

1-15-2022

Factors affecting student educational choices regarding OER material in Computer Science

Anastasia Angelopoulou

Rania Hodhod

Alfredo J. Perez

Follow this and additional works at: <https://digitalcommons.unomaha.edu/compscifacpub>



Part of the [Computer Sciences Commons](#)

Please take our feedback survey at: https://unomaha.az1.qualtrics.com/jfe/form/SV_8cchtFmpDyGfBLE

Factors affecting student educational choices regarding OER material in Computer Science

Anastasia Angelopoulou¹, Rania Hodhod¹, Alfredo J. Perez¹

¹ TSYS School of Computer Science, Columbus State University, 4225 University Ave, Columbus, GA USA

Abstract

The use of Open Educational Resources (OER) in course settings provides a solution to reduce the textbook barrier. Several published studies have concluded that high textbook costs may influence students' educational choices. However, there are other student characteristics that may be relevant to OER. In this work, we study various factors that may influence students' educational choices regarding OER and their impact on a student's perspectives on OER use and quality. More specifically, we investigate whether there are significant differences in the frequency of use and perceived quality of the OER textbook based on gender, prior academic achievements, income, seniority, sentiment about online format, and motivation to learn. Our study involved students enrolled in the "Data Structures" course at Columbus State University (N=61) and analyzed students' feedback before and during the COVID-19 pandemic to provide insights that can inform the decision of adopting OER in higher education settings. The results indicate that there is no significant difference between most of the students' characteristics and the perception of the quality and use of the OER textbook. However, two student characteristics presented significant differences. Students who used the OER textbook more frequently were more likely to have a less positive attitude towards the online format of the textbook. Also, students with higher motivation to learn perceived it as a better resource than the traditional textbook compared to students with lower motivation to learn.

Keywords

Open educational resources, Computer science, Student perceptions, Student motivation to learn, Textbook quality, COVID-19

Introduction

The inflating cost of required textbook materials in postsecondary education influences students' educational choices. For instance, students may forgo the purchase of required course textbooks (Florida Virtual Campus, 2016; Martin et al., 2017), take fewer courses, drop or withdraw from a course, all due to high textbook costs (Florida Virtual Campus, 2016). As a potential solution to reduce the textbook

barrier, Open Educational Resources (OER) have been authored, adopted, and used in course settings. OER are broadly defined as “the open provision of educational resources, enabled by information and communication technologies, for consultation, use, and adaptation by a community of users for non- commercial purposes” (UNESCO, 2002, p. 24). OER are free, openly licensed, and often peer-reviewed, online learning content, software tools, and accumulated digital curricula (Hilton III et al., 2016).

Past published studies have investigated the Cost, Outcomes, Use, and Perceptions (COUP) related to OER in recent years. Findings have generally shown significant financial benefits for students and cost savings on textbooks due to the implementation of OER in classes (Bliss et al., 2013; Fischer et al., 2015; Hilton III et al., 2013; Watson et al., 2017). Studies have also shown that the use of OER materials can eliminate the inequity in course material access among students, increase student engagement and retention in class (Young Mi and Carpenter, 2017), and improve student success and learning (Ashadevi & Muthamil Selvi, 2017; Dichev et al., 2015). Moreover, when students have access to affordable and accessible OER course materials, their achievements and success rates increase (McGreal, 2013).

Several studies have also looked at the impact of OER on students’ learning suggesting that there may be no effect of OER on students’ learning or change in educational outcomes (Hilton III et al., 2013; Croteau, 2017). This could be explained by the access hypothesis, which states that only students who are not able to purchase a traditional commercial textbook would benefit from having course materials freely available (Grimaldi et al., 2019). Indeed, a recent study (Colvard et al, 2018) showed that students who were from lower income backgrounds (based on financial aid eligibility) experienced more of a benefit from OER than their peers from other backgrounds. However, there are other student characteristics, such as prior academic achievement, student seniority, and motivation to learn, that may be also relevant to OER.

Objective of the study

The authors conducted this study to evaluate various factors that may affect the

quality and frequency of use of OER textbooks in Computer Science from the students' perspective before and during the coronavirus disease 2019 (COVID-19) pandemic. The objective is to understand how students in computer science courses perceive the quality and use of OER based on the following students' characteristics: motivation to learn, prior academic achievements, student seniority, sentiment about online textbook, gender, and income background (based on financial aid eligibility) and identify any changes in student perceptions and OER usage due to the pandemic. The study also aims to evaluate the frequency of use of the OER material, analyze the impact of different factors on student use of open textbooks, and present the results and student feedback before and during the pandemic. Although we may not be able to generalize these factors due to the scope of the research, the findings can still provide recommendations and insights to computer science instructors and institutions on how to select and implement OER materials in their courses.

Significance of the study

The paper presents a case study of OER material adopted in a computer science course. More specifically, the course instructors of the Data Structures course at our university adopted OERs and publicly licensed interactive material beginning in the Fall 2019 semester. Our study is expected to contribute to further exploratory or descriptive research in the area of OER adoptions in Computer Science. Even though our research is solely based on student perceptions, the authors expect that instructors and academic experts will be able to find out the factors and student sentiment about the quality and use of OER textbooks and identify any changes in student sentiment due to the COVID-19 pandemic. The COVID-19 pandemic, despite the health and economic impact, allowed us to research the use and perceptions of OER on students under conditions that would have been impossible to replicate in a lab environment. The outcome of this study will still provide useful insights for faculty to adopt or create OER in their courses.

Background

Student perceptions of the quality and use of OER are of particular

importance as they may impact student learning and performance. This section discusses the literature on the factors that may influence the perceptions of the students about the quality of OER and affect the frequency of using these open source, digital resources. The present paper focuses on several student characteristics, including motivation to learn, prior academic achievements, income background, gender, student seniority, and sentiment about online format that may affect how students perceive the quality and use of OER.

Motivation to learn

The first characteristic of interest is motivation to learn. The concept of motivational pedagogy has a variety of components that can help with students' learning, including student readiness (health, self-confidence, level of attention, sense of control over learning), cultural and social incentives and disincentives. When studied in the context of behavior, motivation is classified as intrinsic or extrinsic (Hayamizu, 1997). Motivation is classified as intrinsic when students' behavior is motivated by their internal desire. When students' motivation can be affected by external factors, then motivation is classified as extrinsic. In the context of OER, Rowell (2015) found no statistical difference in students' motivations when adopting OER in an Information Technology (IT) course compared against students' motivations in a non-IT course with OER.

Prior academic achievement

The second characteristic of interest is prior academic achievement, based on the Grade Point Average (GPA). The influence of student achievement on OER has been studied in the past. Research conducted by Engler and Shedlosky-Shoemaker (2019) found the SAT score to be a predictor of content mastery when studying OER adoption in an introductory psychology class ($N = 63$). The results of research conducted by Grewe and Davis (2017) indicated a significant positive moderate correlation between OER and student achievement (GPA). In this study, we have followed Grewe and Davis' recommendation (Grewe & Davis, 2017) that GPA should be controlled for any potential influence when assessing the impact of instructional

modifications (such as adopting an OER textbook).

Income background

The third characteristic of interest is the income background, based on financial aid eligibility. Textbooks represent a significant percentage of expenses encountered by college students and a substantial portion of the overall cost of higher education in the United States (Hilton, 2016; Hilton et al., 2014). Low-income students face greater difficulties in paying textbook fees (Kuh et al., 2006), which may result in some of the students deciding to take courses without purchasing the required course textbook (Watson, Domizi, & Clouser, 2017). This decision may negatively affect their understanding of the course material and their performance in the class (Fischer et al., 2015). The lack of finances can also hinder students at risk from academic success due to low engagement (Finn & Rock, 1997) and high stress.

