER. A *t*-test was performed on the data to determine whether there was a statistically significant difference in student performance between the two courses. Because the number of students in each course was very small (between 15 and 30), the sample size was also small and the results of a *t*-test are of limited value by themselves. Therefore, the effect size was also determined by calculating Cohen's *d* (Cohen, 1977). The LMS automatically records these data. Students' perceptions of the quality of the customized OER versus traditional textbooks was assessed by administering an anonymous survey at the end of the term (provide the survey at the end of the paper).

RESULTS

Demographic Data of the Student Population

The demographic information of the student population is shown in Table 2. These data were collected as responses to an anonymous survey (appendix A) administered at the end of the term. The survey questions used were developed by Bliss et al (Bliss, Robinson, Hilton, Wiley, 2013).

Table 2. Demographic data of students from courses with OER textbooks

		CHEM 110	GS 105
Age	Under 18	2	2
	18 – 19	9	7
	19 – 20	3	5
	21 – 22	6	0
	23 – 25	0	1
	26 – 30	3	2

	30 – 35	3	0
Gender	Female	14	11
	Transgender	0	0
	Male	10	5
	Other / prefer not to say	0	0
Terms in College	1 – 2	13	5
	3 – 4	3	3
	5 – 6	4	2
	7 – 8	1	6
	9 – 10	1	0
	More than 10	2	0
Courses per Term	1 – 2	0	1
	3	2	3
	4	13	5
	5	7	5
	6	1	1
	7	0	0
	8 or more	1	1
Cumulative GPA	Less than 2.6	0	0
	2.6 – 3.0	8	3
	3.1 – 3.5	9	5
	3.6 – 4.0	4	8
	I don't know	3	0

Students' responses were also collected about financial behavior with respect to loans and grants (Table 3) used to finance their education.

Table 3. Survey data of students' financial behavior

		CHEM 110	GS 105
Have you received any loans to fund your education?	Yes	12	3
	No	12	13
Have you received any Pell Grants or Fee Waivers to fund your education?	Yes	18	6
	No	6	9

Students' Cost of Traditional Textbooks vs. OER Textbooks

RQ1: What are the cost savings to students when an OER is used in place of a traditional textbook?

The amount of money that students saved because they did not have to purchase a traditional textbook is summarized in tables 4, 5, and 6. The dollar amounts in the table are the prices

charged by the campus bookstore for each textbook. The traditional textbook used for CHEM 110 was “General, Organic, and Biological Chemistry”, by Frost and Deal, 3rd edition (ISBN: 978-0134162003). This book was priced at \$160.00 new from the campus bookstore. The CHEM 110 course typically enrolls between 30-40 students per term, an average of 35 students. As such, the amount of money that students spent on textbooks for this course was about \$5600 per term. The traditional textbook used for GS 105 was “Introductory Chemistry, Essentials” by Tro, 5th edition (ISBN: 978-0321910295). This book costs \$144.50 new from the campus bookstore. The GS 105 course typically enrolls between 18-24 students per term, with an average of 21 students. As such, the amount of money that students spent for textbooks in this course was about \$3035 per term. Adapting and adopting an OER textbook saved students about \$8635 during the 2016-2017 winter term.

Table 4. *Cost of CHEM 110 and GS 105 traditional textbooks, number of students, and total cost for students during winter quarters 2016 and 2017*

	New traditional textbook	Number of Students	Amount per Course
CHEM 110	\$160.00	35	\$5600.00
GS 105	\$144.50	21	\$3034.50
<i>Total Cost to Students</i>			<i>\$8634.50</i>

Table 5. CHEM 110 and GS 105 OER textbooks, number of students, and cost savings for students during winter quarters 2016, 2017

	OER textbook	Number of Students	Amount per Course
CHEM 110	\$0	35	\$0
GS 105	\$0	21	\$0
<i>Total Savings for Students</i>			<i>\$8634.50</i>

