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As Good or Better than Commercial Textbooks: Students' Perceptions and Outcomes from Using Open Digital and Open Print Textbooks

Rajiv S. Jhangiani
Kwantlen Polytechnic University, rajiv.jhangiani@kpu.ca
Farhad N. Dastur
Kwantlen Polytechnic University, farhad.dastur@kpu.ca
Richard Le Grand
Kwantlen Polytechnic University, richard.legrand@kpu.ca
Kurt Penner
Kwantlen Polytechnic University, kurt.penner@kpu.ca

As Good or Better than Commercial Textbooks: Students' Perceptions and Outcomes from Using Open Digital and Open Print Textbooks

Abstract
The increase in the cost of college textbooks together with the proliferation of digital content and devices has inspired the development of open textbooks, open educational resources that are free, openly licensed, and often peer-reviewed. Although several published studies have investigated the impact of open textbook adoption on educational outcomes, none have separated the effects of textbook openness and format and only two have taken place in Canada (Hendricks, Reinsberg, & Rieger, 2017; Jhangiani & Jhangiani, 2017). This study investigates the perceptions, use, and course performance of Canadian post-secondary students assigned a commercial or open textbook in either print or digital format. Results show that students using the print format of the open textbook perceive its quality to be superior to the commercial textbook. Moreover, students assigned an open textbook in either format perform either no differently from or better than those assigned a commercial textbook. These results are consistent with the existing literature and support the conclusion that the cost savings to students associated with the adoption of open textbooks do not come at the expense of resource quality or student performance.

L'augmentation du coût des manuels universitaires ainsi que la prolifération du contenu numérique et des appareils électroniques ont inspiré le développement de manuels ouverts, des ressources éducationnelles qui sont gratuites, dont les licences d'exploitation sont ouvertes et qui sont souvent évalués par les pairs. Bien que plusieurs études publiées aient étudié l'impact de l'adoption de manuels ouverts sur les résultats éducationnels, aucune n'a séparé les effets du caractère ouvert des manuels et du format et seulement deux études ont été menées au Canada (Hendricks, Reinsberg & Rieger, 2017; Jhangiani & Jhangiani, 2017). Cette étude examine les perceptions, l'emploi et les résultats des étudiants dans des établissements d'enseignement supérieur canadiens à qui on avait assigné un manuel commercial ou un manuel ouvert en format imprimé ou numérique. Les résultats ont montré que les étudiants qui avaient utilisé le format imprimé du manuel ouvert avaient perçu que sa qualité était supérieure à celle du manuel commercial. De plus, les étudiants à qui on avait assigné un manuel ouvert dans l'un ou l'autre des formats avaient obtenu des résultats semblables à ceux des étudiants à qui on avait assigné un manuel commercial. Ces résultats concordent avec les publications existantes et confirment la conclusion que les économies de coûts pour les étudiants liées à l'adoption de manuels ouverts n'entraînent pas une dégradation de la qualité des ressources ni des résultats des étudiants.

Keywords
open textbooks, open educational resources, open educational practices, post-secondary education, access, Canada

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The cost of textbooks in the United States rose by 142% between December 2001 and July 2017, a rate that is almost four times that of inflation (U.S. Bureau of Labor Statistics, 2017). Although comparable Canadian data are not publicly available, the cost of textbooks in this smaller market is often higher due to a 10-15% tariff imposed on imported books (Justice Laws, 2008), a piece of legislation that costs students an estimated $30 million per year (Hall, 2013). As a result, students' educational choices and outcomes are increasingly being influenced by the cost of required course materials. For instance, a survey of over 22,000 students in Florida found that 67% reported not having purchased a required course textbook (Florida Virtual Campus, 2016). This is despite the fact that 94% of students believe that not having access to the textbook negatively impacts their course performance (U.S. PIRG, 2014). The same survey in Florida found that 48% of students had taken fewer courses, 26% had dropped a course, and 21% had withdrawn from a course, all due to high textbook costs (Florida Virtual Campus, 2016).

Despite significantly lower tuition fees, it appears that similar pressures exist in the Canadian post-secondary system. A survey of 320 post-secondary students from 12 institutions in British Columbia found that 54% had not purchased at least one required course textbook, 27% had taken fewer courses, 26% had dropped or withdrawn from a course, and 30% had earned a poorer grade, all specifically due to high textbook costs (Jhangiani & Jhangiani, 2017). Similar results have since been found in surveys of 152 students at the University of British Columbia (Hendricks et al., 2017) and 4,240 students at the University of Guelph (Martin et al., 2017).

This state of affairs has prompted state governments (e.g., 26 states from Arizona to Wisconsin), international higher educational authorities (e.g., British Columbia Ministry of Advanced Education), philanthropic organizations (e.g., The William and Flora Hewlett Foundation), universities and colleges (e.g., State University of New York), and even professional bodies (e.g., Center for Computer-Assisted Legal Instruction) to fund the development of open textbooks for the highest-enrolled undergraduate courses. Open textbooks are a type of open educational resource (OER) that are available to students at no cost (in a variety of digital formats) or at very low cost (in print format). Beyond providing free, immediate, flexible, and permanent access to required course materials, open textbooks are also openly licensed (e.g., Creative Commons), a feature that bestows upon adopting faculty a suite of additional permissions that enable users to reuse, revise, remix, retain, and redistribute these resources (Wiley, Bliss, & McEwen, 2014). This ability to readily update and contextualize course textbooks arguably represents a new layer of academic freedom, as faculty are no longer bound by the limitations of the offerings of commercial publishers vis-à-vis content, currency, clarity, and cultural relevance.

The goal of the present study is to investigate the impact of open textbook adoption on exam performance, study habits, and perceptions of textbook quality in a sample of Canadian undergraduate students taking a semester-long, introductory psychology course.

Commercial vs. Open Textbooks

As the adoption of open textbooks has proliferated (collectively saving students worldwide more than $174 million [Creative Commons, 2015]), a growing number of researchers have begun to investigate the impact of OER adoption on educational outcomes along with how students assigned OER perceive their quality.

Student performance. Numerous studies of the impact of OER on student outcomes—conducted across diverse disciplinary, institutional, and jurisdictional contexts—have repeatedly confirmed the same result: that students using OER perform just as well as or, in

some cases, better than those using commercial course materials (see Hilton, 2016 for a review). For example, Allen and his colleagues (2015) compared the exam performance of 478 students enrolled in a general chemistry course that used a web-based OER known as ChemWiki for its primary textbook with the performance of 448 students enrolled in a control class that used a commercial textbook. These two sections were taught during the same semester at consecutive hours with the same faculty member and team of teaching assistants. All students received identical exams. Beginning of semester pre-tests and final exams showed no significant differences in individual learning gains between the two groups, suggesting that commercial textbooks could be substituted with OER without negatively impacting learning.

In a non-experimental case study, Hilton and Laman (2012) compared the performance of 690 students using an adapted open textbook in an introductory psychology class to the performance of 370 students who had used a commercial textbook in a previous semester. The results showed that students who used the open textbook had a lower withdrawal rate (7.1% vs. 14%) and scored better on the final examination (71.1% vs. 67.6%).