Gender

The fourth characteristic of interest is gender. Most studies that have investigated the impact of gender on the student perspectives on OERs have concluded that there is no association between the gender and the student perceptions about the OER quality and usage (Hu et al., 2015; Yoo & Roh, 2019). For example, You and Roh (2019) investigated the impact of gender on the intention to adopt and use digital textbooks. The study concluded that the gender had no influence of performance and effort expectancy on the intention to use digital textbooks. Other studies have also concluded that gender has no influence when both males and females are equally motivated to adopt the technology (Hashim et al., 2015). However, there are studies that predicted that gender could influence the performance and effort expectancy related to the adoption and acceptance of technology (Venkatesh et al., 2003). Thus, our study explores whether the gender may influence the students' perspective on the quality and use of OER.

It should be noted that studies that have investigated the impact of gender on the student perspectives on OERs usually invite an equal representation of female and male participants (Cronin, 2017). In the social and life sciences, women are well

represented (Su & Rounds, 2016). However, girls and women are underrepresented in Computer Science (Burke & Mattis, 2007; Ceci & Williams, 2011). In our study, female participants are 30% of the total number of students who completed the survey.

Student seniority

The fifth characteristic of interest is student seniority based on terms completed so far. Students in the early years of their studies may study or use an OER textbook in a different way than more senior students. Studies have shown that senior students study more according to their own learning needs/interests and become better self-directed learners during the years of training (Van Den Hurk et al., 1999). On the other hand, first- and second-year students are usually not yet experienced self-directed learners and may need more external regulation during their individual study. In this study, we investigate whether the student seniority may influence the student perception of the quality and the frequency of use of the OER material.

Even though the quality of OER materials is often better perceived because of the materials being openly available for improvement or products of teamwork, there are OER materials and textbooks that may not always match the learning needs for the given students' grade level (Mishra, 2017). Moreover, it is difficult to prove that students learn better due to a particular OER textbook because OER are static pieces of digital content that do not act independently but need to be part of a process of use for an outcome or impact to emerge (Smith & Seward, 2017).

Sentiment about online format of textbook

The final characteristic of interest is student sentiment about online format of text- books and instructional material. Textbooks and other course materials are an integral part of the students' learning experience. The use of digital textbooks and different technologies, in general, in a teaching environment can directly influence student performance (Dille & Mezack, 1991). Past research has shown that students' decisions to use different types of technologies depend greatly on their individual preferences (Grasha & Yangarber-Hicks, 2000). This in turn can influence student's preference and acceptance of using OER textbooks in class (Millar & Schrier, 2015).

OER are usually found to be as good as or better than traditional textbooks in quality, access, and engagement (Cooney, 2017; Ikaiahifo et al., 2017). Students generally hold positive opinion towards the adoption of free, open textbooks, primarily due to their cost saving advantage. Portability, ease of use, convenience, and ease of access are other factors that students usually highlight in their responses (Brandle et al., 2019; Ozdemir & Hendricks, 2017). Portability and ease of access are particularly of crucial importance for students with multiple responsibilities and long commutes (Cooney, 2017). In other studies, students have reported the advantages of mobile learning and how OERs foster the development of self-directed skills (Lin, 2019). However, students have also reported challenges associated with OER, such as need for internet access, slow internet connections, unclear instruction and guidance, and insufficient self-regulation skills.

Study design

This research studied students from three class sections through the adoption of OER material and an end-of-term survey. The survey included questions about the quality and use of OER as well as motivation to learn, prior academic achievements, income background, student seniority, sentiment about online textbook, and gender. Most of the questions were multiple-choice with a couple of open-ended questions related to the students' overall thoughts about the OER textbook used in class. The study was designed for two primary reasons: (1) to investigate how students in computer science courses perceive the quality and use of OER, and (2) to examine how gender, motivation to learn, prior academic achievements, income background, student seniority, and sentiment about online textbook format may impact student perceptions. The study can provide insights on the student–OER interactions and further recommendations on the use of OER in computer science courses.

Procedure

Data were collected through a brief (10–15 min) Qualtrics online survey, distributed to undergraduate students enrolled in three sections of the same course (“Data Structures”) during the Fall 2019, Fall 2020, and Spring 2021 semesters. To

achieve higher response rates and reduce bias in sampling, the instructors offered extra credit points to complete the survey. This methodology may limit the generalizability of the research findings (Padilla-Walker et al., 2005) and doesn't determine the reliability of the study. Sixty-one ($N = 61$) students (51%) completed the survey. The different sections were taught by different instructors but used the same OER materials. All students participated voluntarily, with the assurance of anonymity. The instructors invited students to complete the survey through announcements in class and on the course websites. This study received an exempt approval from the University's Institutional Review Board (Research Ethics Board).

OER material

The Data Structures course is a core course for computer science undergraduate majors at our university and at most undergraduate computer science programs in the world that follow the Association for Computer Machinery's (ACM) Computer Science Curricula (ACM, 2013). This course is the third course in the sequence of programming courses and students usually take it in their sophomore year.

In previous deliveries of the Data Structures course, instructors used the book titled "Java Foundations: Introduction to Program Design and Data Structures" (Lewis et al., 2016) as the required course textbook. At the time of writing this work, the listed price for this book is \$173.00 USD (Pearson, 2020). We replaced this book with the Open Data Structures and Algorithms (OpenDSA) OER material developed at Virginia Tech (Fouh et al., 2014). This OER textbook is a platform to teach data structures, algorithms, and finite automata theory, and has been developed under an open source license. The OpenDSA material was supplemented with the free to use CodeWorkout online training exercises from Virginia Tech (Edwards & Murali, 2017), the Visualising Data Structures and Algorithms Through Animation (Visu- Algo) platform which is a free to use website developed at the National University of Singapore to teach data structures and algorithms (Halim, 2015), and some web- sites with free materials that describe implementations of data structures in the Java programming language. The monetary cost to use these materials was zero to the instructors and students. The instructors linked the appropriate hyperlinks for the topics in each OER in

each of the course sections' website at the university's online course management system.

Data analysis

A 28-item online survey was administered to gather data from students enrolled in the three Data Structures sections that used OER. At the end of the survey period, the instructors aggregated student responses by classroom using descriptive statistics, such as averages for each selected response survey item. Additional analysis was conducted by comparing the results of groups of students using independent-sample statistical t tests to determine if students who are eligible for financial aid respond differently on key questions about the quality and frequency of use of textbook than students who are not. We did the same process to compare the other characteristics in the study: student motivation to learn, prior academic achievements, gender, student seniority, and sentiment about online format. The independent variables were income (based on financial aid eligibility), prior academic achievement (based on GPA), motivation to learn, gender, seniority (based on terms completed so far), and sentiment about online textbook. The dependent variables were the student perception rating for the quality of the textbook and the frequency of textbook use. The analysis was performed using Minitab. The results are summarized aggregated by classroom and by question.

Student characteristics' statistics

This section summarizes the results from the questions that are relevant to the use of OERs in past courses and in the current course in terms of student characteristics (independent variables). The results are presented before and during the COVID-19 pandemic as well as aggregated in the next sections.

