

Understanding Mathematics Instructors' Perceptions of OER

A Mixed Methods Study

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Keywords: Open Educational Resources, pedagogy, mathematics, needs assessment, barriers

Abstract

The adoption of open educational resources (OER) in an institutional setting has been shown to reduce the cost of course materials for students, minimize inequities, and allow instructors to customize course materials. This study tapped into instructors' perspectives of limited adoption of OER in a Mathematics department at a large university in the Southeastern United States. A convergent mixed-methods study was conducted to determine how Mathematics instructors used course materials, how OER were perceived within the Mathematics department, and to gauge barriers to the adoption of OER. Quantitative and qualitative data were collected by a preliminary survey administered to the Mathematics department and along with follow-up semi-structured interviews with voluntary faculty participants. The results show that numerous barriers deter Mathematics faculty from the use of OER including content quality, time concerns, and difficulties customizing content. An additional theme derived from the interviews was that textbook adoption for the lower-level mathematics courses is often determined by a department-level committee. However, mathematics instructors have attempted to integrate OER in their teaching. The findings of this study provide practical implications for raising mathematics instructors' awareness of OER and identify an action plan for implementing OER in mathematics classrooms.

Introduction

Open Educational Resources (OER) are openly licensed educational materials that allow for user customization at no cost (Hilton, 2016). These resources can help students who cannot afford expensive

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course materials to remove financial learning barriers, especially those from low-income communities and Pell Grant recipients (Colvard et al., 2018). In recent years, open course materials have been gaining popularity among colleges across the United States (Spilovoy et al., 2020).

Since 2015, our institution, the University of South Carolina, has coordinated an OER initiative. This initiative aims to help faculty become comfortable with using OER in their courses and to save students money by providing access to no-cost course materials, including OER and library-licensed content. Despite the institutional success of the OER initiative, some departments tend to still rely heavily on traditional textbooks. Numerous courses offered by the Department of Mathematics are taught with commercial texts and digital courseware. Many students, regardless of major, are required to take Mathematics courses to fulfill their graduation requirements. If affordable learning resources were adopted within the department, especially in high-enrollment courses, the potential cost savings for thousands of students annually would be tremendous.

To better serve the pedagogical goals of instructors, and the learning and financial needs of students, we wanted to know under what circumstances instructors select OER over commercial content, as well as the hardships and difficulties that exist in the selection and integration of OER into syllabi. In this article, we will discuss the implementation and results of a survey developed to understand the use of OER and commercial textbooks in the Mathematics department of our institution.

Literature Review

The rise of open educational resources (OER) can be dated back to UNESCO's 2002 Forum on Open Courseware when the term "OER" was initially coined. According to UNESCO (2012), OER includes:

...teaching, learning and research materials in any medium, digital or otherwise, that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions. (p. 1)

Advantages to the use of OER stem from their innate characteristics; they are free, open, and customizable. In contrast to the increasing price of traditional textbooks, OER are advantageous in affording educators' and students' free access to a wide range of educational resources, which has the potential to significantly reduce the financial burden for students to attend college (Bliss et al., 2013; Hilton et al., 2014). Furthermore, since OER are typically shared under the terms of Creative Commons licenses, OER can be adopted in a variety of educational contexts with minimal concerns regarding copyright restrictions (D'Antoni, 2009; Hilton et al., 2013, 2014). For customization, OER provides users with permission to retain (e.g., save a copy), reuse (e.g., use a portion of or the whole materials in another context), revise (e.g., make needed changes), remix (e.g., combine two resources), and redistribute (e.g., share materials in a class) available resources in line with their needs (Wiley & Hilton, 2018). Another advantage of OER is the time-effectiveness of access to updated resources since revised versions become immediately available for use without waiting for long publication cycles (Kimmons, 2015).