Another study by Hilton and his colleagues focused on 1400 math students at a community college in Arizona, comparing average student performance on a standard departmental exam (Hilton, Gaudet, Clark, Robinson, & Wiley, 2013). The researchers did not find any significant differences in performance between the year when all classes used OER and the previous two years when no classes used OER.

The single largest study to date evaluated the impact of OER adoption among students enrolled in 15 courses at 10 institutions (Fischer, Hilton, Robinson, & Wiley, 2015). In two out of the fifteen classes, students in the treatment (OER) group were significantly more likely to complete the course (there were no differences in the remaining thirteen) whereas in five of the classes students in the treatment group were significantly more likely to receive a C- or better (there were no significant differences in nine of the classes and only in one class were control students more likely to receive a C- or better)[1]. Finally, treatment students were found to have enrolled in significantly more classes than control students during the semester of OER implementation as well as the subsequent semester[2].

The sole published Canadian open textbook efficacy study investigated the use of OER among 143 students enrolled in a physics course at the University of British Columbia (UBC; Hendricks et al., 2017). Compared with students enrolled in the same course in previous semesters, the students assigned OER showed no significant differences in final exam grades or course grade distributions.

Student perceptions. A number of studies have measured the student perceptions of OER (see Hilton 2016 for a review). Once again, these studies reveal a consistent pattern across several disciplines and institutional contexts. For example, of 490 students at seven U.S. community colleges, 50% rated their open textbooks as comparable in quality to their commercial textbooks, with an additional 40% rating the open textbooks as superior (Bliss, 2013). Similarly, approximately two-thirds of 315 business students surveyed by Feldstein and his colleagues (2012) indicated that they preferred OER to commercial textbooks while 78% of these respondents felt that the OER "provided access to more up-to-date material than is available in my print textbooks" (p. 6). Finally, 78% of 910 mathematics students surveyed by Hilton and his colleagues (2013) indicated that they would recommend OER to their peers while 83% endorsed the statement that "Overall, the materials adequately supported the work I did outside of class" (p. 43).

[1] For these analyses, 9264 control participants were compared against 1087 treatment participants.

[2] For these analyses, 4147 control participants were matched with 4147 treatment participants using propensity score matching.

The two published Canadian studies of student perceptions of OER echo the rest of the literature, with 93% of 143 physics students at UBC and 96% of 320 post-secondary students across BC rating their open textbooks as equal to or better than their commercial textbooks (Hendricks et al., 2017; Jhangiani & Jhangiani, 2017).

Although the reviewed studies measured perceived quality differently, in every case, a majority of respondents indicated favorable perceptions of OER when compared against commercial textbooks.

Print vs. Digital Textbooks

The disruptive opening of the commercial textbook market to free or low cost open textbooks with flexible copyright parallels and interacts with another disruption: the availability of content (both commercial and open) on digital platforms. Digital textbooks (also called e-textbooks) are typically accessed via the Internet and read or downloaded on digital devices such as desktops, laptops, tablets, netbooks, e-readers, or smartphones. Digital textbooks come in two forms (Railean, 2015): the first are page-fidelity digital textbooks that are simply scanned photos of the original print textbook (e.g., a PDF file). The second are reflowable digital textbooks that use a flexible formatting system and are paginated for the type of reading device and size. Reflowable digital textbooks allow for interactive features such as dynamic media, hyperlinks, layout modification, discussions, polling, simulations, and learning analytics.

Digital textbook adoptions have been increasing due to their lower cost, greater convenience, and wider access to the Internet and digital platforms (de Noyelles, Raible, & Seilhamer, 2015; Reynolds, 2011), with one 2014 study reporting that 60% of U.S. college students have used a digital textbook for at least one course (an increase of 18% from 2012; Dahlstrom & Bichsel, 2014). McGraw Hill Education (which currently holds a 21% market share) saw its digital content sales surpass its print sales for the first time in 2015 (McGraw Hill Education, 2016). However, the adoption of digital textbooks is still impeded by non-standardization of digital platforms, issues with distribution and discoverability, quality concerns, differences in the reading experience, and resistance to change.

Student performance. Several studies have investigated the impact of textbook format on learning. In one case, 538 undergraduate and graduate students showed no differences in grades or perceived cognitive learning when using print and reflowable digital formats (Rockinson-Szapkiw, Courduff, Carter, & Bennett, 2013). However, students who chose the e-textbook demonstrated higher perceived affective and psychomotor learning than students who chose the print textbook. Another study, which compared the perceptions and performance of Introductory psychology students using a digital vs. print textbook, found no differences in course grades, even as students using the page-fidelity e-textbook reported spending less time reading for class (Shepperd, Grace, & Koch, 2008).

Daniel and Woody (2013) examined students' use and performance with digital vs. print textbooks in both laboratory and at-home conditions. Students scored similarly across formats and conditions; however, reading time was significantly higher in the digital conditions, with this difference increasing for the home conditions. Self-reports of multi-tasking were significantly higher for the home/digital condition, possibly accounting for the disparities in reading time.

Reading time and text comprehension were also examined in an experimental study in which university students were randomly assigned to read from an Apple iPad tablet, a Kindle 3 eBook reader, or a paper printout. Students reading printed materials had faster reading times than those reading from eBook readers or tablets. However, students found the tablet the most

usable, followed by the eBook reader and then the printed material. There were no differences between groups on reading comprehension (Connell, Bayliss, & Farmer, 2012).

Finally, Ackerman and Goldsmith (2011) evaluated metacognitive regulation of text learning. Participants were asked to predict their multiple choice test performance after reading expository text (1000-1200 words) in either digital or print format. Test performance did not differ between the two formats under a fixed study time but performance was worse for screen readers when the study time was self-regulated. The authors concluded that performance differences between digital and print formats are likely metacognitive because they involved less accurate performance predictions and more erratic study time regulation.

Student perceptions. Most studies have shown that a majority of students prefer print to digital (e.g., Millar & Schrier, 2015; Woody, Daniel, & Baker, 2010). For example, data from 655 student respondents of the 2011 Electronic Book and eReader Device survey revealed that if the choice of textbook for a course were entirely theirs, 75% of students would opt for a print textbook over a digital one (NACS OnCampus Research, 2011). Recent research that explored the reasons for this general preference has found contradictory results. For example, an inability to take notes or highlight text and greater convenience were among the top-cited reasons for a preference for print (Millar & Schrier, 2015). On the other hand, aside from lower cost, greater convenience (e.g., ability to access e-textbooks anywhere, access e-textbooks offline, and store many e-textbooks on the same device) is typically the largest factor that drives e-textbook adoption[3] (de Noyelles et al., 2015). Moreover, three quarters of 707 undergraduate and graduate students using e-textbooks cited functions that support reading (e.g., searching for keywords, zooming) and studying (e.g., highlighting, note-taking) as the top features that influenced their choice to purchase an e-textbook (de Noyelles et al., 2015). A factor that might account for low adoption rates of e-textbooks is low digital literacy on the part of both students and instructors.