Demographics and income background

Participants were asked to indicate their gender and whether they have a student loan or receive financial assistance from the government or the university. They were also asked to input the average amount they spend on textbooks in a typical semester using the following response scale: 1 = Less than \$100, 2 = \$101–\$200, 3 = \$201–

\$300, 4 = \$301–\$400, 5 = \$401–\$500, 6 = More than \$500. Thirty percent of the total participants were females and 70% were male students. Table 1 summarizes the demographic and financial statistics pre-pandemic, during the pandemic, and aggregated. The mean and standard deviation (in parenthesis) are reported. Most of the students indicated that they received financial aid and spent \$101–\$200 on textbooks in a typical semester.

Past academic achievement and student seniority

Participants were asked to indicate the number of terms they have completed using the following response scale: 0 = Less than 1, 1 = 1–2, 2 = 3–4, 3 = 5–6, 4 = 7–8, 5 = 9–10, 6 = More than 10. They were also asked to report their cumulative college GPA on a 4.0 using the following response scale: 0 = 0.0–1.4, 1 = 1.5–2.0, 2 = 2.1–2.5, 3 = 2.6–3.0, 4 = 3.1–3.5, 5 = 3.6–4.0, 6 = *This is my first term*. They were also asked to indicate the number of courses per semester. Table 2 summarizes the results pre-pandemic, during the pandemic, and aggregated. Most students indicated that they had completed 3–4 terms at the time of the survey, had a GPA 2.6–3.0, and were taking 4–5 courses on average per semester. There were no students that took the course during their first term or had GPA less than 2.1.

Motivation to learn

The motivation to learn dimension was measured using five items (#1–#5) included in the OER perceptions survey based on the following response scale: 1 = Strongly Agree, 2 = Agree, 3 = Neutral, 4 = Disagree, 5 = Strongly Disagree (Rowell, 2015). The five items related to the student’s perception of their motivation to learn are reported as motivation to learn item means and are presented in Table 3.

Table 1 Demographic and financial characteristics of the students

	Results pre-pandemic N = 33	Results during the pandemic N = 28	Aggregated N = 61
Female (%)	30	21	26
Male (%)	70	79	74
Loans (%)	70	68	69
Pell grant or fee waivers (%)	58	75	66

Table 2 Past academic achievements

	Results pre-pandemic <i>N</i> = 33	Results during pandemic <i>N</i> = 28	Aggregated Results <i>N</i> = 61
Terms completed	2.56 (1.35)	2.96 (1.26)	2.72 (1.33)
GPA	3.68 (0.93)	3.79 (0.99)	3.72 (0.97)
Number of courses per semester	4.91 (1.04)	4.39 (0.88)	4.67 (1.01)

The motivation to learn items were all 2.56 or less, indicating that students are motivated to learn. The lowest motivation to learn item mean supports student motivation to learn as a result of students enjoying learning challenging things pre-pandemic and during the pandemic. The second lowest motivation to learn item mean supports student motivation to learn as a result of students completing their homework on time.

Sentiment about online format

Participants were asked to rate the online format of the texts used for this course using the following scale: 1 = I like the online format MORE than traditional text- book, 2 = I like the online format LESS than traditional textbook, 3 = I have no preference. Most students (54%) were positive towards the online format of the OER textbook used in the class overall, with 45% being positive towards the online format of the book pre-pandemic and 66% during the pandemic. The mean of the sentiment about the online format is 1.94 with standard deviation 0.94.

Data analysis by question related to frequency of use and quality of OER text

This section summarizes the descriptive statistics by question.

Question 1: *“In general, how often do you purchase the required texts for the courses you take? (1) Never; (2) Rare; (3) About half the time; (4) Often; (5) Always”*

Most students indicated that they would purchase the required text about half of the time for the courses they take. The average rating on the question asking students to

indicate how often they purchase the required textbook in a typical course is 3.39 (SD = 1.05). The average frequency of purchasing a textbook is approximately the same for both female and male students pre-pandemic but higher for female students during the pandemic. The frequency of purchasing the textbooks was higher for students that do not receive financial aid compared to those receiving financial aid in all cases. Also, the results show that the frequency of textbook purchase decreases on average as students complete more terms in the program. Students with higher GPAs also indicated that they purchased textbooks more often than those in the lower GPA scale. Table 4 summarizes the answers grouped by factor.

Table 3 Motivation to learn item means

	Results pre- pandemi c N = 33	Results during pandemic N = 28	Aggregat ed Results N = 61
1. I like to learn things that are challenging	1.78 (0.71)	1.86 (0.76)	1.82 (0.72)
2. I am able to complete my homework on time	2.03 (0.97)	1.86 (0.71)	1.93 (0.85)
3. I enjoy working on my assignments/projects	2.34 (1.18)	2.29 (1.05)	2.31 (1.10)
4. I enjoy learning in an environment that incorporates- digital textbooks	2.41 (1.07)	2.00 (0.86)	2.20 (1.00)
5. I would describe using digital textbooks as interesting	2.56 (1.01)	2.00 (0.86)	2.30 (0.97)
Scale Mean Motivation to learn	2.23 (0.52)	2.00 (0.17)	2.11 (0.22)

Question 2: *“For a typical course, how often do you use the required texts?(1) Never; (2) 2–3 times a Semester; (3)2–3 times a Month; (4)2–3 times a Week; (5) Daily”*

The majority of students indicated that they use the required text 2–3 times a semester. The average rating on the question asking students to indicate how often they use required textbooks is 2.74 (SD = 1.12). Female students indicated that they use the required texts more often on average than the male students in a typical course. Students on average used the required texts on the same frequency regardless financial aid. Students that had completed 5–6 terms used textbooks in a typical course more often than the rest of the students. Students with lower GPA (2.1–2.5) indicated that they used the textbook more often than the rest of the students pre- pandemic, while students with GPA ranging between 2.6 and 3.5 used the textbook in a typical course more often than the rest of the students during the pandemic. Table 5 summarizes the results by factor.

Question 3: *“How often did you use the texts for this course during the semester? (1) Never; (2) 2–3 times a Semester; (3) 2–3 times a Month; (4) 2–3 times a Week; (5) Daily”*

Most students indicated that they use the required text 2–3 times a semester over- all, with the majority of student indicating that they used the required text in this course 2–3 times a semester pre-pandemic and 2–3 times a week during the pandemic. The average rating on the question asking students to indicate how often they use required textbooks is 2.84 (SD = 1.20). Female students indicated that they used the required texts more often on average than the male students in the Data Structures course. Students on average used the required texts on the same frequency regardless financial aid. Students who had completed 1–2 terms and 5–6 terms pre- pandemic used the textbook in this course more often than the rest of the students. Students who had completed 5–8 terms during the pandemic used the textbook in this course more often than the rest of the students. Students with GPA between 2.6 and 3.5 indicated that they used the textbook more often in this course than a typical course pre- pandemic, while students with lower GPA used the textbook in this course more often than the rest of the students with higher GPA during the pandemic. Table 6 summarizes the results by factor.