There are numerous potential benefits to adopting OER. Improving learner achievement is one of the primary goals for instructional interventions in educational settings. Whether the use of OER has improved or inhibited student performance in college courses has garnered much attention. Evidence that OER decreased college students' educational costs without harm to their course performance has been well documented with the use of OER in college-level courses (Cozart, Horan, and Frome 2021; Jaggars, Rivera, and Akani 2019; Schick and Marklein 2013; The College Board 2013). Some researchers referred to students' course grades or exam scores in determining whether OER improved student performance. Grewe and Davis (2017) indicated the use of OER was positively correlated to students' final grades in an online history course. Clinton (2018) found students using OpenStax textbooks in an Introductory Psychology course spent less money on course materials and performed slightly better than those using traditional textbooks. Ross et al. (2018) also noted no significant difference in the average grade existed between two offerings of a college-level introductory sociology course, one of which used OpenStax textbooks while the other taught with commercial counterparts. Colvard et al. (2018) reported Pell Grant recipients had a significant increase in final grades and marked fewer fails and withdrawals, confirming the effectiveness of OER in promoting educational equity. This has been of particular importance during the COVID-19 pandemic when students have not had access to shared textbook programs (e.g., course reserves) often housed at a college library.

Given those advantages of OER, faculty who have used OER provided positive remarks. In a meta-analysis of articles on OER published between 2015 and 2018, Hilton (2020) recapped that faculty consistently perceived OER as the same quality as, or better, than traditional commercial textbooks. In a white paper published by The California OER Council (2016), a majority of sixteen faculty participating in the pilot study expressed positive perceptions of using OER, seven of whom rated OER better than traditional textbooks. Delimont et al. (2016) interviewed thirteen college instructors about their preference for using different types of textbooks for teaching, twelve of whom preferred OER over traditional textbooks. Similarly, Abramovich and McBride (2018) found almost all faculty favored the use of OER for their college-level courses. The faculty's perception of OER influences their decisions to accept OER in their courses, but the faculty's positive perception of OER may not necessarily incur effective teaching (Hilton, 2020).

It is noteworthy that, given that anyone can publish OER, OER need to undergo verifications and curations before being implemented in courses to ensure students learn effectively. Free-standing OER without any pedagogical strategies cannot empower students with specific expertise desired in a domain. To provide accessible resources, screening and then adapting available OER to support instructors' pedagogical demands are required (Hilton et al., 2014). As such, librarians and instructional designers have provided services to support the implementation and use of OER (Reed & Jahre, 2019), ranging from financial allocations for the creation of OER to the provision of learning materials surrounding the use of OER.

Despite support, barriers still exist when it comes to implementing OER across campuses. Various studies have been completed to explore the barriers that faculty face and the majority of them have the same themes (Martin & Kimmons, 2020; McGreal, 2019). McGreal (2019) explored these barriers through a survey encompassing thirteen higher education institutions. McGreal's survey (2019) revealed common frustrations and concerns that faculty have when it comes to electing OER. One such issue is the amount of time that it takes to locate and determine the quality of OER (Martin & Kimmons, 2020; McGreal, 2019; Taylor & Taylor, 2018). Another issue was the lack of technical knowledge and

understanding that faculty possessed that would be needed to implement OER (Martin & Kimmons, 2020; McGreal, 2019). A third issue, which is a common one, is that of navigating copyright issues when utilizing OER (Martin & Kimmons, 2020; McGreal, 2019). In general, faculty awareness of OER was also an issue (McGreal, 2019). Martin and Kimmons (2020) also found that faculty had limited working knowledge of what OER were but did show enthusiasm for wanting to learn more about them. Yet, when they went to implement the 5Rs, they were often frustrated by the technical skills needed to do so (Martin & Kimmons, 2020). Due to the various skills needed to implement OER, it is recommended by various articles to have a team consisting of various personnel (i.e., instructional designers, librarians, technology support, etc.) to help implement OER across campuses. (Ren, 2019; Taylor & Taylor, 2018).

When looking specifically at the area of Mathematics OER, studies primarily focused on cost savings or effectiveness. Chiorescu (2017) implemented a lower-cost course software for a math course which increased course savings for students and raised grades compared to previous courses. Kersey (2019) found no significant increase in final grades between a proprietary calculus course and an OER calculus course, but did see an increase in the homework scores of students using OER. Due to the gap in the literature around OER and college-level mathematics, we wanted to further explore perceptions of OER, understanding of OER, and use of OER by Mathematics professors.

Methods

We utilized a convergent mixed methods (Cresswell and Plano Clark, 2017) approach to answer our research questions. A convergent mixed methods design was selected because it allowed us to collect our quantitative and qualitative data at separate times and to analyze them separately (Creswell, 2014). Quantitative data was collected to develop an understanding of instructors' awareness of OER. Qualitative data was collected to provide additional insights to explain and extend quantitative results. Once all of the data were collected, we were able to make more informed inferences by integrating findings from two data sources than what one method of data collection alone would have provided (Creswell, 2014).