Methodological issues. Research comparing print textbooks to digital textbooks is difficult to assess because of the conflation of platform (e.g., digital vs. print) issues with both content and the structure of content issues (Railean, 2015). Comparing a print textbook to a page-fidelity digital textbook is the simplest comparison and allows for a direct comparison of the experience of reading on paper vs. a screen. Here issues of luminance, reflection, resolution, font, screen size, and spatial landmarks can be addressed (Myrberg & Wiberg, 2015). However, if one compares a print textbook to a reflowable digital textbook, then the visual experience of print vs. screen becomes conflated with the dynamic possibilities afforded by reflowable digital textbooks. Further complexity occurs when one compares a print textbook (the vast majority of which are commercial) with an open, reflowable digital textbook, which may include modifications made by the instructor.

The question of which dependent variables best assess learning also need to be addressed. Although most published studies have utilized course grades or test achievement scores as the measure of learning, differences in textbook format may also influence the cognitive (e.g., attention, memory), affective (e.g., preferences), and psychomotor (e.g., changes in behaviour) dimensions of learning (Frith & Kee, 2003; National Center for Higher Education Management Systems, 1994).

[3] Greater convenience would help explain why 90% of 367 students enrolled in an Introductory Psychology course who were given a choice between a print textbook and a cheaper e-textbook on a compact-disc (CD) elected to purchase a print textbook (Shepperd et al., 2008).

The Present Study

The present study seeks to extend the existing literature in four ways. First, this study constitutes only the second OER efficacy study within the context of a Canadian post-secondary institution. This is notable because almost all of the published OER efficacy research has been conducted within U.S. institutions. Given that post-secondary tuition fees are especially high within the United States, the ratio of the cost of course materials to tuition is typically much higher outside of the U.S., raising the question of the generalizability of the (admittedly uniform) findings of the existing literature. Second, we seek to disentangle the format (digital vs. print) of the course textbook from whether it is open or commercial. This is desirable because open textbooks are available in both digital and print format. We believe that it is important to separate the impact on educational outcomes of enhanced access to course materials from the strengths and limitations of the particular format(s) in which users choose to interact with their textbook. Third, we seek to measure how students interact with their textbook (i.e., their study habits) in order to better understand this potential mediator of course performance. Fourth, we wish to assess the textbook perceptions and preferences of students enrolled in sections that have adopted an open textbook as well as those that have adopted a commercial textbook. This is desirable because every other published study has investigated the perceptions of students assigned OER (typically asking them to compare their current experience with their previous experiences), a method that is susceptible to reconstructive memory bias.

In the present study we sought to address the following six questions, all within a Canadian post-secondary context:

1. Do students using an open textbook perform differently on course exams from students using a commercial psychology textbook?
2. Do students using an open textbook in page-fidelity digital format perform differently on course exams from students using the same open textbook in print format?
3. Do students' study habits vary as a function of textbook openness and format?
4. Do students' perception of quality vary as a function of textbook openness and format?
5. Do students' perceptions of a fair price vary as a function of textbook openness and format?
6. Do students' textbook format preferences vary as a function of textbook openness and format?

Method

Participants

The sample consisted of 178 students enrolled in seven sections of an Introductory Psychology course taught by three instructors (Dastur, Le Grand, and Penner) at Kwantlen Polytechnic University, a mid-sized, public, Canadian undergraduate university. During the Spring 2015 semester, two sections were assigned to adopt the digital format of an open textbook (n = 44), and two sections were assigned to adopt the print format of an open textbook (n = 51). For each of these conditions, one section was taught by the second author (Dastur) and the other by the third author (Le Grand). During the Summer 2015 semester, three sections were assigned to adopt the incumbent commercial textbook (n = 83). One of these sections was taught by the third author (Le Grand) and the other two by the fourth author (Penner) (see Table 1). Given that all students within each section were assigned to that condition, this study

employs a quasi-experimental research design. The assignment of condition to sections was constrained by the instructors' previously-determined teaching schedules. Consequently (and given the importance of the instructor variable), Le Grand's sections provide the best insight into the impact of textbook openness whereas both Dastur's and Le Grand's sections provide insight into the impact of open textbook format.

Table 1
Course Sections by Semester, Textbook Condition, and Instructor

Semester	Commercial	Open Print	Open Digital
Spring 2015		1 x Dastur 1 x Le Grand	1 x Dastur 1 x Le Grand
Summer 2015	1 x Le Grand 2 x Penner	-	-

The modal age of the aggregated sample (between 20 and 21), the proportion of females (59%), ethnic minorities (63%), and those for whom English was a second or subsequent language (48%) did not vary significantly across the conditions. Two pre-existing differences were found between students across the three conditions: (a) students assigned the commercial textbook had completed significantly more undergraduate courses, and (b) students assigned the commercial textbook were enrolled in significantly fewer concurrent courses.

This study received approval from the Kwantlen Polytechnic University Research Ethics Board.

Materials

Textbooks. The commercial textbook was the 10th edition of Worth Publishers' *Psychology* (Myers, 2014), whereas the open textbook was the first edition of OpenStax College's *Psychology* (OpenStax College, 2014). Both textbooks are used for both semesters of the popular Introductory Psychology course. The bestselling Worth textbook includes 16 chapters across 685 pages whereas the OpenStax textbook (which is adopted within U.S. higher education institutions at a similar rate to most commercial textbooks; Seaman & Seaman, 2017) includes 15 chapters across 631 pages. Both books align with the American Psychological Association's (2014) recommended content commonality with at least two topics drawn from each of the five main pillars of the field (biological, cognitive, development, social and personality, and mental and physical health). With the exception of one additional topic in the OpenStax book (Industrial-Organizational Psychology), both textbooks cover identical topics, with coverage of two chapters in the OpenStax book each split into two chapters in the Worth book. Both textbooks include learning aids such as quizzes, critical thinking exercises, lists of key terms, and leaning objectives. Despite all of these similarities, differences remain between the two books in content, structure, and style.

Students using the commercial textbook had the option of purchasing a print (loose-leaf binder) format from the university bookstore (at a cost of just over CDN $100) or 180-day access to the (reflowable) digital format (at a cost of CDN $71). Of course, students may have acquired the textbook using other means including purchasing older or international editions, illegally downloading the textbook, using online retailers like Amazon.com, using the copy of the textbook on library reserve, sharing the book with a classmate, or simply going without the

textbook. We did not constrain these options for ethical reasons. We also wished for the sections utilizing the commercial textbook to serve as a naturalistic control.

The students assigned the (page-fidelity) digital format of the open textbook had the option to order a low-cost print copy (at their own cost) or even to print the textbook at home. Conversely, the students assigned the print format of the open textbook were able to download the digital format for free. Because we wanted to investigate the impact of the print vs. the digital formats of the open textbook while holding the cost constant (at zero), free[4] print copies of the open textbook were distributed to students in those two sections.