Table 4 Frequency of purchase by factor

Factor	Definition	Count pre-pandemic	Average frequency of text- book purchase pre-pandemic	Count during pandemic	Average frequency of textbook purchase during pandemic	Count total	Average frequency of textbook purchase
Gender	Female	10	3.50 (0.71)	6	4.17 (0.75)	16	3.75 (0.77)
	Male	23	3.47 (1.20)	22	3.05 (1.00)	45	3.27 (1.12)
Financial Aid	Yes	19	3.21 (1.06)	21	3.05 (1.02)	40	3.13 (1.02)
	No	14	3.86 (1.03)	7	4.00 (0.82)	21	3.90 (0.94)
Terms completed so far	Less than 1	0	–	0	–	0	–
	1–2	7	3.86 (1.21)	2	4.50 (0.71)	9	4.00 (1.12)
	3–4	15	3.47 (1.60)	10	3.10 (1.29)	25	3.32 (1.22)
	5–6	3	3.34 (0.58)	7	3.00 (0.58)	10	3.10 (0.57)
	7–8	4	3.50 (1.00)	7	3.29 (1.11)	11	3.36 (1.03)
	9–10	3	2.67 (0.58)	0	–	3	2.67 (0.58)
	More than 10	1	4.00	2	4.00	3	4.00
	GPA	0–1.4	0	–	0	–	0
	1.5–2.0	0	–	0	–	0	–
	2.1–2.5	3	3.00 (1.00)	4	2.50 (1.73)	7	2.71 (1.38)
	2.6–3.0	13	3.46 (0.88)	5	3.20 (0.84)	18	3.39 (0.85)
	3.1–3.5	9	3.22 (1.30)	12	3.75 (0.97)	21	3.52 (1.12)
	3.6–4.0	8	4.00 (1.07)	7	3.00 (0.58)	15	3.53 (0.99)

Table 5 Frequency of textbook use in a typical course by factor

Factor	Definition	Count pre-pandemic	Average frequency of text- book use in a typical course pre-pandemic	Count during pandemic	Average frequency of text- book use in a typical course during pandemic	Count total	Average frequency of textbook use in a typical course
Gender	Female	10	3.00 (0.89)	6	3.67 (1.21)	16	3.25 (1.06)
	Male	23	2.39 (0.94)	22	2.73 (1.30)	45	2.56 (1.10)
Financial Aid	Yes	19	2.63 (0.96)	21	2.81 (1.29)	40	2.73 (1.13)
	No	14	2.5 (0.94)	7	3.29 (1.38)	21	2.76 (1.14)
Terms completed so far	Less than 1	0	–	0	–	0	–
	1–2	7	2.86 (1.07)	2	3.50 (0.71)	9	3.00 (1.12)
	3–4	15	2.47 (0.99)	10	2.30 (1.34)	25	2.40 (1.22)
	5–6	3	3.34 (1.15)	7	2.86 (1.21)	10	3.00 (1.15)
	7–8	4	2.00	7	3.57 (1.40)	11	3.00 (1.34)
	9–10	3	2.67 (0.58)	0	–	3	2.67 (0.58)
	More than 10	1	2.00	2	3.50 (0.71)	3	3.00 (1.00)
	GPA	0–1.4	0	–	0	–	0
	1.5–2.0	0	–	0	–	0	–
	2.1–2.5	3	3.00 (1.00)	4	2.50 (1.73)	7	2.71 (1.38)
	2.6–3.0	13	2.69 (0.95)	5	3.20 (0.84)	18	2.83 (0.92)
	3.1–3.5	9	2.00 (0.71)	12	3.42 (1.16)	21	2.81 (1.21)
	3.6–4.0	8	2.88 (0.99)	7	2.14 (1.35)	15	2.53 (1.19)

Question 4: *“How would you rate the quality of the texts used for this course? (1) WORSE than the quality of the texts in my other courses; (2) About the SAME AS the quality of the texts in my other courses; (3) BETTER than the quality of the texts in my other courses”*

Participants were asked to rate the quality of text in the surveyed course compared to texts used in other courses. Most students (77%) perceived the quality of the OER material about the same as the quality of texts in other courses. Although no student responded that the textbook quality was worse than the traditional text- book pre-pandemic, they provided comments about features of the book being worse, such as lack of depth and limited practice examples that made it harder to understand some concepts. Students who rated the textbook quality as worse than traditional textbooks during the pandemic commented on the lack of breakdown of each individual section and the difficulty of understanding it the way it was worded. Students also provided comments about features of the book being better, such as the price (free), accessibility (online access), and interactivity (examples with step- by-step visualizations of concepts). Tables 7 and 8 summarize the Quality of Text- book statistics.

Question 5: *“How do you feel about the online format of the texts used for this course? (1) I like the online format MORE than traditional textbook; (2) I like the online format LESS than traditional textbook; (3) I have no preference”*

The average rating for the online format of text is 1.74 (SD = 0.87). The percentage of students that liked the traditional format of text more than the online was 15% pre-pandemic, 21% during the pandemic, and 18% overall. The students, who answered that they liked the online format less than the traditional textbook, had used the textbook in this course more frequently. However, 28% of students answered that they had no preference, with 39% of students having no preference pre-pandemic and 14% during the pandemic. Table 9 summarizes the results.

Question 6: *“How likely are you to register for a future course with online texts like those used in this course? (1) Very Unlikely; (2) Somewhat Unlikely; (3) Somewhat Likely; (4) Very Likely”*

Most students (82% pre-pandemic and 93% during the pandemic) indicated that it is “Somewhat Likely” or “Very Likely” to register for a future course with similar online

texts. The average rating is 3.18 (SD = 0.79). Students that are somewhat or very unlikely to register for future courses with online text used the textbook more frequently pre-pandemic. Table 10 summarizes the results.

Question 7: “Overall, what do you think of the texts used in this course?”

Overall, students liked the OER material. Most of the students commented that they found the textbook useful, helpful, accessible, simple, and free to use. Some students found the textbook adequate but mentioned that some chapters could benefit from improvement, other chapters were not so informational as other material or as the lectures, and that the textbook did not always help to complete class assignments. Two students indicated that they would prefer physical material, hard or soft covers.

Impact of factors on the frequency of use and perceived quality of OER textbook

Independent-samples t tests and χ^2 tests were used to determine whether there were significant differences in the frequency of use and the perceived quality of the textbook based on the following independent variables: gender, financial aid, GPA, terms completed, and sentiment about online format. The dependent variables were the *Frequency of Use of OER* rating and the *Perceived Quality of Text of the OER* rating. The analysis included the aggregate dataset $N = 61$, as well as the pre-pandemic ($N = 33$) and during the pandemic ($N = 28$) datasets. Mann–Whitney tests were also performed for the analysis of the pre-pandemic and during the pandemic datasets due to their smaller sample size.

Gender, income background, past academic achievement, and student seniority

Independent-samples t tests and Mann–Whitney tests were performed to determine if differences in the mean scores on the *Frequency of Use of OER* rating and the *Perceived Quality of Text of the OER* could be attributed to the gender (male or female) and income background (financial aid or not) pre-pandemic, during the pandemic, and across all semesters. χ^2 Tests were performed to determine if differences in the mean scores on the *Frequency of Use of OER* rating and the *Perceived Quality of Text of the OER* could be attributed to prior academic achievement

Table 6 Frequency of textbook use in this course by factor

Factor	Definition	Count pre-pandemic	Average frequency of textbook use in this course pre-pandemic	Count during pandemic	Average frequency of textbook use in this course during pandemic	Count total	Average frequency of textbook use in this course
Gender	Female	10	3.1 (1.19)	6	2.83 (1.17)	16	3.00 (1.15)
	Male	23	2.43 (1.19)	22	3.14 (1.17)	45	2.78 (1.22)
Financial Aid	Yes	19	2.53 (1.07)	21	3.10 (1.18)	40	2.83 (1.15)
	No	14	2.78 (1.42)	7	3.00 (1.15)	21	2.86 (1.31)
Terms completed so far	Less than 1	0	–	0	–	0	–
	1	7	3.14 (1.06)	2	2.00 (1.41)	9	2.89 (1.17)
	1–2	15	2.54 (1.44)	10	2.80 (1.23)	25	2.64 (1.22)
	3–4	3	3.34 (2.08)	7	3.14 (1.21)	10	3.20 (1.40)
	5–6	4	2.00 (0.81)	7	3.57 (0.98)	11	3.00 (1.18)
	7–8	3	2.67 (0.58)	0	–	3	2.67 (0.58)
	9–10	1	1.00	2	3.50 (0.71)	3	2.67 (1.53)
GPA	More than 10	0	–	0	–	0	–
	0–1.4	0	–	0	–	0	–
	1.5–2.0	3	2.67 (0.58)	4	3.50 (1.73)	7	3.14 (1.35)
	2.1–2.5	13	2.77 (1.09)	5	3.20 (0.84)	18	2.89 (1.02)
	2.6–3.0	9	2.34 (1.58)	12	3.08 (1.16)	21	2.76 (1.37)
	3.1–3.5	8	2.75 (1.28)	7	2.71 (1.11)	15	2.73 (1.16)
3.6–4.0							

