Beyond the Basics: Adapting an Open Textbook to Accommodate a Flipped Class

Ariana Eichelberger
University of Hawaii at Manoa,
USA

Hong Ngo
University of Hawaii at Manoa
USA

Abstract

Through a collaborative effort between an instructional design team and the Biology Department at the University of Hawai‘i at Mānoa, the OpenStax Biology 2e open, online textbook was modified with new features to improve student engagement and learning outcomes. This study investigated students' perceptions of the customized textbook. A survey of 22 questions was completed by 446 students using the textbook as a part of an introductory Biology course. Changes made to the textbook were well received by the majority of students and suggestions were made for improvements. Current and future revisions to the textbook are discussed.

Keywords: OER**,** OpenStax, biology, flipped classroom

Assigning university students readings to complete outside of class is not new. Outside readings are an important way for students to learn, as undergraduate courses typically have limited in-class time (Bergmann & Sams, 2012; Ryan, 2006). Students who complete readings prior to class tend to understand instructional material better and are more prepared for class (Gurung, 2003; Narloch et al., 2006). Completing work outside of class may also contribute to student satisfaction and sense of self-determination (Sergis et al., 2018).

Completing work outside of class is a significant component of the flipped classroom model. In a flipped classroom, "students gain first exposure to new material outside of class, usually via reading or lecture videos, and then use class time to do the harder work of assimilating that knowledge, perhaps through problem-solving, discussion, or debates" (Brame, 2013, p. 1). The flipped model has been shown to improve learning performance (Bhagat et al., 2016), increase student satisfaction (Bösner et al., 2015), engage students (Khanova et al., 2015), improve critical thinking (van Vliet et al., 2015) and enhance application skills (Liou et al., 2016).

However, there are also challenges, including students not completing out-of-class work (Al-Zahrani, 2015), and instructors' inability to know if students have completed work (Fautch, 2015). Students commonly fail to spend adequate amounts of time studying outside of class (Akçayır & Akçayır, 2018; Lai & Hwang, 2016) and those students may not succeed in a flipped class (Sayeski et al., 2015). It has been suggested that engaging students during out-of-class work and keeping them accountable are key factors for student success in the flipped model (Hwang et al., 2015).

While the flipped model's effectiveness in increasing student outcomes has been well established, less attention has been paid to its impact on students' internal dispositions or intrinsic motivation to remain engaged in the learning process (Sergis et al., 2018). A student's engagement and learning are influenced by their motivation (Elliot, 2019). Student motivation to engage with the out-of-class content becomes critical in a flipped environment as students who fail to do so are not able to fully participate in class (Aidinopoulou & Sampson, 2017) and increasingly fall behind as a flipped course progresses (Chen et al., 2014).

Inspired by the possibilities, and aware of the challenges, the University of Hawai‘i at Mānoa's (UHM) Biology department partnered with the College of Education's Distance Course Design and Consulting Group (DCDC) to redesign its introductory Biology course, BIOL 171, to incorporate the flipped classroom model. Biology team members included the course professor and lab coordinator serving as subject matter experts. DCDC team members included a project manager, instructional designer, web developer, programmer, and graphic designer. From fall 2017 to summer 2018, the OpenStax Biology 2e textbook was customized, then piloted in fall 2018 with 463 students. This study examined students' perceptions of using the customized textbook. The questions guiding the study were:

1. How did BIOL 171 students perceive the design features added to the OpenStax Biology 2e textbook?
2. Did the new design features influence students' motivation and satisfaction when participating in the course?
3. What improvements to the textbook did students suggest?

Customizing the OpenStax Biology 2e Textbook

The OpenStax Biology 2e textbook is an Open Educational Resource (OER), as it resides in the public domain and is released under an intellectual property license allowing for free use or re-purposing (Atkins et al., 2007). Educator reported benefits of OER include knowing that all students have access to course materials (Weller et al., 2015), an increased sense of control over curriculum, better ability to serve the needs of diverse learners, and positive changes in pedagogy (Pitt, 2015).

Students report favoring online OER textbooks over traditional print texts, finding them more up-to-date and useful (Feldstein et al., 2012). Students have also reported satisfaction with the quality of OER materials (Gil et al., 2013; Pitt et al., 2013), and their accessibility (Weller et al., 2015). In addition, students also report that OER textbooks support their course work, and would recommend OER to their classmates (Hilton et al., 2013). Another common reason for students preferring OER textbooks is low cost (Lindshield & Adhikari, 2013; Petrides et al., 2011). High prices for traditional textbooks have resulted in students choosing to not take courses (Donaldson et al., 2012), not purchase materials while enrolled in a course (Allen, 2011) and to be more concerned about book costs than tuition (Bonner, 2014 as cited in Pitt, 2015).