General knowledge of Psychology pre-test. On the first day of class, students in all sections were given a 24-item, four-option, multiple-choice test that assessed their general knowledge of psychology across each of the eight topics to be covered during the course: Introduction to Psychology, Psychological Research, Biopsychology, States of Consciousness, Sensation & Perception, Learning, Thinking & Intelligence, and Memory. The Pre-Test was adapted from a larger set of 851 multiple choice questions created by psychology instructors from six local institutions as part of a Test Bank Sprint. The questions and their potential answers were clearly phrased and unambiguous.

Course exams. Students in all sections wrote three non-cumulative exams consisting of approximately 60, four-option, multiple-choice questions. All of the questions assessed students' grasp of concepts that were covered in both textbooks. The questions and their potential answers were clearly phrased and unambiguous.

Questionnaire. At the end of the semester, students completed an in-class questionnaire that included both open-ended and closed-ended questions about demographic characteristics (e.g., age, sex, ethnic minority status), level of employment (e.g., hours worked per week), educational status (e.g., total credits completed, GPA), textbook preferences (e.g., print, digital, or both), perceptions of the quality of their current textbook (including a modified[5] version of the Textbook Usage and Assessment Scale [TAUS]; Gurung & Martin, 2011), and study habits (e.g., hours spent studying per week). Students using the open textbook were additionally asked about whether they had used the alternate format (print or digital). The last five digits of their student numbers were requested so that questionnaire data could be matched with course performance data (described further in the Procedure section).

Procedure

Students registered for their sections using normal procedures and learned of their assigned textbook by visiting the university bookstore, emailing the instructor, reading the course syllabus on the course management system, or during the first day of class. A downloadable digital (PDF) copy of the open textbook was posted to the course webpage of the sections that were assigned this format. Print copies of the open textbook were distributed, free of charge, to students enrolled in those two sections by the course instructor on the first day of class.

During the final class of the semester, a research assistant visited each of the sections to describe the study, obtain informed consent, and administer the questionnaire. The course instructors were not present during this time. The students were informed that their decision to

[4] BCcampus, a provincial organization that provides a range of shared services to post-secondary institutions, provided the print open textbooks.

[5] We used 16 out of the 22 TAUS items. Three of the deleted items were concerned with the placement of the figures, tables, and photographs in relation to the material while the other three measured how often these three types of resources were used to study.

participate or not was voluntary and that their decision would not be revealed to their instructor until after the course grades had been submitted. Student participants were offered a 1% bonus using the Departmental Psychology Lab research pool. Students who chose not to participate were also offered equivalent bonus marks if they completed a different study in the research pool. The research assistant addressed any questions posed by the students before distributing the informed consent forms and a copy of the questionnaire. The students took about 10 minutes to complete the questionnaire. At the end of this procedure, the research assistant gathered the informed consent forms and completed surveys, thanked the students for their participation, and left the classroom.

Upon the conclusion of the course, the instructors submitted the pre-test and exam grades for all students enrolled in the seven sections to the research assistant, who merged these data with the questionnaire data using the last five digits of the student numbers. Once the data had been merged, the partial student numbers were deleted from the dataset.

Timeline of assessments. The study involved 7 sections of Introductory Psychology. Assessments ran across two, 15-week semesters (including 1 week for Reading Break). We assessed four sections during the Spring semester (January - April, 2015): 2 sections were assigned the open, print textbook and 2 sections were assigned the open, digital textbook. All three sections assessed during the Summer semester (May - August, 2015) were assigned the commercial textbook.

On the first day of class, those students in attendance completed the General Knowledge of Psychology Pre-Test. The Pre-Test was administered in-class by the course instructor and students were given feedback shortly after completion. Referenced against the first day of class (±1 week to accommodate different sections), the three course exams were delivered after 5 weeks, 11 weeks, and 15 weeks.

Instructional mode. All three instructors taught their classes once a week in 3-hour lecture format. The instructors were not blind to condition but were careful to coordinate their respective lectures so that the same topics were being covered. The three course exams were identical across instructors and sections. However, the instructors did not coordinate the amount of time spent on each topic, their instructional delivery style (e.g., more formal lecturing vs. more class discussion), or the types of assessments used beyond the course exams.

Results

General Psychology Knowledge Pre-Test

There were no significant differences in general psychology knowledge between students enrolled in the sections assigned the commercial (M = 41.8%, SD = 11.4%), open print (M = 42.2%, SD = 8.2%), or open digital (M = 41.0%, SD = 10.2%) textbooks [$F(2, 149) = 0.16$, $p = .85$, $\eta_p^2 = .002$].

Exam Performance

A MANOVA with textbook condition (commercial vs. open print vs. open digital) as the independent variable, instructor as a covariate, and performance on the three exams as the dependent variables attained statistical significance for both textbook condition [Pillai's Trace = .126, $F(6, 342) = 3.83$, p = .001, $\eta_p^2 = .06$] and instructor [Pillai's Trace = .077, $F(3,170) = 4.73$, $p = .003$, $\eta_p^2 = .08$]. A univariate F test showed an impact of textbook condition on students' performance on the third exam [$F(2,172) = 3.42$, $p = .04$, $\eta_p^2 = .04$], with pairwise comparisons indicating that students assigned the commercial textbook scored significantly

lower than those assigned the digital format of the open textbook (p = .01). There were no differences in exam performance across types of textbook for the first two exams (see Figure 1).