Table 7 Perceived textbook quality compared to traditional textbook

Factor	Definition	Count pre-pandemic	Average frequency of textbook use in this course	Count during pandemic	Average frequency of textbook use in this course during pandemic	Count total	Average frequency of textbook use in this course
Perceived textbook quality compared to traditional textbook	Worse	0	-	2	2.5(1.15)	2	2.5(1.15)
	Same	27	2.57 (1.22)	20	3.00 (1.13)	47	2.74 (1.19)
	Better	6	3.00 (1.26)	6	3.50 (1.14)	12	3.25 (1.20)

Table 8 Quality of textbook used in this course by factor

Factor	Definition	Count pre-pandemic	Average rating of this course pre-pandemic	Count during pandemic	Average quality rating of textbook this course during pandemic	Count total	Average quality rating of textbook this course
Gender	Female	10	2.20 (0.42)	6	1.83 (0.41)	16	2.06 (0.44)
	Male	23	2.13 (0.34)	22	2.23 (0.53)	45	2.20 (0.46)
Financial Aid	Yes	19	2.11 (0.32)	21	2.19 (0.40)	40	2.15 (0.36)
	No	14	2.29 (0.47)	7	2.00 (0.82)	21	2.19 (0.60)
Terms completed so far	Less than 1	0	-	0	-	0	-
	1-2	7	2.14 (0.38)	2	2.00	9	2.11 (0.33)
	3-4	15	2.33 (0.49)	10	2.00	25	2.20 (0.41)
	5-6	3	2.00	7	2.43 (0.79)	10	2.30 (0.67)
	7-8	4	2.00	7	2.00 (0.58)	11	2.00 (0.45)
	9-10	3	2.00	0	-	3	2.00
	More than 10	1	2.00	2	2.50 (0.71)	3	2.33 (0.58)
	GPA	0-1.4	0	-	0	-	0
	1.5-2.0	0	-	0	-	0	-
	2.1-2.5	3	2.00	4	2.00 (0.82)	7	2.00 (0.58)
	2.6-3.0	13	2.15 (0.38)	5	2.40 (0.55)	18	2.22 (0.43)
	3.1-3.5	9	2.22 (0.44)	12	2.00	21	2.10 (0.30)
	3.6-4.0	8	2.25 (0.46)	7	2.29 (0.76)	15	2.27 (0.59)

Table 9 Sentiment about online format compared to traditional textbook

Factor	Definition	Count pre-pandemic	Average frequency of textbook use in this course pre-pandemic	Count during pandemic	Average frequency of textbook use in this course during pandemic	Count total	Average frequency of textbook use in this course
Sentiment about online format	More	15	2.33 (0.90)	18	3.05 (1.11)	33	2.72 (1.07)
	Less	5	4.20 (0.83)	6	3.33 (1.37)	11	3.72 (1.19)
	No Preference	13	2.38 (1.26)	4	2.75 (1.26)	17	2.47 (1.23)

Table 10 Likelihood to register for a future course with online text

Question	Definition	Count pre-pandemic	Average frequency of textbook use in this course pre-pandemic	Count during pandemic	Average frequency of textbook use in this course during pandemic	Count total	Average frequency of textbook use in this course
Likely to register for a future course with online text	Very Unlikely	2	4 (1.41)	1	3.00	3	3.66 (1.07)
	Somewhat Unlikely	4	3.25 (1.71)	1	1.00	5	2.80 (1.19)
	Somewhat Likely	16	2.25 (1.26)	15	3.26 (1.26)	31	2.74 (1.23)
	Very Likely	11	2.72 (1.35)	11	3.50 (1.35)	22	2.86 (1.35)

(GPA scores; 2.1–2.5, 2.6–3.0, 3.1–3.5, 3.6–4.0) and student seniority (Term completed so far; 1–2; 3–4; 5–6; 7–8; more than 9).

Frequency of Use of OER

The *t* tests' results indicate that there was no significant difference in Frequency of Use of OER across all semesters:

- for female ($M = 3.00$, $SD = 1.15$) and male ($M = 2.78$, $SD = 1.22$) students; $p = 0.523$, 95% CI [- 0.478, 0.918], despite female students using the OER text- book more frequently than male students, and
- for students receiving financial aid ($M = 2.83$, $SD = 1.15$) and students not receiving financial aid ($M = 2.86$, $SD = 1.31$); $p = 0.930$, 95% CI [- 0.717, 0.657].

The χ^2 tests for association results indicate that there is no significance difference between:

- Frequency of OER use (Never; 2–3 times a Semester; 2–3 times a Month; 2–3 times a Week; Daily) and GPA (2.1–2.5, 2.6–3.0, 3.1–3.5, 3.6–4.0); $\chi^2(12, N = 61) = 5.61$, $p = 0.935$.
- Frequency of OER use (Never; 2–3 times a Semester; 2–3 times a Month; 2–3 times a Week; Daily) and Terms Completed so far (1–2; 3–4; 5–6; 7–8; more than 9); $\chi^2(16, N = 61) = 15.5$, $p = 0.49$.

We also tested the pre-pandemic and during the pandemic datasets using Mann–Whitney tests, as well as χ^2 tests for association by merging GPAs to lows (2.1–3.0) and highs (3.1–4.0). There was no significant difference in Frequency of Use of OER based on the gender, income background, seniority, and past academic performance of students taking this course pre-pandemic and during the pandemic at the 0.05 level of significance.

The χ^2 tests for association results indicate that there is no significance difference between:

- Perceived Quality of Text of the OER (worst, same, better) and GPA (2.1–2.5, 2.6–3.0, 3.1–3.5, 3.6–4.0); $\chi^2(6, N = 61) = 4.5687$, $p = 0.6$.
- Perceived Quality of Text of the OER (worst, same, better) and Terms Completed so far (1–2; 3–4; 5–6; 7–8; more than 9); $\chi^2(8, N = 61) = 5.08$, p

= 0.53.

We also tested the pre-pandemic and during the pandemic datasets using Mann–Whitney tests, as well as χ^2 tests for association by merging GPAs to lows (2.1–3.0) and highs (3.1–4.0). There was no significant difference in *Perceived Quality of Text of the OER* based on the gender, income background, seniority, and past academic performance of students taking this course pre-pandemic and during the pandemic at the 0.05 level of significance.

Perceived Quality of Text of the OER

The *t* tests' results indicate that there was no significant difference in *Perceived Quality of Text of the OER* across all semesters:

- for female ($M = 2.06$, $SD = 0.46$) and male ($M = 2.20$, $SD = 0.46$) students; $p = 0.396$, 95% CI $[-0.472, 0.192]$, despite male students rating the OER text- book higher than female students, and
- for students receiving financial aid ($M = 2.15$, $SD = 0.36$) and students not receiving financial aid ($M = 2.19$, $SD = 0.60$); $p = 0.781$, 95% CI $[-0.333, 0.253]$.

