Increasing the Open Education Resources Capacity of Precalculus Courses at York College and Queensborough Community College

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To cite this article:

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Article Info	Abstract
	This paper presents a case study conducted by two universities seeking to explore Open Education Resources (OER) in their precalculus course. Students not only gained access to their textbook for free on the first day of class, but also Lumen OHM, an online mathematics assessment platform. The majority of students involved in the study were satisfied with the textbook, characterizing it as useful, accessible, and affordable, and agreeing that they would be very likely to register for a future course with an online text like that used in the course. This study also found that when comparing OER to non-OER settings using the final exam scores, for the most part, there was no significant difference observed in the learning outcomes. Based on these findings, the researchers believe that there is no need to continue teaching with costly physical textbooks when students can achieve the same academic level results with OER.

Introduction

Textbooks are an integral part of the college experience in teaching and learning. In nearly two decades, however, textbook prices have jumped about 135% (U.S. Bureau of Labor Statistics, 2021), creating barriers for students wishing to pursue their education but cannot afford the high cost textbook fees. These increased prices, coupled with the rising cost of higher education, have led some institutions to explore alternative, affordable, but still reliable options, namely Open Education Resources (Hilton, 2016). These resources are "educational materials made freely and legally available on the internet for anyone to reuse, revise, remix and redistribute" (Hewlett Foundations, 2013, p. 4). A typical OER course uses not only zero-cost textbooks, but also research articles, videos, interactive assessments, digital assignments, simulations, and more. Students can access these materials anywhere via a smartphone, tablet, laptop, or computer. Instructors have the ability to adapt these resources to suit their individual teaching styles, and moreover have the freedom to develop content that is relatable, meets the students' diverse needs, and promotes inclusion and equitable access to education.

Recognizing the benefits of OER, two colleges of the City University of New York (CUNY), York College and Queensborough Community College (QCC), agreed to redesign one of their gateway courses, precalculus, to include open resources. Too often, in classes that require students to purchase a textbook and/or an online HW

access key, some students go weeks or the entire semester without being able to purchase these materials, putting them on the path to dropping out or failing the course. Students should not be subjected to this experience. The precalculus course is normally taken by students majoring in STEM type fields. OER can help lower the barriers to students in these fields who cannot afford costly textbook fees.

This paper presents a case study seeking to determine the impact on mathematics students' academic achievement and overall satisfaction levels when OER is used in a precalculus course. Furthermore, this study will add to existing empirical work in this field, supplying additional analysis that has the potential to strengthen the OER movement.

Literature Review

The immediate benefit students experience with OER is not having to pay for the course textbook, gaining access to it on the very first day of class. Research has found evidence that when students do not have early access to learning materials and homework tasks, it negatively impacts their ability to succeed academically (Agnihotri, Essa, & Baker, 2017; Florida Virtual Campus Survey, 2019; McKenzie, 2017). This problem raises the question of why students fail to purchase textbooks early or at all. The top predicable reason reported by the Student Public Interest Research Group in a case study of 2,039 students from 150 university campuses is that textbooks are too expensive, as stated by 65% of the participants (Senack, 2014). Of those students who went without the textbook, almost all (94%) were quite concerned, knowingly accepting the risk that doing so would hurt their grade in the course. In other studies, students reported that they did not purchase the required textbook due to procrastinating, not receiving financial aid on time, or realizing that only a few chapters from the book are used in the course (Agnihotri et al., 2017; Nawotka, 2012).

A recent survey administered to over 21,000 college students revealed that students purchased an average of 3.6 textbooks that were not used at all in the current academic year (Florida Virtual Campus Survey, 2019). However, students are actively seeking alternative learning methods to compensate for not purchasing the textbook, such as making copies of the text, downloading unauthorized copies found online, renting the book, or relying on relevant content and videos (e.g., YouTube, Khan Academy) found online.