For this study, we chose to focus on a department on campus that the vast majority of students move through for the general education requirements. Given the gap in the current literature about using OER in college-level math courses, we selected the Mathematics department to contribute to the theoretical implications and practical impact of OER. A preliminary survey was sent to the email lists held by the Libraries' Mathematics liaison to ascertain instructor perspectives on student access and availability of course materials. The survey was modified based on the instrument developed by Jhangiani (2017) in order to reflect its applicability to mathematics courses and our institution. The survey consisted of four sections: (1) eligibility, (2) demographics, (3) textbooks, and (4) open educational resources. Demographic information (see Table 1 for demographics), such as how long the instructors have been teaching, the modality of their courses, and the textbook selection process were collected. An invitation was also included to solicit participants for our follow-up interviews. This survey was sent to 39 instructors and six of them responded to our survey. Descriptive statistics were used to process quantitative data to present a description of math instructors' awareness of OER.

Table 1
Demographics

Instructor	Years Taught	Status	Participated in Interview
P1	> 30	Associate Professor	Yes
P2	1 - 10	Associate Professor	Yes
P3	> 30	Professor	Yes
P4	11 - 20	Associate Professor	Yes
P5	11 - 20	Professor	No
P6	1 - 10	Professor	No

A total of four instructors volunteered to complete a follow-up interview. A series of interviews were then conducted via Microsoft Teams. The interviews were semi-structured which allowed researchers to address a preset list of questions and also ask follow-up questions to provide additional information (Creswell, 2014). Sample interview questions included items such as “What is the selection process for the course materials you use?” “What was your experience using OER (if applicable)?” and “What support would you need or expect when using OER?.” Each of the interviews was 45-60 minutes long. All interviews were recorded and then transcribed through the software program Temi before being coded to determine the hardships and needs surrounding the availability and access of course materials within the Mathematics department. For qualitative data analysis, inductive analysis (Saldana, 2021) was applied via two cycles of coding. Open coding (Saldana, 2021) was applied for the first cycle to assign codes and revise or replace existing codes if needed. Pattern coding (Saldana, 2021) was used to compare codes generated in the first cycle to solicit categories and themes about participants’ perceptions of OER. To ensure the rigor and trustworthiness of qualitative findings, peer debriefing was conducted with two OER scholars (Spall, 1998). Also, rich descriptions from the participants’ interview quotes were provided to reinforce the rigor of the findings (Creswell, 2014).

Results

Demographics

All respondents were tenured professors with the ranking of either Associate Professor or Professor. Each respondent was solely responsible for the decision of textbook adoption for their courses but, in the qualitative interview, they mentioned that there is a textbook adoption committee in the Department of Mathematics that determines the textbooks for lower-level mathematics courses. Those courses may be taught by graduate assistants, adjuncts, or other non-tenure-track professors. Those courses were open to around 100-150 students before the pandemic. For higher-level math courses, the instructors who are tenure-track or tenured usually have a smaller class size. From the demographics portion of the study, we found that:

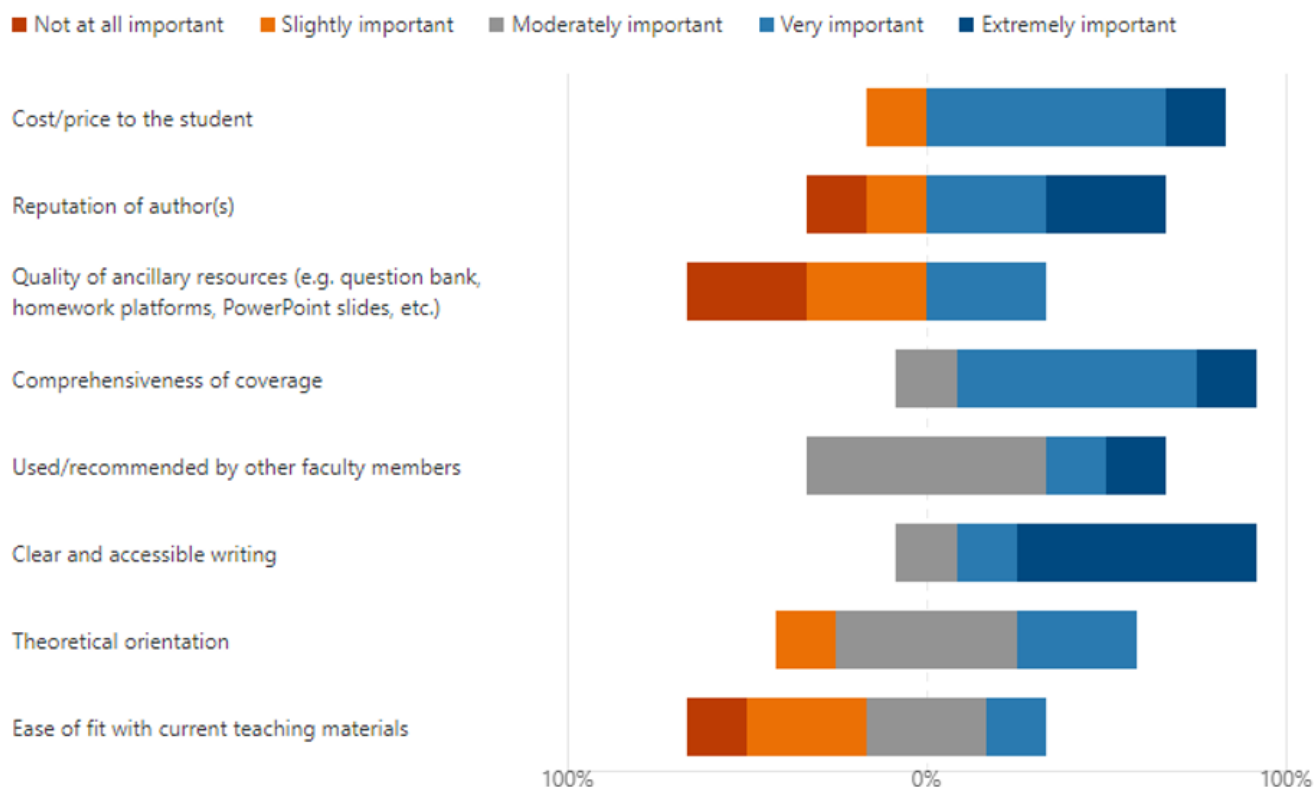
- Only one out of six instructors have not required students to purchase an access code for an online resource that comes bundled with a required textbook;
- During the past three years, only one instructor often (per semester) received queries from students about whether they really needed the required course textbook;
- Only two out of those six instructors teach at least one undergraduate/graduate course without a formal textbook;
- A majority of the instructors (n=4) assign students work that can only be completed with the purchase of an online access code or homework system.

Textbook Adoption

When asked how important each of several factors were when selecting a required textbook (Figure 1), instructors provided a range of responses. Clear and accessible writing was the most important factor for the six math instructors. Other leading factors were the comprehensiveness of content coverage and the cost and price to the students. The quality of ancillary materials was ranked of least importance.