The χ^2 tests for association results indicate that there is no significance difference between:

- Perceived Quality of Text of the OER (worst, same, better) and GPA (2.1–2.5, 2.6–3.0, 3.1–3.5, 3.6–4.0); $\chi^2(6, N = 61) = 4.5687$, $p = 0.6$.
- Perceived Quality of Text of the OER (worst, same, better) and Terms Completed so far (1–2; 3–4; 5–6; 7–8; more than 9); $\chi^2(8, N = 61) = 5.08$, $p = 0.53$.

We also tested the pre-pandemic and during the pandemic datasets using Mann–Whitney tests, as well as chi-square tests for association by merging GPAs to lows (2.1–3.0) and highs (3.1–4.0). There was no significant difference in *Perceived Quality of Text of the OER* based on the gender, income background, seniority, and past academic performance of students taking this course pre-pandemic and during the pandemic at the 0.05 level of significance.

Sentiment about online format

χ^2 Tests were performed to determine if differences in the mean scores on the Frequency of Use of OER rating (Never; 2–3 times a Semester; 2–3 times a Month; 2–3 times a Week; Daily) and the Perceived Quality of Text of the OER (worst, same, better) could be attributed to the Sentiment about online format (MORE, LESS, No Preference). The independent variable was the sentiment and the dependent variables were the Frequency of Use of OER rating and the Perceived Quality of Text of the OER rating.

The results indicate that the relationship between the Perceived Quality of OER use and sentiment $\chi^2(4, N = 61) = 3.3, p = 0.5$ is not significant. However, the relationship between the Frequency of OER use and sentiment $\chi^2(8, N = 61) = 16.54, p = 0.035$ is significant at the 0.05 α level. After performing a residual analysis, we identified the specific cells that made the greatest contribution to the χ^2 test result: Daily—LESS (Adjusted Residual = 2.39) and 2–3 Times a Semester—MORE (Adjusted Residual = 2.48). Students that used the OER textbook more frequently were more likely to have a less positive attitude towards the online format of the textbook.

We also tested the relationship between the Frequency of OER use and sentiment pre-pandemic and during the pandemic using the Fisher's exact test for the specific cells that made the greatest contribution. The results indicate that there is no significant difference pre-pandemic ($p = 0.0545$) or during the pandemic ($p = 0.25$).

Motivation to learn

Independent-samples t tests and Pearson correlation tests were used to determine if differences in the mean scores on the Frequency of Use of OER rating and the Perceived Quality of Text of the OER could be attributed to the motivation to learn pre- pandemic, during the pandemic, and across all semesters. The independent variable was the motivation to learn and the dependent variables were the Frequency of Use of OER rating and Quality of Text rating.

Frequency of Use of OER

The null hypothesis is defined as follows: " $H_0 =$ There is no significant difference in the mean scores on the Frequency of Use of OER rating based on students with high

motivation to learn ≤ 2.5 taking the OER course and students with lower motivation to learn > 2.5 taking the OER course.”

There was no significant difference in the Frequency of Use of OER rating for students with high motivation to learn ($M = 2.65$, $SD = 1.23$) and students with lower motivation to learn ($M = 3.19$, $SD = 1.08$); $p = 0.083$, 95% CI [- 1.155, 0.074] across all semesters. However, there was a significant difference in the mean scores on the Frequency of Use of OER rating based on high/low motivation to learn pre-pandemic. Students with high motivation to learn were likely to use the OER textbook more frequently than lower motivated students before the pandemic.

Perceived Quality of Text of the OER

The null hypothesis is defined as follows: “ $H_0 =$ *There is no significant difference in the mean scores on the Quality of Text of the OER perceptions survey based on students with high motivation to learn ≤ 2.5 taking the OER course and students with lower motivation to learn > 2.5 taking the OER course.”*

There was a significant difference in the Perceived Quality of Text of the OER for students with high motivation to learn ($M = 2.275$, $SD = 0.506$) and students with lower motivation to learn ($M = 1.952$, $SD = 0.218$); $p = 0.001$, 95% CI [0.1363, 0.509] across all semesters. We also tested the relationship between the perceived textbook quality and the motivation to learn pre-pandemic and during the pandemic and we found a significance difference in both cases. Therefore, the null hypothesis was rejected; students with higher motivation perceived the quality of the OER text- book as better than traditional textbooks compared to students with lower motivation to learn.

Frequency of Use vs. Perceived textbook quality

We also investigated if differences in the mean scores on the Frequency of Use could be attributed to the Perceived Quality of Text of OER. The independent variable in this case was the Perceived Quality of Text of OER (same, better). The null hypothesis was defined as follows:

$H_0 =$ There is no significant difference in the mean scores on the Frequency of Use of OER based on students perceiving the OER quality as the same as other

courses and students perceiving the OER quality as better than other courses.

The results indicate that there was no significant difference in Frequency of Use of OER for students perceiving the OER quality as the same as other courses ($M = 2.74$, $SD = 1.21$) and students perceiving the OER quality as the better than other courses ($M = 3.25$, $SD = 1.06$); $p = 0.167$, 95% CI [- 1.242, 0.231]. There was no significant difference in the mean scores on the Frequency of Use of OER based on the perceived quality across all semesters, pre-pandemic, or during the pandemic.

Discussion

The purpose of this study was to analyze factors that may contribute to the students' frequency of use and perceived quality of OER text in computer science courses before and during the COVID-19 pandemic. Specifically, we examined six factors that may affect the students' perspectives on the frequency of use and quality of OER textbook pre-pandemic, during the pandemic, and across all semesters (Fall 2019, Fall 2020, and Spring 2021). These factors were: gender, income background, motivation to learn, prior academic achievement, seniority, and sentiment about online format.

To address our research objectives, we analyzed the students' responses to our survey and provided descriptive statistics of the students' perspectives of frequency of use and quality and the factors that may affect them by classroom and as a total. Students reported an increased frequency of use for the OER textbooks in the different sections of this course compared to the frequency of using textbooks in past courses. They also reported that the quality of OER textbooks was perceived as the same as or better than traditional textbooks and the shift to OER textbooks saved them \$101–\$200 on average in a typical semester. These findings are consistent with the results from a report, which states that students saved more than \$100 per course when using OER (Griffiths et al., 2017). They are also consistent with research that found that approximately half of the students reported the OER textbooks had the same quality as traditional textbooks and nearly 40% reported that they were better (Bliss et al., 2013). Nevertheless, in our study, it is notable that students who preferred traditional textbook format or who would be unlikely to register for courses with online textbooks reported that they used the OER textbook more often than the students who preferred online

textbook formats or would be more likely to register for future courses with a similar textbook.

We also examined the impact of these factors on the frequency of use and quality of OER textbook. The six factors (gender, income background, motivation to learn, prior academic achievement, seniority, and sentiment about online format) were considered as independent variables in our analysis. The dependent variables were the frequency of use and the quality of text rating based on the students' perception. The findings from the statistical tests revealed that there were no significant differences between four of the independent variables (gender, income background, prior academic achievement, and seniority) and the frequency of use or the quality of OER textbook perception.

However, we found a correlation between the sentiment about online format and the frequency of using the textbook across all semesters (Fall 2019, Fall 2020, and Spring 2021). More frequent use of the OER textbook indicated an increased likelihood to have a less positive attitude towards the online format of the book. The negative attitude in this case may be attributed to the wording of the OER textbook or to the preference of reading a traditional book. Students who used the textbook more frequently (i.e. daily) mentioned that the textbook wording for some concepts was difficult to understand compared to when the instructor explained them. They also noted that they would prefer to use an actual textbook.