Table 6. Survey data of student’s typical textbook purchasing behavior

		CHEM 110	GS 105
How often do you purchase the required texts for the courses you take?	Never	0	0
	Rarely	3	4
	About half the time	3	1
	Often	7	8

	Always	11	3
How much do you typically spend on Textbooks each year?	Less than \$100	1	1
	\$101 - \$200	1	2
	\$201 - \$300	4	3
	\$301 - \$400	6	6
	\$401 - \$500	6	3
	More than \$500	6	1
Did you purchase any textbooks for this course?	Yes	6	4
	No	17	12
Were the textbooks used in this course available to you primarily online?	Yes	22	15
	No	1	1
If you did buy one or more textbooks for this course, how much did you spend?	Less than \$20	6	4
	\$21 - \$40	3	4
	\$81 - \$100	2	0
	More than \$100	0	1
Did you print the textbook for this course?	Yes	1	0
	No	22	15
If you did print the materials, then how much did you spend?	Less than \$10	7	10
	More than \$10	0	1

Students' Usage of Traditional Textbooks vs. OER Textbooks

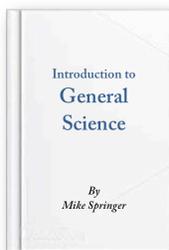
RQ2: Do students use OER differently than they use traditional textbooks, in terms of their study habits?

Figure 2 below shows a screenshot of the appearance of the course portal to students. The number of times that students clicked on each link was recorded and reported in Tables 7 and 8.

The screenshot displays the course portal for CHEM 110 01 - Foundations Of General, Org, Bio. On the left is a red sidebar with navigation links: Science News, Textbook, Announcements, Course Information, Syllabus, Assignment Schedule, Homework, Lecture Materials, Lecture Videos, Exam Reviews, Gradebook, and Extra Credit Lectures. The main content area shows a feed of news items. The first item is titled "Antibacterial molecule may discourage resistance" with a date of 6/15/2017 6:01:00 PM and a brief description: "Agent blocks bacterial but not human RNA polymerase active site". Below the description are social sharing options: Email this, Save to del.icio.us, Digg This!, Share on Facebook, Discuss on Newsvine, and Stumble It!. The second item is titled "More moves with metathesis" with a date of 6/15/2017 5:58:03 PM and a brief description: "Chemists swap substituents on C-S and C-P bonds". It also has social sharing options: Email this, Save to del.icio.us, Digg This!, Share on Facebook, Discuss on Newsvine, and Stumble It!.

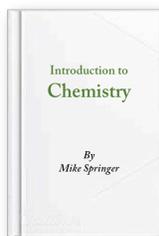
Figure 2. A screenshot of the learning management system webpage for CHEM 110 in winter 2017.

The finished versions of the customized OER textbooks created CNX platform can be found here:



Link to customized OER for GS 105:

<https://legacy.cnx.org/content/col12103/latest/>



Link to customized OER for CHEM 110:

<https://legacy.cnx.org/content/col12104/latest/>

Both courses, GS 105 and CHEM 110, utilized the learning management system, *Jenzabar*. Clickstream data, the number of times that each link was clicked, were automatically recorded to determine how students used the portal, as shown in Tables 7 and 8. Because a traditional textbook was used in winter 2016, there was not a link to the textbook included in the LMS portal.

Table 7. Clickstream data from the CHEM 110 learning management system course portal. The number of visitors and views is reported for each link, as well as the percentage of the total

	Textbook		Gradebook		Lecture Materials		Total	
	Visitors	Views	Visitors	Views	Visitors	Views	Visitors	Views
Winter 2016 (<i>N</i> = 30) ^b	^a	^a	33	836 (18.2%)	27	170 (3.7%)	33 ^b	4591
Winter 2017 (<i>N</i> = 32) ^b	26	73 (2.4%)	36	617 (20%)	29	251 (8.2%)	36 ^b	3074

^a A traditional textbook was used in winter 2016, so there wasn't a textbook link on the LMS page.