A growing number of universities have adopted the use of OER in their courses, saving students millions of dollars. OpenStax, a leading peer- reviewed, openly-licensed textbook, after launching a decade ago has saved students more than $1.2 billion in textbook savings, just reported in 2021 (Falk, 2021). Research by the Achieve the Dream OER initiative estimated aggregated cost savings between $6.5 and $12 million for students (over the two academic years from 2016 to 2018) from 38 community colleges across the United States, including consortia colleges in four states (Griffith et al., 2018). The City and State University of New York (CUNY and SUNY) received $8 million in funding to scale up and sustain ongoing OER initiatives across CUNY campuses (New York State, Office of the Governor, 2018). In the 2017–2018 academic year, these institutions saved $4.9 million by replacing the traditional textbooks with OER for about 1,500 courses with new enrollments of more than 40,000 students (Huggins, 2018). On a larger scale, the U.S. Congress introduced the Affordable College Textbook Act,

a legislative bill intended to support the use of open textbooks and thereby strengthen course material affordability efforts on college campuses (Congress.gov, n.d.). The National Association of College Stores (NACS), the professional trade association representing the collegiate retailing industry endorses that bill, supporting the expansion of the research development, use, and evaluation of OER at universities (Nemec, 2019). According to their most recent Student Watch Attitudes & Behaviors survey, the average price students spent on required course materials has declined 28% since 5 years ago, from $602 to $456 (NACS, n.d.).

Nonetheless, beyond the zero-cost and savings aspects of OER, many have wondered whether the adoption of OER is connected to the improvement of student learning outcomes (Grimaidi, Mallick, Waters, & Baraniu, 2019). According to Hilton (2019), who examined 16 different research studies (published from 2015 to 2018) that compared OER settings to non-OER, "more than 95% of the published research indicates OER does not lead to lower student learning outcomes." Grimaidi et al. (2019) obtained similar results after reviewing various published articles discussing whether OER resources improve student learning, concluding that "a majority of comparisons in the literature find null effects of OER adoption on learning outcomes." In Wiley's (2013) opinion, "saving significant amounts of money and doing no harm to learning outcomes (or even slightly improving learning outcomes) is clearly a win", which suggests the education community should examine the rationale for obligating students to purchase traditional textbooks when OER is available (Hilton, 2019).

In most studies of OER, students and faculty reported positive experiences using such resources and claimed they would utilize them again (Brandle et al., 2019; Griffiths et al., 2020; Hilton, 2019). Student participants from the Achieve the Dream OER initiative from 38 colleges nationwide reported in a focus group that they experienced higher quality learning in OER courses, with most (70% of the 2,400 surveyed) not describing any difficulties using OER materials (Griffiths et al., 2020). They furthermore appreciated that these resources could be accessed online and that the content was relevant and up-to-date.

The instructors involved in this study (1,206 surveyed) had mostly positive perceptions of OER, but they also noted the following barriers: 1) the limited availability of suitable, high-quality OER, 2) the lack of time, skills, and support in locating/vetting OER, and 3) difficulties ensuring that OER has appropriate licensing. Other studies reported similar barriers and more, including the challenge of finding relevant and high-quality OER for the subject area (de Ios Arcos et al., 2015), the perception of OER as "poor quality" compared with proprietary material (Jhangiani, Pitt, Hendricks, Key, & Lalonde, 2016), the amount of time required to redesign courses after adopting OER (Seaman & Seaman, 2018), the need to overcome technical difficulties when modifying resources (Ovadia, 2019; Pounds & Bostock, 2019), the lack of institutional support (Martin, 2018), and the low interest in pedagogical innovation among colleagues (Hylen, n.d.).

Nevertheless, such obstacles have not hindered the overall progress of OER, which has convinced instructors not to return to teaching with costly traditional textbooks. In fact, researchers predict that the overall use of traditional textbooks in colleges will die off, being replaced with OER (Phare, 2019, Preville, 2020, Young, 2017), suffering a similar fate to the floppy diskettes, musical records, and CDs that were used widely for decades. David Wiley, an OER pioneer, predicts the death of the textbook in community colleges by 2024, mainly due to the increased

use of OER in such institutions.

Study Purpose

The purpose of this paper is to share a case study that seeks to determine the impact on mathematics students' academic achievement when OER is used in a precalculus course. To determine this impact, we compared the final exam scores for the OER setting to non-OER classes, where the courses administered a common (or similar) final examination. This study also surveyed students to gauge their overall satisfaction levels regarding OER being used in their course. The research questions (RQ) that guided this investigation are as follows:

> RQ1. What are students' attitudes/opinions and overall satisfaction, including obstacles encountered, toward the OER sections?
>
> RQ2. How do the results for the final exam in the OER section compare to the final exam for the course sections that did not utilize OER (for York College only)?