We also found a correlation between the motivation to learn and the quality of textbook across all semesters as well as between the motivation to learn and the frequency of use pre-pandemic. These findings demonstrate that students who had higher motivation to learn perceived the quality of OER textbook better than a traditional textbook across all semesters and used it more often than the rest of the students who has lower motivation to learn pre-pandemic. Students with lower motivation to learn may have found it difficult to stay focused while reading online textbooks or completing online tasks (Smart & Cappel, 2006; Smidt et al., 2014) pre-pandemic. Distractions (Felix, 2001) or lack of experience with using online books and technology (Smart & Cappel, 2006) may have affected the frequency of use of OER by less motivated students pre-pandemic compared to the frequency of use of OER during the pandemic when the use of technology and the completion of online assessments was required. It

can also be concluded from the findings of the study that students were highly motivated to learn as a result of them enjoying learning challenging topics. Our impact findings on students' motivation to learn and the frequency of use and perceived quality of OER textbook seem to agree with those reported by Morales and Baker (2018), but we note that Morales and Baker's analysis investigated whether the open textbook made any difference to the student's motivation to study.

OER can present significant benefits not only for students but also for course instructors. Based on our findings, the analysis of the students' responses and feedback can provide insights to future computer science instructors who intend to adopt similar OER material in their course and, especially, in the Data Structures course. The results and students' feedback can also be used by the computer science community to inform decisions about the adoption, development, and revision of existing or future OER resources. Although we may not be able to generalize the impact of all the factors due to the scope of the research, the findings can still provide recommendations and insights to computer science instructors and institutions on how to select and implement OER material in their courses.

References

- ACM. (2013). *Computer science curricula 2013*. ACM and IEEE Computer Society, Incorporated. <https://www.acm.org/education/curricula-recommendations>.
- Ashadevi, B., & Muthamil Selvi, P. (2017). Open educational resources in computer science: Opportunities and challenges. *International Journal of Computer Science Issues*, 14(5), 42–49. <http://www.ijcsi.org/papers/IJCSI-14-5-42-49.pdf>.
- Bliss, T. J., Robinson, J. T., Hilton, J., III., & Wiley, D. A. (2013). An OER COUP: College teacher and student perceptions of open educational resources. *Journal of Interactive Media in Education*. <https://doi.org/10.5334/2013-04>
- Brandle, S., Katz, S., Hays, A., Beth, A., Cooney, C., DiSanto, J., ..., Morrison, A. (2019). But what do the students think: Results of the CUNY cross-campus zero-textbook cost student survey. *Open Praxis*, 11(1), 85–101.
- Burke, R. J., & Mattis, M. C. (2007). *Women and minorities in science, technology, engineering, and mathematics: Upping the numbers*. Edward Elgar.

- Ceci, S. J., & Williams, W. M. (2011). Understanding current causes of women's underrepresentation in science. *Proceedings of the National Academy of Sciences of USA*, *108*, 3157–3162.
- Colvard, N. B., Watson, C. E., & Park, H. (2018). The impact of open educational resources on various student success metrics. *International Journal of Teaching and Learning in Higher Education*, *30*(2), 262–276.
<https://eric.ed.gov/?id=EJ1184998>.
- Cooney, C. (2017). What Impacts do OER have on students? Students share their experiences with a health psychology OER at New York City College of Technology. *International Review of Research in Open and Distributed Learning*.
<https://doi.org/10.19173/irrodl.v18i4.3111>
- Cronin, C. (2017). Openness and praxis: Exploring the use of open educational practices in higher education. *International Review of Research in Open and Distributed Learning*, *18*(5), 15–34.
- Croteau, E. (2017). Measures of student success with textbook transformations: The Affordable Learning Georgia Initiative. *Open Praxis*, *9*(1), 93–108.
<https://doi.org/10.5944/openpraxis.9.1.505>
- Dichev, C., Dicheva, D., Agre, G., & Angelova, G. (2015). Trends and opportunities in computer science OER development. *Cybernetics and Information Technologies*, *15*(3), 114–126.
<https://www.wssu.edu/profiles/dichevc/trendsoportunities-in-cs-oer.pdf>.
- Dille, B., & Mezack, M. (1991). Identifying predictors of high risk among community college telecourse students. *The American Journal of Distance Education*, *5*(1), 24–35.
- Edwards, S. H., & Murali, K. P. (2017, June). CodeWorkout: Short programming exercises with built-in data collection. In *Proceedings of the 2017 ACM conference on innovation and technology in computer science education* (pp. 188–193). <https://doi.org/10.1145/3059009.3059055>.
- Engler, J. N., & Shedlosky-Shoemaker, R. (2019). Facilitating student success: The role of open educational resources in introductory psychology courses. *Psychology Learning and Teaching*, *18*(1), 36–47.

- <https://doi.org/10.1177/1475725718810241>
- Felix, U. (2001). A multivariate analysis of students' experience of web based learning. *Australasian Journal of Educational Technology*.
<https://doi.org/10.14742/ajet.1770>
- Finn, J. D., & Rock, D. A. (1997). Academic success among students at risk for school failure. *Journal of Applied Psychology*, 82(2), 221. <https://doi.org/10.1037/0021-9010.82.2.221>
- Fischer, L., Hilton, J., III., Robinson, T. J., & Wiley, D. A. (2015). A multi-institutional study of the impact of open textbook adoption on the learning outcomes of post-secondary students. *Journal of Computing in Higher Education*, 27(3), 159–172. <https://doi.org/10.1007/s12528-015-9105-6>
- Florida Virtual Campus. (2016). *2016 Florida student textbook survey*.
<https://florida.theorange grove.org/og/file/3a65c507-2510-42d7-14cffdefd394b6c/1/2016%20Student%20Textbook%20Survey.pdf>.
- Fouh, E., Karavirta, V., Breakiron, D. A., Hamouda, S., Hall, S., Naps, T. L., & Shaffer, C. A. (2014). Design and architecture of an interactive eTextbook—The OpenDSA system. *Science of Computer Programming*, 88, 22–40.
<https://doi.org/10.1016/j.scico.2013.11.040>
- Grasha, A., & Yangarber-Hicks, N. (2000). Integrating teaching styles and learning styles with instructional technology. *College Teaching*, 48(1), 2–10.
- Grewe, K., & Davis, W. P. (2017). The impact of enrollment in an OER course on student learning outcomes. *The International Review of Research in Open and Distributed Learning*. <https://doi.org/10.19173/irrodl.v18i4.2986>
- Griffiths, R., Mislevy, J., Wang, S., Shear, L., Mitchell, N., Bloom, M., & Desrochers, D. (2017). *Launching OER degree pathways: An early snapshot of Achieving the Dream's OER Degree Initiative and emerging lessons*. SRI International.
- Grimaldi, P. J., Mallick, D. B., Waters, A. E., & Baraniuk, R. G. (2019). Do open educational resources improve student learning? Implications of the access hypothesis. *PLoS ONE*, 14(3), e0212508.
<https://doi.org/10.1371/journal.pone.0212508>
- Halim, S. (2015). VisuAlgo—Visualising data structures and algorithms through animation.