^b Total student population (*N*) does not match the number of visitors because some students visited the portal before they dropped the course.

Table 8. Clickstream data from the GS 105 learning management system course portal. The number of visitors and views is reported for each link, as well as the percentage of the total

	Textbook		Gradebook		Lecture Materials		Total	
	Visitors	Views	Visitors	Views	Visitors	Views	Visitors	Views
Winter 2016 (<i>N</i> = 18)	^a	^a	18	327 (16.7%)	14	87 (4.4%)	18	1959
Winter 2017 (<i>N</i> = 22) ^b	15	54 (3.8%)	24	376 (26.6%)	15	89 (6.3%)	24 ^b	1414

^a A traditional textbook was used in winter 2016, therefore there was not a textbook link on the LMS page.

^b Total student population (*N*) does not match the number of visitors because some students visited the portal before they dropped the course.

In addition to collecting clickstream data about *actual* student use of course resources, survey questions collected data about students' *perceived* use of course resources, as reported in Tables 9 and 10.

Table 9. Survey data of students' perceived use of course resources

How often did you use the textbook this term?	Never	7	5
	2 – 3 times per term	4	4
	2 – 3 times per month	3	4
	2 – 3 times per week	8	3
	Everyday	0	0

Students' Performance Between Using Traditional Textbooks and OER Textbooks

RQ3: Do students using an OER perform differently on course exams from students that use a traditional textbook?

To determine whether there were any significant differences in student performance between courses taught with a traditional textbook and those taught with an OER textbook, the mean score was calculated for a variety of assignments within each course. Table 10 shows the mean score for each type of assignment in the GS 105 course, as well as the p -value from a student's t -test and Cohen's d to measure the effect size. The GS 105 course with a traditional textbook was taught during the winter term of 2016 and had 16 total students ($N = 16$). The GS 105 course with a customized OER was taught during the winter term of 2017 and had 22 total students ($N = 22$). Though most of the assignments in the course were kept the same between terms, the homework system was changed and each term was working with a different online homework system.

Table 10. Comparison of average student scores in two terms of GS 105. In one term, a traditional textbook was used and in the other, a customized open educational resource

	Traditional Textbook ($N = 16$)	Custom OER Textbook ($N = 22$)	p -value	Cohen's d
Homework ^a	82.81	92.63	0.0002	0.516
Lab	90.82	95.65	0.0019	0.422
Worksheets				
Midterm	73.24	80.32	0.0385	0.483
Exams				
Final Exams	69.02	83.27	0.0031	1.126
Final Scores	81.58	91.63	0.0004	1.287

^aThe online homework program was changed from WT16 to WT17.

Table 11 shows the mean score for each type of assignment in the CHEM 110 course, as well as the p -value from a student's t -test and Cohen's d to measure the effect size. The CHEM 110 course with a traditional textbook was taught during the winter term of 2016 and had 30 total students ($N = 30$). The CHEM 110 course with a customized open educational resource was taught during the winter term of 2017 and had 24 total students ($N = 24$). Again, students in the course with a traditional textbook were using a different online homework system than the students in the course with a customized OER textbook.

Table 11. Comparison of average student scores in two terms of CHEM 110. In one term, a traditional textbook was used and in the other, a customized open educational resource.

	Traditional Textbook ($N = 30$)	Custom OER Textbook ($N = 32$)	p -value	Cohen's d
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Homework ^a	91.72	82.51	0.0001	0.807
Midterm Exams	71.58	78.01	0.0147	0.470
Final Exams	61.08	70.80	0.0155	0.699
Final Scores	81.44	81.13	0.9157	0.029

^aThe online homework program was changed from WT16 to WT17.

Students' Perceptions of Open Educational Resources vs. Traditional Textbooks

RQ4: Do students perceive OERs to be of similar quality to traditional textbooks?