Method

Context of the Study

This study took place in the fall semester of 2018 and spring semester of 2019 at York College and QCC, both CUNY institutions located in suburban areas of Queens, New York. Two mathematics faculty members, one from each of the colleges, collaborated to build the OER capacity in one of their gateway courses, precalculus. While this was the first time OER was used in any mathematics course at York, it was an addition to the list of courses using OER at QCC. Both colleges agreed to utilize the *Precalculus* textbook by OpenStax, with Lumen's online homework manager (OHM). The OpenStax precalculus textbook was a good choice for the OER-based course, as it had been quickly growing in popularity across the United States.

York had been using Pearson's *Precalculus* textbook by Michael Sullivan along with MyMathLab (MML) since 2011. The coordinator of the course was satisfied with the overall quality of the textbook, including its content organization, relevant/relatable problem sets, and lesson activities. Students also benefited from the interactive assessments provided in MML; however, the cost of the Pearson textbook and access code for MML increased nearly every academic year, leaving students unable to afford it. Depending on where and how students purchased the textbook and code for MML, or the MML code alone, they could have paid from $100 to just over $200 for this material. To help address this issue, in 2016, Pearson offered York a loose-leaf option of the same textbook that came with a 6-month access code to MathXL (a trimmed down version of MML) for a lower price of $78. York's precalculus students had been purchasing that package until this study; however, they still complained about the cost.

Some mathematics courses at QCC were already using OER for certain sections before this study (e.g., OpenStax with WeBWorK since 2016). However, for most courses, including the precalculus course involved in this study, the costly traditional textbook was the department standard. QCC's precalculus course had been using the Precalculus, Custom Edition for Queensborough Community College textbook by McGraw-Hill with ALEKS

(Assessment and Learning in Knowledge Spaces) since 2017, which provided interactive online assessments similar to Pearson's product. Students paid $100 for the textbook with access to ALEKS or $50 if they wanted access to ALEKS without purchasing the textbook. Similarly, to York College, QCC were satisfied with the materials they were using for the course, but requiring students to pay for a textbook and online homework in a mathematics course was becoming increasingly undesirable.

Both colleges found that Lumen had similar components compared to MathXL and ALEKS, such as the capability to create a course from scratch, or copy an existing ready-to-use model. As in MathXL and ALEKS, Lumen users had access to an enormous about of problem solving questions from a test bank they could practice with repeatedly, while receiving immediate feedback results. Students had access to video resources and links to textbooks, and they could ask their instructor for help (if needed) with answering particular questions. Lumen also has a gradebook feature that can be set up to display students' grades. A notable functionality in Lumen was the option to add questions to the existing test bank of questions, as well as share (or not share) the questions with other Lumen users. This feature was a plus, enabling Lumen course instructors to add original problem sets (and provide detailed solutions) that may have not been represented in the database to be shared openly.

The immediate benefit students experienced in this study was gaining access to the course textbook and Lumen at no cost on the very first day of the class, which does not occur in traditional courses. The first day of class was spent briefly showing students how to navigate through Lumen to access the textbook and other resources. It should be noted that each student would ordinarily have had to pay the standard low cost of $25 to use Lumen; however, at the time of the study, CUNY covered this fee, allowing the students to access Lumen for free.

Participants

In the fall 2018 semester, both York and QCC explored the use of OER in one of their precalculus sections ($N =$ 33, $N = 25$ respectively). In the spring 2019 semester, two of the precalculus sections at York explored OER ($N =$ 34, $N = 34$), while one section at QCC participated ($N = 25$).

Instruments Used

To answer RQ1, a survey was used to determine the students' overall opinion and attitudes toward learning with OER materials. The survey was administered in both semesters of the study, at the end of the term. It contained multiple-choice options, a Likert-type scale, and open-ended questions. Everyone registered for the course could choose to participate (or not) in filling out the survey (unless prevented due to age constraints).

Specifically, 95 students (62 from York, and 33 from QCC) completed the survey (see Table 1). To answer RQ2, the final exam scores from the OER courses were compared to the non-OER courses for both semesters for York College precalculus courses, whereas York administered a common departmental final exam. The final exam scores at QCC were compared to the scores obtained on similar final exams given in earlier semesters (when OER was not used).