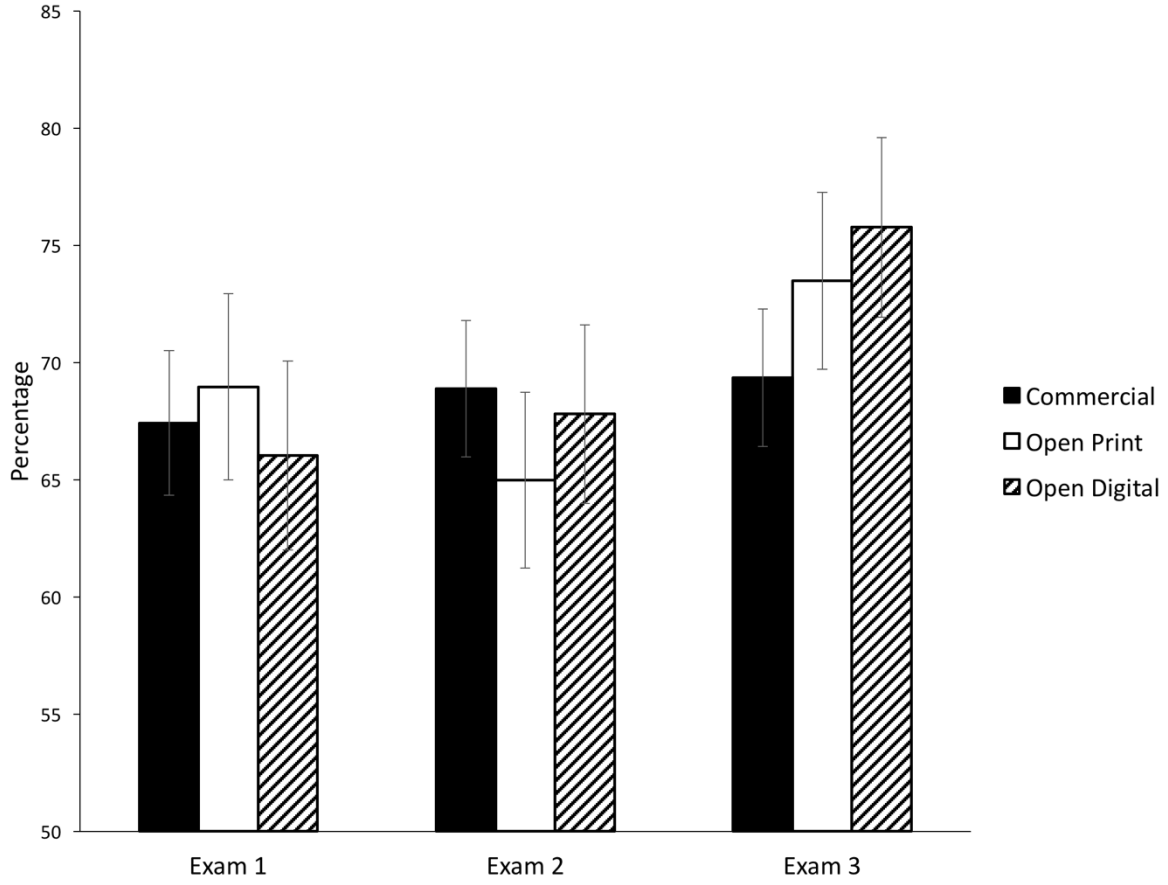

Figure 1. Mean performance on three course exams as a function of textbook openness and format (all sections). 95% confidence intervals are represented in the figure by the error bars attached to each column.

Because of the significant impact of instructor on exam performance, we ran a second MANOVA, with data only from the one instructor (Le Grand) who taught one section in each of the three conditions. Once again, textbook condition impacted exam performance [Pillai's Trace = .511, $F(6, 138) = 7.901$, $p = .000$, $\eta_p^2 = .26$]. In this case, the univariate F test showed an impact of textbook condition on students' performance on the first exam [$F(2,70) = 18.98$, p=.000, $\eta_p^2 = .35$], with pairwise comparisons revealing that students assigned the commercial textbook scored significantly lower than those assigned either the print or digital formats of the open textbook (p's = .000). There were no differences in exam performance across types of textbook for the first and third exams (see Figure 2).

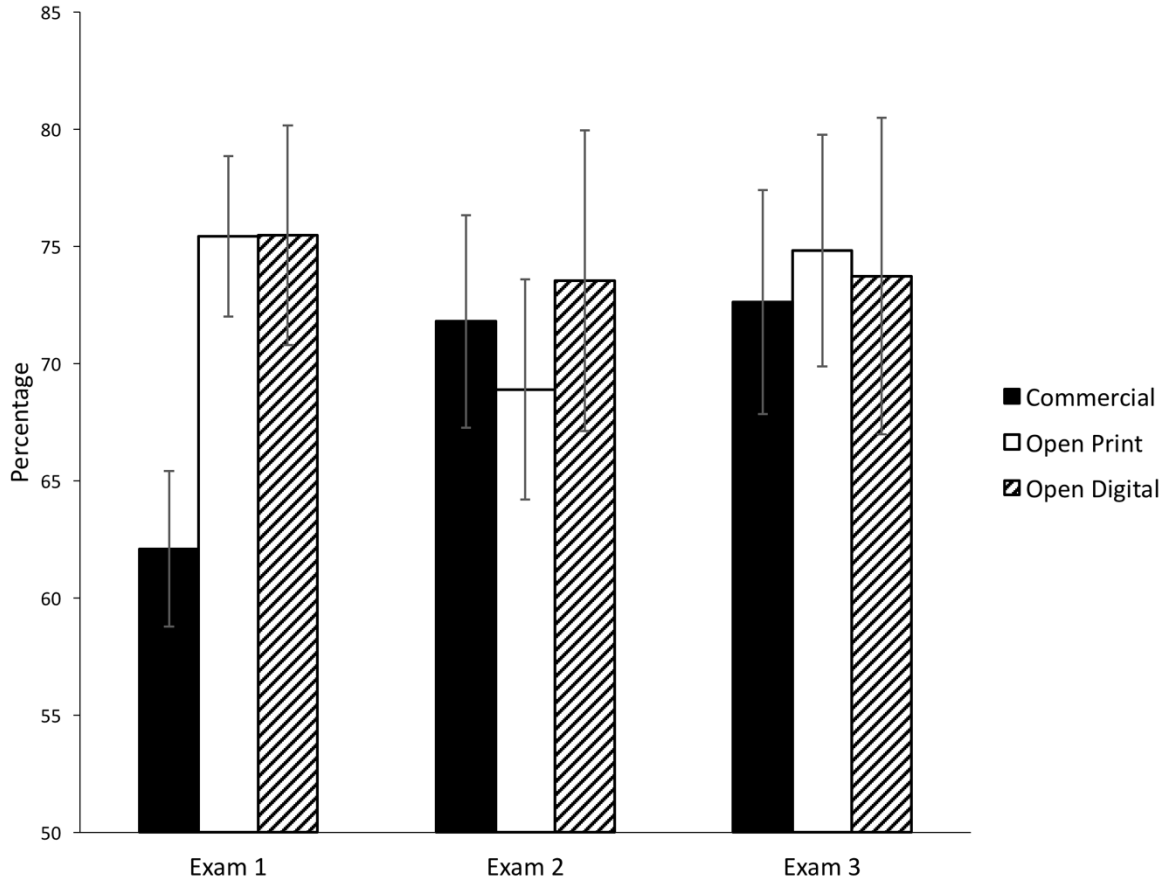

Figure 2. Mean performance on three course exams as a function of textbook openness and format (Le Grand's sections). 95% confidence intervals are represented in the figure by the error bars attached to each column.

Study Habits

In order to investigate students' study habits, a MANOVA was conducted with textbook condition (commercial vs. open print vs. open digital) as the independent variable and instructor as a covariate. The dependent variables included the proportion of weekly readings completed, the amount of time per week spent studying for the course, the amount of time per week spent studying the textbook, and the amount of time per week spent studying the lecture material. The MANOVA attained statistical significance for textbook condition [Pillai's Trace = .162, $F(8, 338) = 3.72$, $p = .000$, $\eta_p^2 = .08$]. Univariate F tests showed that students across the three conditions spent different amounts of time per week studying for the course [$F(2, 171) = 4.35$, $p = .01$, $\eta_p^2 = .05$] and the lecture material [$F(2, 171) = 7.88$, $p = .001$, $\eta_p^2 = .08$]. Pairwise comparisons showed that students assigned the commercial textbook reported spending significantly more time per week studying than those assigned either the print or digital format of the open textbook (p's = .007 and .02; see Figure 3). There were no differences between the conditions in the amount of time students reported spending reading their textbook [$F(2, 171) = 2.38$, $p = .10$, $\eta_p^2 = .03$] or the proportion of completed weekly readings [$F(2, 171) = 0.45$, $p = .64$, $\eta_p^2 = .01$].