In addition to demographic questions and questions about use of course resources, student survey responses about student's perceptions of the quality of the OER resources used in their courses and their preference for either online or traditional course materials (Table 12).

Table 12. Survey data of student's perception of OER textbook quality

		CHEM 110	GS 105
How would you rate the quality of the textbook used for this course?	WORSE than texts in other courses	1	0
	SAME AS texts in other courses	18	10
	BETTER than texts in other courses	1	6
How do you feel about the online format of the textbook used for this course?	WORSE than texts in other courses	9	2
	SAME AS texts in other courses	7	8
	BETTER than texts in other courses	5	6
How likely are you to register for a future course with online textbooks like the one used in this course?	Very Unlikely	2	1
	Somewhat Unlikely	3	1
	Somewhat Likely	16	6
	Very Likely	1	8
Imagine a future course you are required to take. If two different sections of this course are offered by the same instructor during equally desirable time slots, but one section used OER texts similar to those used in this course and the other used traditional printed texts, which section would you prefer to enroll in?	Traditional Text	8	4
	OER Text	8	8
	No Preference	7	4

LIMITATIONS

Because of the limitations of this project, it is presented here as more of a case study than an experiment. First, the sample sizes were quite small, making statistical analysis difficult. To address the small sample size, Cohen's d was calculated and reported as a measurement of the effect size, but this, too, was quite small. As such, it is difficult to make any definitive conclusions based on statistical analysis. Second, although most of the modules used to remix the customized OERs were from OpenStax, a peer-reviewed resource, some of the modules were not. The author took care to review the modules included for accuracy, but this is not the same as a peer-review process and it is possible that the OERs created contained factual errors. Although assessing the *factual content* of a customized OER is certainly a vital process, it is beyond the scope of this paper; determinations about factual accuracy should be left to the content experts by using a peer-review process. Finally, although care was taken to present the same lecture material and use the same assignments in courses taught with OERs and with traditional textbooks, the online homework system was changed between 2016 and 2017, so it is difficult to make any conclusions about differences in homework scores.

DISCUSSION AND CONCLUSIONS

The most non-controversial benefit of adopting an OER textbook was the cost savings to students. Textbooks costs continue to increase, and the number of students wishing to obtain a credential and that are unable to pay for tuition and course materials is also increasing. The average amount of student debt of 2016 college graduates was \$37,172 per student (<https://www.debt.org/students/>).

Of course, it comes as no surprise that OER textbooks are cheaper than traditional textbooks. The real question is whether students are equally able to learn with them, as well as whether they are equally satisfied with them. The results of this study suggest that this is the case, though confounding variables prevent definitive conclusions from being drawn. Although care was taken to ensure that assignments between the two courses were consistent, if it was determined that a change in assignments between the two terms would be beneficial to student learning, then modifications were made accordingly. Therefore, it is likely that the two courses were similar, but it is probable that slightly different material was covered and with slightly different delivery. In addition, not only was the textbook changed between sections, but so too was the homework system. This change alone is enough to cast doubt on any inferred cause of a statistically significant difference between the two sections.

The results reported in Tables 5 and 6 on student performance included a variety of course assignments, but it is important to note that any observed difference in scores between the two sections could be the result of a difference in the abilities of the students in each group before the course began. Since a pretest was not administered to the students in either section before the course began, it is not possible to determine any differences in the academic abilities or previous

knowledge between the two groups. The p -values shown in Table 5 and Table 6 suggest that there are some significant differences between the scores of the students taught with a traditional textbook versus those taught with a customized open educational resource.