Table 1. Survey Count

Semester	York n	QCC n	Totals
Fall 2018	20	15	35
Spring 2019	42	18	60
Totals	62	33	95

York ran five sections of precalculus in the fall 2018 semester, with one section taught using OER materials, while the other four utilized non-OER materials. Similarly, in the spring 2019 semester, six sections of precalculus ran, with two sections with OER materials, and the other four taught with non-OER materials. Tables 2 and 3 below show the data count for the final exams results in this study for York.

Table 2. Fall 2018 York Final Exam Counts

Setting	n
OER (1)	21
Non-OER (1)	29
Non-OER (2)	30
Non-OER (3)	30
Non-OER (4)	27

Table 3. Spring 2019 York Final Exam Counts

Setting	n
OER (2)	27
OER (3)	27
Non-OER (5)	25
Non-OER (6)	28
Non-OER (7)	27
Non-OER (8)	28

QCC ran one OER precalculus course in fall 2018, and one in spring 2019. The final exam results for these courses were compared to three non-OER courses (that used similar final exams) that ran in the spring 2017, fall 2017, and spring 2018 semesters. Tables 4 and 5 below show the data count for the final exam results for QCC.

Table 4. QCC Final Exam Counts

Setting	n
Spring 2019 (OER)	23
Spring 2017 (Non - OER)	19
Fall 2017 (Non - OER)	19
Spring 2018 (Non - OER)	21

Table 5. QCC Final Exam Counts

Setting	N
Fall 2018 (OER)	21
Spring 2017 (Non - OER)	19
Fall 2017 (Non - OER)	19
Spring 2018 (Non - OER)	21

Data Analysis

SPSS software was used to analyze the multiple-choice and Likert-type question results. Open-ended responses were examined, and categorized separately by both researchers for data interpretation. Cohen's (1960) Kappa statistic was calculated to determine the extent to which both raters agreed with the codes developed for the qualitative responses. An independent samples *t*-test, Welch's *t*-test, and Mann-Whitney *U* test was executed in SPSS to determine whether there was a statistically significant difference in achievement for OER and non-OER settings, having the null hypothesis equal to zero for all test. A Bonferroni correction was applied due to the repetition of compared means using the same sample. Specifically, the critical value was divided by the number of comparisons, and any *p*-value below .0125 ($\frac{.05}{4}$) for York's data and below .0167 ($\frac{.05}{3}$) for QCC's data indicated statistical significance. In addition to these measures, the data was tested for normality and homogeneity of variance using the Shapiro-Wilks test and Levene's test respectively**.**

Results

Survey Results

In total, 95 students completed the OER satisfaction survey in this study. A large majority (92.7%) of the students reported taking 4–5 courses each semester. When asked how often they purchased the required textbook for their courses, 37.9% of respondents stated "About half the time," while others (48.4%) claimed "Often" or "Always." When asked how often they used the required textbook, the majority of respondents (38.9%) stated only "2–3 times a semester" and 27.4% reported using it 2–3 times a month. Moreover, 63.2% of students reported that they typically spend $101–$300 on textbooks, with a further 15.8% spending $301–$500.

When asked to rate the quality of the OER text, most students evaluated it as the same (41.1%) or better (35.8%) quality than the textbooks in their other courses. Most of the respondents (63.2%) liked the online format more than traditional printed text, while 12% stated no preference. When asked how often they used the free textbook, 22.1% of students reported 2–3 times a week, 20% reported 2–3 times a month, and 20% reported 2–3 times a semester. In addition, 17.9% reported that they never used the book. This outcome may have been due to these students using the other supplementary files, such as the PPTs, lecture notes, and YouTube videos that were provided as learning aids in addition to the free textbook. Most respondents (64.2%) reported that they would be very likely to register for a future class with an online text like that used in the course. Moreover, 75.8% of students claimed they would enroll in a section with an OER textbook if two different sections of this course were offered by the same instructor during equally desirable time slots, with one section using OER and the other utilizing a

traditional published textbook.

Students were able to elaborate on what they thought of the free textbook used in the course (Table 6). Eighty-one out of 95 participants responded to this question. Almost all (98%) of the comments were positive, with 2% not clearly expressed by the student and therefore not included in the analysis. Both researchers read and re-read through the open-ended responses, developing a list of short phrases that characterized the responses. For example, the comment "I found the text very helpful" was characterized as "helpful," and the comment "It is free and always accessible on [a] mobile [device] or laptop" was labeled as "affordable" and "accessible." After developing the list of phrases, both researchers read through the responses separately and used the list of phrases developed to label individual responses. The column to the left in Table 6 displays the list of phrases, as well as how many times a response reflected each phrase. From the table, one can see that a significant number of students felt that the textbook was good, great, useful, helpful, and effective. The column to the right quotes some of the actual responses from the question results.