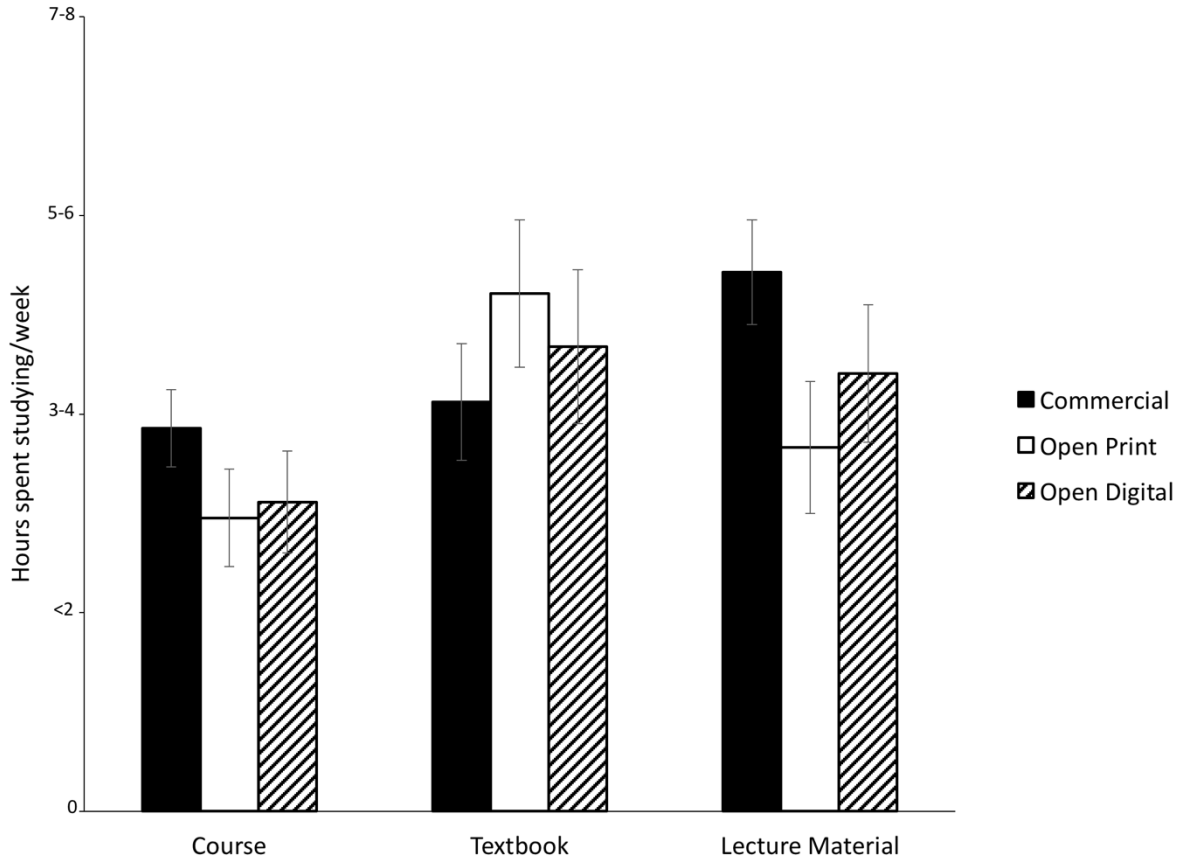

Figure 3. Students' self-reported study habits as a function of textbook openness and format. 95% confidence intervals are represented in the figure by the error bars attached to each column.

Perceptions of Quality

An ANOVA of the global ratings of textbook quality attained statistical significance [$F(2, 174) = 2.14$, $p = .05$, $\eta_p^2 = .03$]. Post-hoc Tukey tests revealed that the print format of the open textbook (M = 3.90, SD = 0.88) was rated significantly higher in quality than the commercial textbook (M = 3.54, SD = 0.83), with the digital format of the open textbook (M = 3.73, SD = 0.82) not significantly different from either. Scores on the modified TAUS (α = 0.91) painted a consistent picture, with a MANOVA attaining statistical significance [Pillai's Trace = .292, $F(32, 310) = 1.66$, $p = .02$, $\eta_p^2 = .15$]. Univariate ANOVAs showed significant differences on seven out of the sixteen dimensions of the modified TAUS, with pairwise comparisons further revealing that the print format of the open textbook was rated significantly higher than the commercial textbook on writing clarity, writing engagement, effective everyday life examples, effective research examples, and helpful study aids. In addition, both formats of the open textbook were rated significantly higher on the number of study aids, and the print format of the open textbook was rated significantly higher than the commercial textbook or the digital format of the open textbook on relevant everyday life examples (all p's <.05; see Table 2). None of the other dimensions of the modified TAUS showed any significant differences between the three conditions. There was no dimension on which the commercial textbook was rated higher than either format of the open textbook.

Table 2

Students' Ratings on the Textbook Assessment and Usage Scale

	Commercial Print (1)		Open Print (2)		Open Digital (3)		
Textbook Characteristics	*M*	*SD*	*M*	*SD*	*M*	*SD*	Post hoc
Helpful figures	4.4	1.2	5.0	1.3	4.5	1.4	1 = 2 = 3
Easy to understand figures	4.6	1.3	5.0	1.3	4.9	1.1	1 = 2 = 3
Helpful tables	4.6	1.3	5.0	1.1	4.6	1.4	1 = 2 = 3
Easy to understand tables	4.6	1.3	5.0	1.3	4.9	1.3	1 = 2 = 3
Relevant photographs	4.8	1.3	5.2	1.5	4.9	1.1	1 = 2 = 3
Effective research examples	4.9	1.1	5.4	1.4	5.1	1.4	2 > 1
Helpful research examples	4.7	1.3	5.5	1.3	5.2	1.1	1 = 2 = 3
Effective everyday examples	4.9	1.3	5.4	1.5	5.0	1.3	2 > 1
Helpful everyday examples	4.9	1.3	5.6	1.5	5.3	1.3	1 = 2 = 3
Relevant everyday examples	4.9	1.2	5.7	1.3	5.0	1.4	2 > 1, 3
Number of study aids	4.3	1.3	5.2	1.3	4.9	1.1	2, 3 > 1
Helpful study aids	4.2	1.5	5.1	1.6	4.8	1.2	2 > 1
Visually appealing textbook	4.9	1.6	4.8	1.9	4.8	1.4	1 = 2 = 3
Visually distracting textbook	3.1	1.6	2.6	1.6	3.3	1.5	1 = 2 = 3
Engaging writing	3.9	1.5	4.6	1.5	4.4	1.4	2 > 1
Understandable/clear writing	4.7	1.3	5.3	1.5	5.2	1.3	2 > 1

Note: The numbers in parentheses in column heads refer to the numbers used for illustrating significant differences in the last column titled "Post hoc."