The data seem to suggest that student learning is significantly improved when the course is taught with a customized OER. However, as mentioned above, there are many reasons to be cautious of such a conclusion. The Cohen's d statistic provides a measure of the effect size. Typically, an effect size of less than 0.8 indicates that the size of the effect is not large enough to be significant. For many of the p -values reported in Tables 5 and 6 that signify statistical difference, the associated values of Cohen's d are small. The smaller the effect, the more difficult it is to determine its cause, especially in an educational environment like a classroom, where there are often many variables. That the two courses were taught by the same instructor during the same term (winter) does limit the number of differences in the delivery of the two courses, as well as the type of students that might enroll in a winter term course. However, it is likely that there were enough differences to cast doubt on whether any observed effect was due to the experimental treatment or to some unintentional difference in delivery or student population.

Tables 7 and 8 report the clickstream data of students, the number of times that they clicked each link on the LMS portal seen in *Figure 1*. There were not any significant differences in student use of course resources between students enrolled in a course with a traditional textbook and those enrolled in a course with an OER textbook. The most notable result from this analysis is that not only did the "textbook" link receive the smallest number of clicks in both courses, there were a surprising number of students that never even clicked the textbook link. The survey data are consistent with the clickstream data as regards the use of the textbook: in CHEM 110, 6 students did not click the textbook link (Table 7) and 7 students reported that they never used the textbook (Table 10) and in GS 105, 7 students did not click the textbook link (Table 8) and 5 students reported that they never used the textbook (Table 10). The number of students that use the textbook in any given course is not likely to be 100%, but the number of students that never even clicked the link once was truly shocking to this instructor. Of course, the link provided on the LMS course portal was not the only way to access the textbook and students might have been accessing it another way, such as through *Google* or the *OpenStax* website.

The most viewed link was the "gradebook", another result that is not particularly surprising. Students have always likely been slightly obsessed with grades, but modern technology allows students to monitor their grades in real-time, so this obsession may have become stronger. The "gradebook" link was the only link that was actually viewed by every student. Another comparison of note is the large difference between clicks on the "textbook" link and clicks on the "lecture materials" link. The "lecture materials" link is where the instructor posts PowerPoint slides and recorded .mp3 files containing audio of each lecture and the notes the instructor made on the board during the lecture. At first glance, it appeared students were not using the textbook, therefore, perhaps, there was a large number that were not studying.

However, it is possible that some students found the PowerPoint slides and lecture notes more useful than the textbook. Although neither the “textbook” link nor the “lecture materials” link were clicked by every student, it is at least conceivable that about half of the students used the textbook to study and the other half used the recorded lectures.

Tables 9 and 10 report survey data collected on student use. Although the clickstream data suggest there were a number of students that never clicked the textbook link once, Table 9 shows that there were 0 students that reported “never purchasing the textbook.” Are students purchasing textbooks that they don’t use? Indeed, several students report that they “never used the textbook” and 0 students reported that they “used the textbook every day.” Further, although an economical option was provided to students to print the textbook at the college bookstore, only 1 student actually elected to print the textbook. These data suggest that students may feel obligated to purchase textbooks that they may not even intend to use, with most students spending hundreds of dollars per year.

A vast majority of students reported that the quality of the customized OER textbook used in their course was “the same as” the quality of textbooks used in other courses (Table 12) – although, since it seems that many of them may never have even looked at the textbook, this doesn’t mean much. Students are more divided about whether they prefer the online format or the traditional format or a textbook, with nearly half of the students in CHEM 110 reporting that they felt the online format was “worse” than in other courses. Some of the open-ended responses from the survey cited the very long time that it takes to load the customized OER after clicking the link as one reason that they did not prefer that format. Students were told, however, that they could download a .pdf of the textbook that would load much faster. A clear majority of students indicated that they either preferred the course with an OER textbook to traditional courses or they had no preference, although about a third of students indicated that they preferred the traditional course format.

These results suggest that student-learning outcomes were not negatively affected by the use of OER. Although the current study is too limited in duration and sample size to provide any definitive determination about student learning, the results indicate that students are not opposed, in most cases, to taking a course with an OER textbook and, in some cases, they would even prefer this option.



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