Students were also asked to list the obstacles they encountered (if any) with using the OER text for the course. Both researchers also characterized these responses. Although there were only 54 responses to this question, most students reported experiencing no difficulties with the OER textbook. Table 7 (similar to Table 6) presents the short phrases or words describing the student's response. It also provides examples of what some students actually stated in their responses. Cohen's Kappa value was constantly above .84 (p < 0.001) for both of the questions, establishing outstanding inter-rater reliability between the raters (Landis & Koch, 1977).

Table 6. Overall, What Do You Think of The Texts Used in This Course?

Comments	n	Example Responses
Good/Great	26	- Good. Explains everything well.
Resourceful, informative	4	- Just as useful as any other textbook.
Useful, helpful and effective	20	- I felt that the online text were just as informative as any traditional printed text for my other classes.
Accessible	12	- It was easy to access on your phone + other electronic devices.
Affordable & Convenient	12	- I think it was perfect, no trouble yet simple which I was happy about.
Just as good or better than the traditional	7	- I liked the fact that it was free and accessible.
Easy to navigate and explains well	10	- It's not much different from a textbook.
Perfect	2	- Easily accessible; Don't have to carry heavy books.
Organized	1	- They were just as useful as others, but free.
Simple	1	

Table 7. List Any Obstacles You Encountered with Using the Text for The Course

Comments	n	*Example Responses*
No Issues	34	-None, really.
Technical Difficulties	8	-There were no many obstacles.
Hard	1	- It was free, minor tech problems, otherwise amazing
Confusing	1	- Never encountered any obstacles.
Too much homework problems	1	- Using the online format
Videos didn't help	1	- Computer not working
Wasn't used to it	1	- There were not any.
Procrastination	1	- Hard, confused

Data Description, Including Normality and Homogeneity Assumptions for Final Exam Scores

The final exam data counts for York College and QCC, along with their averages and standard deviations (which were relatively high for all data sets) for the OER and non-OER courses are presented in Tables 8 through 10. The Shapiro-Wilk's test for York's data revealed that all score were distributed approximately normal (p > .05), except for the Non-OER (4) and Non-OER (7) grades, which yielded p = .004 and p = .010 respectively. The assumption of homogeneity was met for all sample comparisons (p > .05), excluding the case when OER (1) and Non-OER (2) were compared. For that case, Levene's test of homogeneity of variances specifically found $F(1,49) = 5.336$, p = .025, yielding an α less than .05, assuming unequal variances. Shapiro-Wilk's test found all data sets failed to be normally distributed ($p < .05$) for QCC's exam scores, except for the SP17 non-OER dataset, which yielded $p = .472$. The assumption of homogeneity was met for all sample comparisons ($p > .05$).

Table 8. York College Fall 2018 Final Exam Descriptive Results

Setting	*n*	Mean	*SD*
OER (1)	21	65.76	27.58
Non-OER (1)	29	44.90	21.88
Non-OER (2)	30	63.37	19.72
Non-OER (3)	30	53.87	24.40
Non-OER (4)	27	67.76	28.62

Table 9. York College Spring 2019 Final Exam Descriptive Results

Setting	*n*	Mean	*SD*
OER (2)	27	48.04	26.36
OER (3)	27	60.85	25.02
Non-OER (5)	25	43.56	29.88
Non-OER (6)	28	47.46	21.25
Non-OER (7)	27	71.26	20.13
Non-OER (8)	28	66.82	22.14

Table 10. QCC Final Exam Descriptive Results

Setting	*n*	Mean	*SD*
SP19 (OER)	23	87.42	16.66
SP18(Non-OER)	21	86.32	11.30
FA17(Non-OER)	19	83.42	19.26
SP17(Non-OER)	19	79.89	14.39

Table 11. QCC Final Exam Descriptive Results

Setting	*n*	Mean	*SD*
FA18 (OER)	21	82.63	15.95
SP18(Non-OER)	21	86.32	11.30
FA17(Non-OER)	19	83.42	19.26
SP17(Non-OER)	19	79.89	14.39

Comparing Means of Open Educational Resources and Non-Open Educational Resources for York College Data Results

Table 12 reveals the results of the independent samples t-test, Welch's t-test, and Mann-Whitney U test used to compare the OER course to the four different non-OER courses that ran in fall 2018.