Figure 1

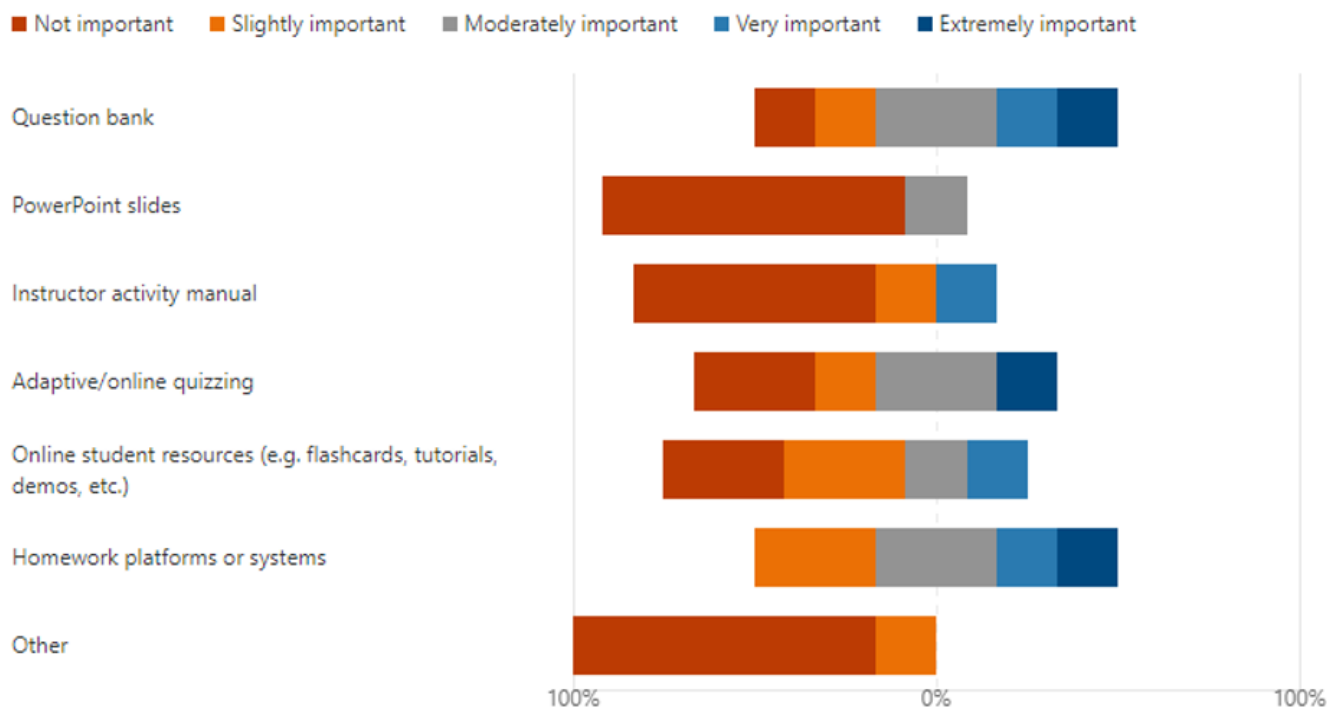
Responses to “When selecting a required course textbook, how important are each of the following factors to you?”



A follow-up (Figure 2) question asked about the importance of various ancillary resources to the instructors' teaching. Overwhelmingly, the availability of homework platforms/systems and question banks ranked as the most important resources for instruction, while PowerPoint slides and instructor activity manuals were ranked as the least important.

Figure 2

Responses to “How important are the following ancillary resources to your teaching?”