- In *Olympiads in informatics*. <https://doi.org/10.15388/ioi.2015.20>
- Hashim, K. F., Tan, F. B., & Rashid, A. (2015). Adult learners' intention to adopt mobile learning: A motivational perspective. *British Journal of Educational Technology*, *46*(2), 381–390.
- Hayamizu, T. (1997). Between intrinsic and extrinsic motivation: Examination of reasons for academic study based on the theory of internalization. *Japanese Psychological Research*, *39*(2), 98–108.
- Hilton, J. (2016). Open educational resources and college textbook choices: A review of research on efficacy and perceptions. *Educational Technology Research and Development*, *64*(4), 573–590. <https://doi.org/10.1007/s11423-016-9434-9>
- Hilton III, J. L., Fischer, L., Wiley, D., & Williams, L. (2016). Maintaining momentum toward graduation: OER and the course throughput rate. *International Review of Research in Open and Distributed Learning*, *17*(6), 18–27.
<http://www.irrodl.org/index.php/irrodl/article/download/2686/3942>.
- Hilton III, J. L., Gaudet, D., Clark, P., Robinson, J., & Wiley, D. (2013). The adoption of open educational resources by one community college math department. *International Review of Research in Open and Distributed Learning*, *14*(4).
<http://www.irrodl.org/index.php/irrodl/article/view/1523/2652>.
- Hilton III, J. L., Robinson, T. J., Wiley, D., & Ackerman, J. D. (2014). Cost-savings achieved in two semesters through the adoption of open educational resources. *International Review of Research in Open and Distributed Learning*, *15*(2), 67–84.
<https://doi.org/10.19173/irrodl.v15i2.1700>
- Hu, E., Li, Y., Li, J., & Huang, W. H. (2015). Open educational resources (OER) usage and barriers: A study from Zhejiang University, China. *Educational Technology Research and Development*, *63*(6), 957–974.
- Ikahihifo, T. K., Spring, K. J., Rosecrans, J., & Watson, J. (2017). Assessing the savings from open educational resources on student academic goals. *International Review of Research in Open and Distributed Learning*, *18*(7), 126–140.
- Kuh, G. D., Kinzie, J., Buckley, J. A., Bridges, B. K., & Hayek, J. C. (2006). *What matters to student success: A review of the literature*. Jossey-Bass.
https://nces.ed.gov/npec/pdf/Kuh_Team_Report.pdf.

- Lewis, J., DePasquale, P., & Chase, J. (2016). *Java Foundations: Introduction to program design and data structures*. Pearson.
<https://www.pearson.com/us/higher-education/program/Lewis-Java-Foundations-Introduction-to-Program-Design-and-Data-Structures-4th-Edition/PGM76634.html>.
- Lin, H. (2019). Teaching and learning without a textbook. *The International Review of Research in Open and Distributed Learning*, 20(3), 1–18.
- Martin, M., Belikov, O., Hilton, J., Wiley, D., & Fischer, L. (2017). Analysis of student and faculty perceptions of textbook costs in higher education. *Open Praxis*, 9(1), 79–91. https://eric.ed.gov/?id=EJ114_2913.
- McGreal, R. (2013). Creating, using and sharing open education resources.
<https://www.fosteropenscience.eu/sites/default/files/pdf/514.pdf>.
- Millar, M., & Schrier, T. (2015). Digital or printed textbooks: Which do students prefer and why? *Journal of Teaching in Travel and Tourism*, 15(2), 166–185.
<https://doi.org/10.1080/15313220.2015.1026474>
- Mishra, S. (2017). Open educational resources: Removing barriers from within. *Distance Education*, 38(3), 369–380. <https://doi.org/10.1080/01587919.2017.1369350>
- Morales, R., & Baker, A. (2018). Secondary students' perceptions of open science textbooks. *Journal of Interactive Media in Education*, 2018(1), 4, 1–9.
<https://doi.org/10.5334/jime.455>.
- Ozdemir, O., & Hendricks, C. (2017). Instructor and student experiences with open textbooks, from the California open online library for education (Cool4Ed). *Journal of Computing in Higher Education*, 29(1), 98–113.
- Padilla-Walker, L. M., Zamboanga, B. L., Thompson, R. A., & Schmersal, L. A. (2005). Extra credit as incentive for voluntary research participation. *Teaching of Psychology*, 32(3), 150–153.
- Pearson. (2020). *Website for Java Foundations: Introduction to program design and data structures* (4th ed.). Retrieved April 28, 2020, from
<https://www.pearson.com/us/higher-education/program/Lewis-Java-Foundations-Introduction-to-Program-Design-and-Data-Structures-4th-Edition/PGM76634.html>.
- Rowell, J. L. (2015). Student perceptions: Teaching and learning with open educational

- resources. Doctoral Dissertation, East Tennessee State University.
<https://dc.etsu.edu/cgi/viewcontent.cgi?article=3925&context=etd>.
- Smart, K. L., & Cappel, J. J. (2006). Students' perceptions of online learning: A comparative study. *Journal of Information Technology Education: Research*, 5(1), 201–219.
- Smidt, E., Bunk, J., McGrory, B., Li, R., & Gatenby, T. (2014). Student attitudes about distance education: Focusing on context and effective practices. *The IAFOR Journal of Education*, 2(1), 40.
- Smith, M. L., & Seward, R. (2017). Openness as social praxis. *First Monday*, 22(4).
- Su, R., & Rounds, J. (2016). All STEM fields are not created equal: People and things interests explain gender disparities across STEM fields. *Frontiers in Psychology*, 6, 189. <https://doi.org/10.3389/fpsyg.2015.00189>
- United Nations Educational, Scientific, and Cultural Organization (UNESCO). (2002). Forum on the impact of open courseware for higher education in developing countries. In *Conference Proceedings Final Report*, July 1–3. Author.
<http://unesdoc.unesco.org/images/0012/001285/128515e.pdf>.
- Van Den Hurk, M. M., Wolfhagen, I. H., Dolmans, D. H., & Van Der Vleuten, C. P. (1999). The impact of student-generated learning issues on individual study time and academic achievement. *Medical Education*, 33(11), 808–814.
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), 425–478.
- Watson, C. E., Domizi, D., & Clouser, S. (2017). Student and faculty perceptions of OpenStax in high enrollment courses. *International Review of Research in Open and Distance Learning*, 18(5). <https://eric.ed.gov/?id=EJ1151910>.
- Yoo, D. K., & Roh, J. J. (2019). Adoption of e-books: A digital textbook perspective. *Journal of Computer Information Systems*, 59(2), 136–145.
<https://doi.org/10.1080/08874417.2017.1318688>

Anastasia Angelopoulou is an Assistant Professor at the TSYS School of Computer Science at Columbus State University. She obtained her M.Sc. and Ph.D. in Modeling and Simulation from the University of Central Florida. Her research interests include

modeling and simulation, machine learning, and serious games. Her research work has been supported by the Office of Naval Research (ONR), the National Science Foundation (NSF), and Epic Games, among others.

Rania Hodhod is an Associate Professor and Assistant Chair at the TSYS School of Computer Science, Columbus State University (CSU) in the USA. She received her Ph.D. in Computer Science from the University of York, UK. She has an extensive background in artificial intelligence, intelligent systems, and serious games as well as 70 + peer-reviewed publications in these areas. Her research projects have been supported by NSA and ITIDA.

Alfredo J. Perez is an Associate Professor at the TSYS School of Computer Science, Columbus State University. He received his Ph.D. and M.S. Degrees in Computer Science and Engineering from the University of South Florida (Tampa, FL). His research interest includes mobile/ubiquitous computing/sensing, privacy/cyber security and computer science education. His research projects have been supported by the NSF, DoD, DoE and Google.