Table 12. Fall 2018 Results Comparing means of OER and Non-OER for York College

Independent t-Test Results							
Group	*N*	*M*	*SD*	*SEM*	*t*	*df*	*P*
OER (1)	21	65.76	27.58	6.02	-2.98	48	.004
Non-OER (1)	29	44.90	21.88	4.06			
Welch's t-Test							
Group	*N*	*M*	*SD*	*SEM*	*t*	*df*	*P*
OER (1)	21	65.76	27.58	6.02	-.34	48	.735
Non-OER (2)	30	63.37	19.71	3.60			
Independent t-Test Results							
Group	*N*	*M*	*SD*	*SEM*	*t*	*df*	*P*
OER (1)	21	65.76	27.58	6.02	-1.62	49	.111
Non-OER (3)	30	53.87	24.40	4.45			
Mann-Whitney Test Results							
Group	*N*	**Mean Rank**	*U*	*P*			
OER (1)	21	24.31	279.50	.934			
Non-OER (4)	27	24.65					

There was insufficient evidence at 1.25% level of significance to conclude that the final exam scores for OER and non-OER courses were different when comparing the OER (1) course to Non-OER (2), Non-OER (3), and Non-

OER (4). However, there was a significant difference observed when comparing OER (1) to Non-OER (1), due to p < .0125. In this case, the OER course performed better than the non-OER course. Tables 13 and 14 also present the results of the independent samples *t*-test, ANOVA Welch's *t*-test, and Mann-Whitney *U* test utilized to compare each of the two OER courses to the four non-OER courses that ran in spring 2019.

Table 13. Spring 2019 Results Comparing means of OER and Non-OER for York College

Independent t-Test Results

Group	N	M	SD	SEM	t	df	P
OER (2)	27	48.04	26.36	5.07	-.574	50	.569
Non-OER (5)	25	43.56	29.87	5.98			

Independent t-Test Results

Group	N	M	SD	SEM	t	df	P
OER (2)	27	48.04	26.36	5.07	-.089	53	.930
Non-OER (6)	28	47.46	21.25	4.02			

Mann-Whitney Test Results

Group	N	Mean Rank	U	P
OER (2)	27	20.39	172.50	.001
Non-OER (7)	27	34.61		

Independent t-Test Results

Group	N	M	SD	SEM	t	df	P
OER (2)	27	48.04	26.36	5.07	2.87	53	.006
Non-OER (8)	28	66.82	22.14	4.18			

Table 14. Spring 2019 Results Comparing means of OER and Non-OER for York College

Independent t-Test Results

Group	N	M	SD	SEM	t	df	P
OER (3)	27	60.85	25.02	4.82	-2.27	50	.028
Non-OER (5)	25	43.56	29.87	5.98			

Independent t-Test Results

Group	N	M	SD	SEM	t	df	P
OER (3)	27	60.85	25.02	4.82	-2.142	53	.037
Non-OER (6)	28	47.46	21.25	4.02			

Mann-Whitney Test Results

Group	N	Mean Rank	U	P
OER (3)	27	31.07	268.00	.095
Non-OER (7)	27	23.93		

Independent T-Test Results

Group	N	M	SD	SEM	T	df	P
OER (3)	27	60.85	25.02	4.82	.938	53	.353
Non-OER (8)	28	66.82	22.14	4.18			

It was observed that when comparing OER (2) to Non-OER (7) and OER (2) to Non-OER (8), the non-OER courses performed significantly better than the OER courses ($p < .0125$). There was insufficient evidence at 1.25% level of significance to conclude whether the final exam scores for OER and non-OER courses were different when comparing OER (2) to Non-OER (5) and OER (2) to Non-OER (6). In addition, when comparing OER (3) to Non-OER (5), Non-OER (6), Non-OER (7), and Non-OER (8), there was insufficient evidence at 1.25% level of significance to conclude that the final exam scores were different.