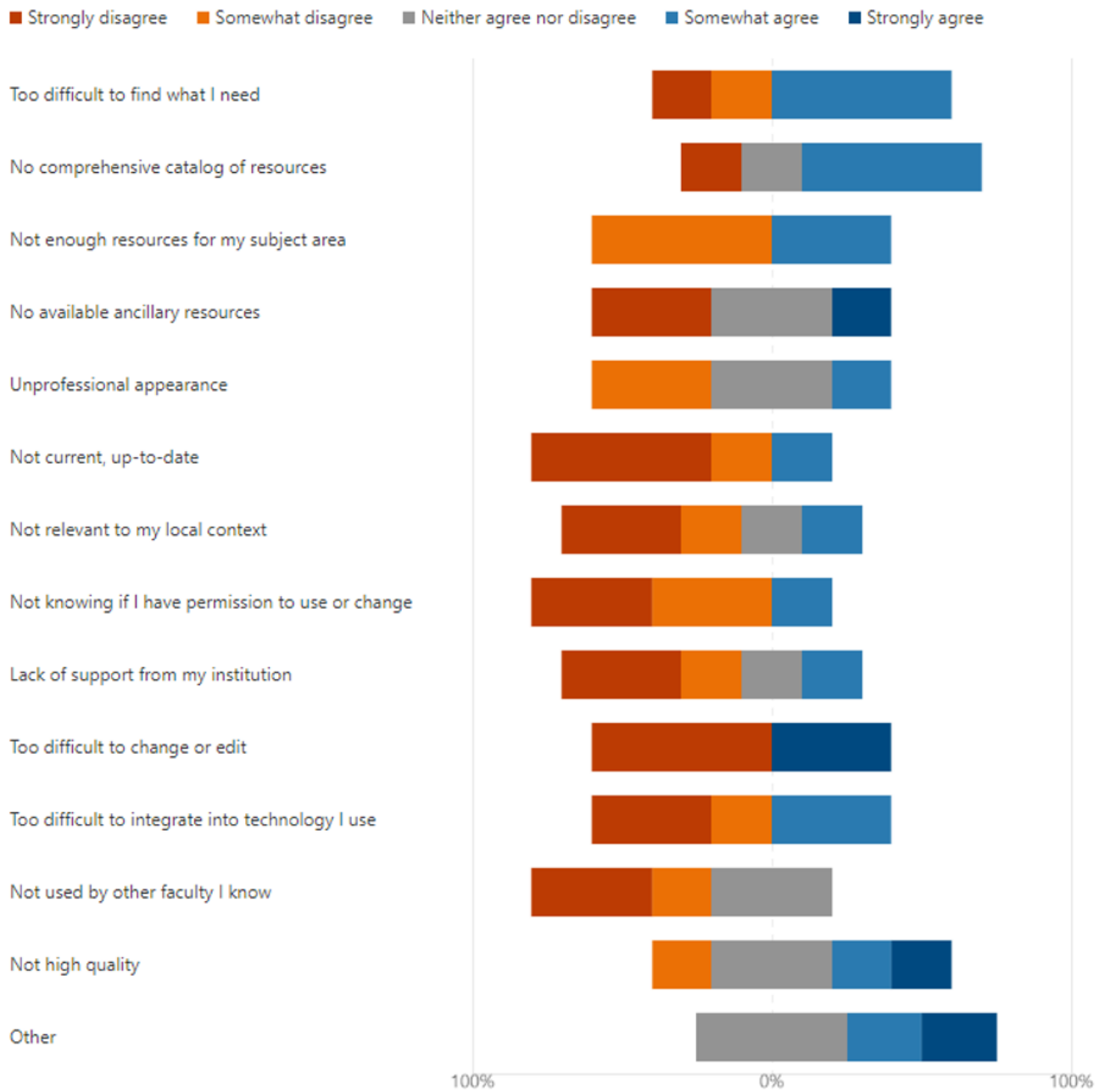
Open Educational Resources

Four out of six responding instructors were aware of the existence of open educational resources but only two of those who were aware of OER had used them in their courses. The other two who were aware of OER understood how OER could be used in the classroom, but had not adopted them for use. The two remaining instructors had heard of OER but did not know much about them.

When asked about the deterrents to the use of OER (Figure 3), the most important deterrent was the perception that OER are “not high quality.” This viewpoint was also reflected in our interviews. In contrast, “not current, up-to-date” was the least important deterrent preventing math instructors from using OER.

Figure 3

Responses to “If you are aware of OER, to what extent do you feel that the following are deterrents to the adoption of OER in your courses?”



Qualitative Themes

Three themes describing Mathematics instructors’ perception of OER emerged from the analysis of the interview transcripts: 1) Textbook adoption for the lower-level mathematics courses is determined by a department-level committee; 2) Math instructors attempted to integrate OER in their teaching; and 3)

There are some barriers in the integration of OER in math instructions. The following is a description of the themes and examples of faculty perceptions from the transcripts.

Theme 1: Textbook adoption for the lower-level mathematics courses is determined by a department-level committee.

This theme described participants' experience with decision-making about textbook adoption in college-level math courses. Two categories subsumed this theme, including the committee's decision and no control over cost.

Committee's decision

This category describes the participants' awareness that the textbook adoption decision for most entry-level courses in the mathematics department is made by a department-wide committee. In contrast, for some upper-level math courses, the instructor chose the textbook solely on their own.

P1: For some of the lower-level courses, it's kind of a committee and departmental decision. So I participate in that process, but for upper-level classes, you know, it's my choice.

P2: For our very low division classes, there's the department as a whole has decided on textbooks that are to be used by the instructors, and this happens at a committee level.

No control on cost

This category describes the participants' perception that instructors teaching lower-level math courses have no control over textbook costs. Participants generally agreed that the costs may not be the primary concern for the committee when selecting the textbooks. Even though some instructors wanted to select a different textbook, it wasn't always possible as the course information was linked with the school bookstore so that students could purchase books directly.

P2: Well, one of the issues is that it sets the bookstore automatically, I have no power over that even.

P3: And for some of the people who are involved with the selection process, all of that ancillary stuff is important because they're adjuncts or part-time instructors or something. And they're teaching hundreds of students compared with me teaching dozens.

Theme 2: Math instructors attempted to integrate OER into their teaching.

This theme described participants' efforts to integrate OER into their classes. The interviewed participants had used or at least heard about OER before and shared their experience with OER. Two categories were discussed below.