Readability Analyses

In order to ascertain whether the commercial and open textbooks are comparable on readability, we ran computer-conducted readability analyses (using seven readability algorithms) of eight representative sections in each textbook[6]. As seen in Table 3, although the mean word length of these sections did not significantly differ across textbooks, the open textbook scored significantly higher on four out of the seven indices of readability (indicating a higher required level of education).

Table 3
A Comparison of Seven Measures of Readability between the Commercial and Open Textbooks

	Commercial		Open				
	M	*SD*	*M*	*SD*	*t*	*p*	Cohen's *d*
Word length	1287	1007	1100	506	0.467	0.647	0.24
Flesch-Kincaid Grade Level	9.51	0.79	11.65	1.66	-3.296	0.005	1.65
Gunning-Fog Score	12.46	1.04	14.84	2.03	-2.951	0.011	1.48
Coleman-Liau Index	14.2	1.12	14.31	0.86	-0.225	0.825	0.11
SMOG Index	12.08	0.64	13.81	1.43	-3.135	0.007	1.56
Automated Readability Index	10.04	0.74	12.14	1.83	-3.01	0.014	1.51
Spache Score	4.46	0.34	4.84	0.44	-1.919	0.076	0.97
Dale-Chall Score	6.08	0.66	6.38	0.38	-1.118	0.282	0.56
Average Grade Level	9.83	0.64	11.13	1.18	-2.746	0.016	1.37

Note. $N = 8$

Perceptions of Fair Price

When asked what they consider to be a fair price for their textbook (regardless of what they paid), students assigned the commercial textbook (which cost >$100) estimated that a fair price for it would be $53.51 (SD = $29.71). This was not significantly different from the estimated fair prices for the print (M = $49.90, SD = $27.22) or digital (M = $47.68, SD = $24.20) formats of the (free) open textbook [$F(2, 169) = 0.67$, $p = .51$, $\eta_p^2 = .01$].

[6] These sections focused on correlational research, neural structure and communication, structuralism and functionalism, reconstructive memory, schedules of reinforcement, components of language, stages of sleep, and Gestalt principles of perception.

Preferences for Print vs. Digital Format

When asked about their preference between print and digital textbooks (and told to not consider cost), students in all three conditions reported a preference for print textbooks (whether commercial or open) [$\chi^2(4, N = 178) = 6.52, p = .16$; see Figure 4]. Having both print and digital formats was the second most popular preference while digital-only was the least popular. Despite these reported preferences, over the course of the semester only 16% of students assigned the print format of the open textbook reportedly downloaded a digital copy and only 18% of students assigned the digital format of the open textbook chose to print it (of these, 75% elected to print it all at once). Ten percent of the students assigned the commercial print textbook reported using its digital format, with a further ten percent using both print and digital formats.

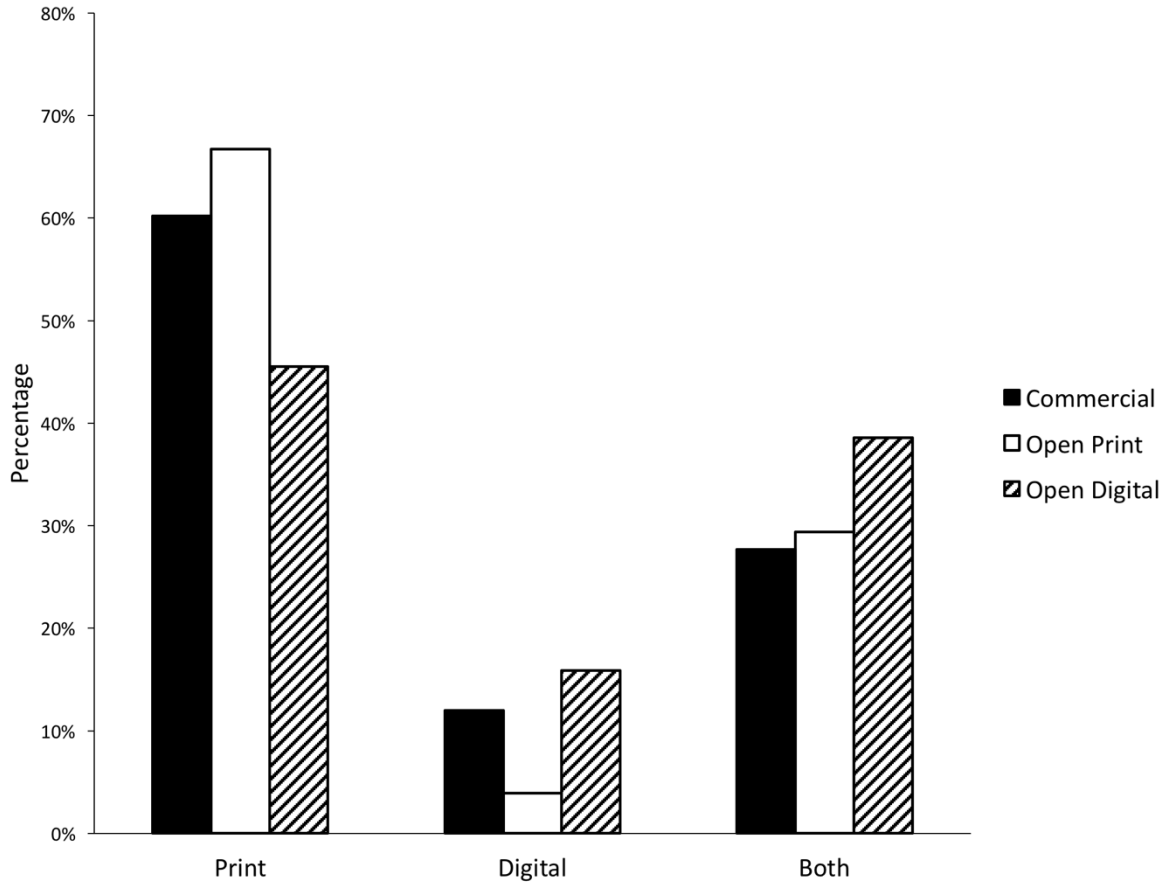

Figure 4. Students' textbook format preferences as a function of textbook openness and format.

Discussion

This study sought to address six key questions, the first of which concerned whether students using an open textbook perform differently from students using a commercial textbook. We found that students assigned the open textbook, in either print or digital formats, performed either no differently or better on their course exams than students assigned the commercial textbook. These results mirror the rest of the OER efficacy literature. Students in all three conditions were comparable on most demographic variables with the exception of students in the commercial textbook condition having completed a greater number of undergraduate credits and taking fewer concurrent courses, most likely due to a seasonal

selection bias. However, this confound only reinforces the result because it is reasonable that students who have taken more courses and who have a smaller course load should perform better on their course exams.

There were no differences in exam performance between students assigned the digital and print formats of the open textbook. This result, which addresses the second research question, is encouraging given the general preference students express for print textbooks. This finding also carries great practical significance as open textbooks in digital format can be distributed to students entirely free of cost, evidently with no negative impact on exam performance. Of course, this does not rule out the possibility that the openness and format of the textbook might influence other important outcomes (e.g., metacognition).