Comparing Means of Open Educational Resources and Non-Open Educational Resources for Queensborough Community College Data Results

The Mann-Whitney *U* test was used to compare the final exams from both OER courses to the final exams of three non-OER courses that administered similar exams. The results of the test (see Tables 15 and 16) did not yield sufficient evidence (at 1.67% level) to confirm that there were any significant differences when comparing the final exam outcomes of both settings.

Table 15. Fall 2018 Results Comparing means of OER and Non-OER for QCC

Mann-Whitney Test Results

Group	*N*	Mean Rank	*U*	*P*
FA18 (OER)	21	21.07	211.50	.821
SP18 (Non-OER)	21	21.93		
Group	***N***	**Mean Rank**	***U***	***P***
FA18 (OER)	21	20.05	190.00	.797
SP18 (Non-OER)	19	21.00		
Group	***N***	**Mean Rank**	***U***	***P***
FA18 (OER)	21	22.33	161.00	.297
SP18 (Non-OER)	19	18.47		

Table 16. Spring 2019 Results Comparing means of OER and Non-OER for QCC

Mann-Whitney Test Results

Group	*N*	Mean Rank	*U*	*P*
SP19 (OER)	23	22.87	233.00	.841
SP18 (Non-OER)	21	22.10		
Group	***N***	**Mean Rank**	***U***	***P***
SP19 (OER)	23	21.48	218.00	.797
SP18 (Non-OER)	19	21.53		
Group	***N***	**Mean Rank**	***U***	***P***
SP19 (OER)	21	24.35	153.00	.098
SP18 (Non-OER)	19	18.05		

Discussion and Conclusion

The goal of this research was to present a case study that would determine the impact on precalculus students' academic achievement and their overall satisfaction levels when OER is used in their course. After comparing final exam scores for the OER to non-OER courses, it was seen that for the most part, there was no significant difference observed in the learning outcomes. Based on these findings, both researchers believe there is no need to continue teaching with traditional for-cost textbooks when students can achieve the same academic level results with OER. These results were consistent with the past and current research (Hilton, 2016; Kılıçkaya, & Kic-Drgas, 2021; Wynants & Dennis', 2022) on the influence of OERs on students' academic success. In Hilton's view (2016), after analyzing sixteen studies on the achievement of courses that use OERs, one must question the value of traditional textbooks when the use of OERs does not appear to negatively affect students learning.

Most studies on student perception of OER in higher education report positive experiences (Hilton, 2020, Griffiths et al., 2020 & Brandle et al., 2019), and this study's results were no different. Student's in this study were overall satisfied with the OER textbook used in their course, highlighting it as being useful, resourceful, affordable and an accessible tool. Most students furthermore rated the textbook quality as "the same" or "better" than the quality of traditional textbooks used in other courses they were taking. There were even some suggestions of a preference for using online textbooks like the one used in the study over the traditional type in future courses. However, it should be noted that a significant number of students (about 60%) revealed they rarely used the OER textbook, having used it 2–3 times a month, 2–3 times the semester, or not at all.

In addition to what was studied, the researchers felt that it would have also been beneficial to look into what additional resources helped students throughout the course other than the textbook, because they were clearly deriving assistance from other sources. Perhaps the video help from Lumen OHM, internet websites, YouTube videos, tutoring centers, or office hour visits provided additional support for the course. In any event, research should further explore student's expectations and preferences towards textbooks (Su, 2022), specifically what drives them to use them verses utilizing other learning aids. The usage of OERs has attributed to lowing the cost of higher education for many institutions. Further improvement can focus on making sure the textbooks appeal to student's needs.

The original objective of this study initiated in 2018 was to evaluate the use of OER in precalculus and its effects, with the ultimate goal of cutting textbook expenses and increasing the number of OER sections of precalculus at both colleges involved in the study. We did not imagine that in the spring of 2020 (the start of the pandemic) our research would be of tremendous help to us, and other faculty members at our college who since our study adopted OER in their courses due to the direct benefits for students. Building OER capacity in higher education is so vital at this time when students are experiencing so much hardship, despair and anxiety due to the effects of the pandemic. Students should not have to worry about how they will pay for textbooks on top of tuition cost, rent, food, babysitting fees and other pertinent items (Vann Allen & Katz, 2020). As this pandemic continues to cause hindrances to a full return of in-person learning for many educational establishments, and the rapid increase of online platforms being developed, there is an express need for continuous development of OER-based courses to

promote easy and affordable access to content for all learners.

Acknowledgements

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