Considering whether the value of textbooks matched their prices

The participants shared that whether the values of textbooks matched their price was an important motivation for them to consider adopting external resources, such as OER. P1 mentioned that the content in the textbooks drove him to look for other options. Similarly, P2 echoed that there was a gap between the quality of the service provided by the textbook publishers and instructors' need to provide updated, reliable content, and that open textbooks might be an option to close the gap.

P1: I've had to find other, you know, the publisher systems are better. But even they, you know, aren't as good as I would like them to be.... I think it's the content delivery, the content, that is really driving some of the technology.

P2: I have a very low opinion of the textbook companies. They do, they do things like they release a new edition every year. And the only differences are that they've changed the numbering of all the problems so that you can crop prints easily. So the fact that open bracket, there are open textbooks out there that are trying to work against this.

Following 5R principles to integrate OER in math instruction

The participants described their integration of OER in the classrooms. The integration effort was well aligned with the 5R principles of using OER. For example, P2 mentioned content licensed under Creative Commons was integrated into two of his lessons. Also, P4 shared his experience of remixing and reusing open-licensed content in the course.

P2: I've actually given the textbook that I'm teaching two courses with CC courses right now. And I'm just, I'm just uploading the textbooks to the, to the Teams, Microsoft Teams sites that I'm using. So that's nice. And also just that I want to make sure that the students can easily obtain them.

P4: But one thing that we've been more and more interested in is in the more technical licensing aspect with Creative Commons, and working with copyright in terms of the people that we have talked to who do want to, you know, maybe do more mixing and matching between different resources in a more, I guess, a more format rather than sort of coming up with a big course reading list almost to create like a, like a Frankenstein type OER.

Theme 3: There are some barriers to the integration of OER in math instructions.

This theme described the participants' perceived barriers in their effort to integrate OER into math courses. Four categories described below were covered under this theme.

Concerns about quality

The participants shared their concerns about the quality of content in OER. For example, P1 felt that OER should be more polished and was inferior to the design of a published textbook. P2's concern about

the quality of OER mainly resulted from the authorship of open textbooks, as esteemed scholars in the field had seldom written an open textbook. P4's concern also stemmed from the presence of untruthful information in OER.

P1: I think the other concern that I've had is a lot of times a lot of these OER resources aren't, I guess, OER resources as we've done. And isn't it. But, I mean, there's just not quite the level of polishment that that I would get from, from, a published book.

P2: In the sense that I feel that the, the people who want to write these textbooks are not usually people who are very esteemed by mathematics, because they're not, they're not doing sophisticated things. They're doing the basics that everybody knows, somebody who decides to write that is already not, you know, if you're, I have no examples of somebody who is, you know, a Nobel Prize winner.

P4: We found that there's such an overwhelming amount of bad information out there. It can be hard to locate the good information, um, and people kind of want help picking out things like, you know, quality OER, and then incorporating them with more traditionally licensed or copyrighted resources.

Concerns about extra time for adopting OER

The participants discussed their concerns about the extra time necessary for adopting OER. One of the reasons was that they had to revise and remix content if OER could not be used as-is, which might take nearly as much effort as writing new content (P4). In addition, the participants found it time-consuming to personalize custom OER for the instruction for students.

P4: If the material doesn't seem suitable then editing would be nearly as much effort as just rewriting it from scratch. So this is, yeah, this is not something that I usually seriously consider.

P1: Over 10 years we developed 200 of these, you know, for, for a calculus book, you need probably 2000. And you know, they're very individualized. They're not easily reproduced and generalized.

Concerns about ancillary assignment platforms

The participants described their concerns about ancillary resources to OER. The effectiveness of math courses was reliant on students' practices of using acquired knowledge to complete assignments. The participants were concerned about whether OER provided any assignment platforms or exercises, even for OER with high-quality content. P2 also shared one example of choosing traditional textbooks that the department recommended over open textbooks. The decision was made because the publishers provided an online platform that negated the burden of hiring extra graders for his class.

P1: I said that one of my requirements looking at for, for most of the classes that I'm teaching is some kind of an online homework system and most, most of the OER texts that I've seen do not

have integrated, you know, they, you know, they'll say, we'll go, you can put together your own homework problems from, you know, from, from WeBWorK or something like that.

P2: I am planning on using a fully free online Creative Commons licensed textbook for calculus. But that is contingent on being able to use an online homework system. And this is the main reason why I've demanded that the students buy the textbook that the department recommends, because we just don't have enough money to have graders for this class.