The third research question, concerning students' study habits and whether these varied by condition, yielded mixed results. Students across the three conditions did not differ in the number of hours per week they reported spending studying the textbook or in the proportion of their weekly assigned readings that they typically completed. These results suggest that there were no meaningful differences in how often and how effectively students engaged with their assigned textbook. Given that students' exam performance was gauged solely by their answers to multiple-choice questions that could have been answered by reading any of the textbooks, it appears that students' textbook studying habits do not explain the differences in exam performance.

The students assigned the commercial textbook reported spending a significantly greater number of hours per week studying for the course than students in either of the open textbook conditions, a difference that might be traced to the greater amount of time per week that students assigned the commercial textbook also reported spending reviewing lecture material. Clues as to why students assigned a commercial textbook would spend more time reviewing lecture material might appear in their perceptions of the quality of their assigned textbook.

Students rated the quality of the print format of the open textbook to be significantly superior to the commercial textbook. Although it is not clear how exactly the students interpreted the global question of "quality," their TAUS ratings indicate that they perceived the print format of the open textbook to be superior on substantive dimensions such as the effectiveness of the research examples and the clarity of the writing. Although it might be seen as remarkable that the first edition of a textbook that is available for free (in digital format) or at low cost (in print format) was rated as equal or superior in quality to a commercial textbook in its tenth edition, this result also mirrors the existing literature on student perceptions of OER (Hilton, 2016).

Reinforcing this perception are the students' converging estimates across the three conditions of a fair price for their assigned textbook (all around $50), a result that addresses the fifth research question. Recalling that students assigned the commercial textbook would have spent over $100 whereas students assigned either format of the open textbook would have spent nothing, this result also helps address the persistent question of whether students will equally value a resource that they receive free of cost.

The sixth and final research question concerned students' preferences for print vs. digital format. Consistent with earlier research (e.g., Millar & Schrier, 2015), students across all three conditions showed a preference towards print format. Although this result did not vary significantly by condition, this tendency was less pronounced among students who were assigned the digital format of the open textbook. Finally, it is worth noting that although print remained the most popular preference for textbook format, in practice, the vast majority of students accepted the default format, even when this was digital. This finding is consistent with the existing literature on choice and decision-making which shows that making an option the

default choice significantly increases the likelihood that it will be chosen (e.g., Davidai, Gilovich, & Ross, 2012; Johnson, Bellman, & Lohse, 2002).

The present study extends the existing literature in several ways: Importantly, it is the first OER efficacy study that has attempted to disentangle the format of the textbook (digital vs. print) from the cost savings associated with its open license. Second, it is only the second OER efficacy study that includes measures of students' study habits, a potential mediator for any effects of textbook openness and format. Third, the choice of a between-subjects design eliminated the possibility of memory biases colouring participants' textbook perceptions and preferences. Fourth, this study is the first to utilize a multidimensional measure of students' perceptions of textbook quality (the TAUS) that is both reliable and valid. Fifth, unlike the other published study that considered the efficacy of an open textbook in Psychology courses (Hilton & Laman, 2012), the present study measures and controls for preexisting differences between the groups, standardized the commercial textbook, and does not involve the adaptation of the open textbook to include additional pedagogical features. Sixth and finally, this represents only the second OER efficacy study within the Canadian post-secondary system. However, despite important contextual differences between the Canadian and U.S. post-secondary systems, the key results concerning efficacy and perceptions were consistent with the existing literature, which is based almost exclusively on research at U.S. institutions.

Limitations

To enhance our study's ecological validity, we used a quasi-experimental design in the naturalistic setting of students taking a semester-long introductory psychology course. This design choice introduced several limitations. For instance, although we measured a range of demographic characteristics along with the baseline level of general psychology knowledge, we did not randomly assign individual students to the different conditions. Moreover, two out of the three instructors did not teach sections across all three conditions, a function of previously determined teaching schedules. The sections assigned the commercial textbook were also taught only during the summer semester, when students tend to take fewer courses (as reflected in our sample) and, at least in our experience, tend to perform better. Future research would do well to address these potential selection biases.

Another potential confound in our study is that the open textbook (in its first edition) and the commercial textbook (in its tenth) are written by different authors with differences in the breadth and depth of content coverage, organization, and writing style. Of course, this problem is not limited to comparisons between commercial and open textbooks. Indeed, even among commercial introductory psychology textbooks, there is "a heterogeneous assortment of pedagogical and critical thinking programs, with core terminology and references showing minimal overlap" (Griggs & Marek, 2001, p. 256). Our attempt to measure the readability of both textbooks showed mixed results, with four of seven indices showing small differences. We also acknowledge here that readability analyses have been criticized for their use of surface-level indicators (e.g., average sentence length, the number of polysyllabic words, the percentage of unique words, etc.) as substitutes for the complex cognitive processes involved in reading (Duffy, 1985; Griesinger & Klene, 1984; Shriver, 2000).

A separate concern is that the cost savings associated with the open textbook may have created a halo effect (Thorndike, 1920) resulting in more positive perceptions of that textbook. Future research should therefore measure students' perceptions of the different textbooks while holding cost constant. It is also worth noting that students' ratings of textbook quality may not necessarily reflect those of faculty, who may place greater value on the breadth and depth of coverage in the commercial textbook than the engagement of the writing. Of course, the notion

of quality may be operationalized differently and may include the perceptions of faculty, perceptions of students, or impact on learning outcomes.

Finally, given that we relied on self-reports for (a) number of hours spent per week reading the textbook, (b) the proportion of weekly assigned readings completed, (c) number of hours per week spent studying the lecture material, (d) number of hours per week spent studying the lecture material, and (e) number of hours per week spent studying for the course, future research should look to corroborate these findings using more objective measures.

Conclusion

The present study's findings replicate the rest of the OER efficacy literature within a Canadian context by showing that students assigned an open textbook perform the same as or better than those assigned a commercial textbook on course exams. The study also extends the literature by demonstrating no discernible impact of textbook format on exam performance or textbook-related study habits, and finding that students perceive a textbook that is free and open to be superior in quality and similar in perceived market value to one that is expensive and commercially produced. However, the differences in perceived quality between the textbooks together with the seasonal selection bias, the large effect on course performance of the instructors, and other limitations temper a clear-cut interpretation of the results.

On the one hand, given the number of factors that can influence a student's course performance—including intelligence, motivation, and professor-student rapport—it should hardly seem surprising that the choice of assigned textbook does not greatly influence educational outcomes. But on the other, given the negative impact on students of commercial textbook costs and the positive impact of perpetual access to OER, instructors would do well to evaluate the suitability of available open textbooks. Carefully-designed empirical research on the outcomes, perceptions, and use of open textbooks in both naturalistic and experimental settings will help address the limitations of the present study.

Overall, we believe the results provide cautious encouragement for instructors considering adopting open textbooks for their courses. Indeed, given the availability of relevant and high quality open textbooks, the question we believe instructors should ask themselves is: how much better would students have to perform when assigned commercial textbooks to justify the negative impact of their high cost?

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