P4: And I find that there's no substitute for reading your, reading the student's work. And I will say that one disadvantage of some OER is sometimes it doesn't have exercises.

Concerns about the subject culture

The participants discussed how the subject culture in the field of mathematics might hinder the adoption of OER, as mathematic scholars tend to share their works in public without copyright concern. P3 and P4 mentioned that math professionals do not mind sharing resources so may not have to use published OER. Instead, they may use free, high-quality resources shared by esteemed scholars.

P3: The two guys that wrote the two different books that we generally use have written pretty good books, all in all, and they're free.

P4: And so for example, it's very common for mathematicians too, where their creep it's like, you want to read any of my papers. You don't have to fuss around with the journal's website, any of this, you either go to my website or you go to this favorite server called the arXiv and you can get the, and to me, this seems very natural and I know in other disciplines, people are kind of very protective of their papers and it's, it's hard to even find work.

Discussion

The results of this study may offer value to stakeholders concerned with outreach to mathematics departments regarding the use of open educational resources. Survey results and interview responses allow us to better understand who had the decision-making capacity when it came to selecting the textbooks for a course. While the survey was indeterminate as to why there was such a range of responses, interviews revealed that most upper-level courses faculty do have full responsibility for their textbook selection while lower-level courses and general education courses were typically selected by a committee or another faculty member. Therefore, stakeholders may consider outreach beyond individual instructors, additionally focusing on departmental administrators and curriculum designers. Outreach should be designed to better inform all who are involved in the selection of course materials not only of motivating factors for adopting OER, but also of the ways in which low and no-cost materials can be implemented with limited effort.

We also learned that faculty are primarily concerned with clear and accessible writing, the reputation of the authors, and the cost to the student when selecting course materials. Additionally, the availability of

accessible ancillary materials is critical when teaching a high-enrollment course. Understanding the need to proactively address these factors can prepare those involved in OER initiatives to effectively tailor their services and resources to ensure that instructors are confident in locating, selecting, and adopting quality course materials.

The deterrents to using OER as revealed in the survey and interviews also must be addressed. The impression that OER are of low quality, are difficult to locate, change, and edit, and does not offer sufficient supplemental and ancillary content are barriers to approach with education and enterprising solutions. And, of course, the legitimate concerns expressed about the time necessary to effectively implement OER should be foremost when working with instructors. It is necessary to address these concerns in a thoughtful, respectful manner that alleviates concerns and provides suggestions for overcoming these barriers throughout the delivery of the content.

Ultimately, we hope that the insights gleaned from survey and interview results will be influential in encouraging the adoption of OER within Mathematics departments. The results may be used by stakeholders to guide all aspects of the planning and implementation of OER initiatives developed for Mathematics. Future studies will describe the actions taken to create and publish the learning resources developed to address the concerns and needs of Mathematics faculty. In addition, future research will investigate the effectiveness of these materials in addressing the support areas determined by this preliminary study.

Limitations

As with any study, there are limitations that should be considered. The first limitation of the study was the limited size and demographics of our sample. We only had a 15% response rate from the survey and four interview participants. We would have liked to hear from others in the department but, as this research was being conducted during COVID, we are aware that faculty were juggling multiple responsibilities. Furthermore, this impacted our response rate for the subsequent interviews. The second limitation resulted from the subjective interpretation of qualitative data, although we took actions to ensure the rigor and the trustworthiness of our findings. For future research, we would solicit more responses and consider pursuing this research from a multi-institutional perspective. This would allow for a greater understanding of OER perspectives and uses at various institutions.

Conclusion

The use of Open Educational Resources has the potential to greatly reduce the cost of course materials for students enrolled in Mathematics courses, may reduce inequities between students, and would grant instructors greater control over the content with which they teach. However, as evidenced by the results of this mixed-methods study of Mathematics instructors, there are many barriers that complicate the adoption of OER such as concerns of quality control, lack of full control over the textbook selection process, time constraints, and the availability of ancillary and supplemental materials. These insights provide a greater understanding of how support areas, such as libraries, can assist instructors in the selection, adoption, and customization of OER in a Mathematics department.

Acknowledgments

This research was supported by a Partnership Among South Carolina Academic Libraries (PASCAL) SCALE Affordable Learning Grant (SCALE-ing up Mathematics Open Educational Resources at the University of South Carolina). The content is solely the responsibility of the authors and does not necessarily represent the official views of the funding agency.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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