The textbook was redesigned to support a flipped classroom. A fundamental aspect of the flipped model is students interacting with content out-of-class before engaging in learning activities face-to face. This pre-class work provides students with a sense of ownership of their learning (O'Flaherty & Phillips, 2015) and has been attributed in part to the overall success of the flipped model (Gross, 2015). The textbook was specifically focused on to enhance students' out-of-class experience and accountability.

Conceptual Framework

The redesign of the textbook was conceptually guided by Gagne's Conditions of Learning and Theory of Instruction (1985) and Deci and Ryan's (2012) Self-Determination Theory. Considering the flipped model from an instructional design perspective, the primary function of the textbook is to present content. However, according to the Conditions of Learning and Theory of Instruction (1985), presenting content is not enough. To effectively learn, students must move through a series of learning events. Providing learner guidance and opportunities for practice with feedback after content presentation are key learning events. In the absence of sufficient learner guidance, practice, and feedback students in flipped learning environments often lack the self-regulation to be successful with the out-of-class content (Sun et al., 2017). A number of the features added to the textbook were designed to support Gagne's learning events relevant to out-of-class work including providing learner guidance, eliciting performance and providing feedback on performance. To enhance learner guidance, organization and navigational features were added. Additional chapters were added explaining navigation of the textbook and providing tips on being a successful online learner. Text and figure rollovers were included to reinforce concepts introduced. To provide opportunities for practice, interactive flashcards and text and video quizzes were added. Immediate feedback was provided and quizzes could be taken an unlimited number of times. Feedback on overall progress was provided via the redesigned table of contents displaying the student's status on each of the quizzes.

The additional features of the redesigned textbook were also influenced by Self-Determination Theory. Through the lens of Self-Determination Theory (Deci & Ryan, 2012), a learner's intrinsic motivation is strengthened when their actions feel autonomous and they feel

competent or able to master an activity. Intrinsically motivated learners tend to persist at learning tasks, making them more likely to achieve (Vansteenkiste et al., 2006). Therefore, learning materials used as a part of a flipped class should enhance perceptions of autonomy and competence to foster motivation. A number of features were added to increase feelings of autonomy. First, the textbook was designed to be easily accessed via mobile devices allowing access from any location at any time. Second, quiz status icons were added to give students continual feedback on their progress. Third, the table of contents was redesigned based on due dates rather than topics. Each of these features was designed to enhance students' sense of autonomy as they completed out-of-class work. To increase students' sense of competence with the content, practice flashcards and text and video quizzes were added to each chapter.

Text and Video Quizzes

The number of undergraduate students who do not complete textbook readings or postpone them until immediately before an exam is increasing (Clump et al., 2004; Johnson & Kiviniemi, 2009; Sappington et al., 2002). Failure to complete reading assignments is detrimental to learning (Johnson & Kiviniemi, 2009), and negatively impacts in-class performance (Gurung, 2003; Narloch et al., 2006). Regularly scheduled quizzes have been associated with increased exam scores and course performance (Johnson & Kiviniemi, 2009). Flipped students need formative assessment opportunities to understand what they know and do not know (Rotellar & Cain, 2016; Slomanson, 2014) and benefit from incentives to prepare for class (Kim et al., 2014). Additionally, flipped instructors need methods for assessing students' understanding of material (Kim et al., 2014).

To enhance student performance, engagement and accountability, quizzes were embedded in each chapter. A portion of final grades were based on overall quiz completion. Two types of quizzes were added, text and video. Both types used a multiple-choice format and were created using the H5P plugin. Figure 1 shows a text quiz.

Figure 1: Screenshot of a text quiz

Eight additional videos were added to the text. Quizzes were embedded in these videos using the H5P interactive video feature. As seen in Figure 2, quizzes paused the video with questions for students to answer before they could continue watching.

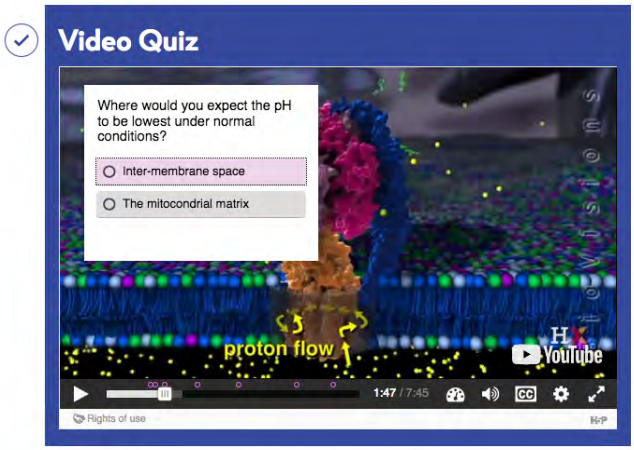

Figure 2: Screenshot of a video quiz

Glossary Term Practice Flashcards

Flashcards are known to increase vocabulary comprehension and retention (Fitzpatrick et al., 2008), are more likely to be used when provided by an instructor (Burgess & Murray, 2014), and are most effective when used over time (Cepeda et al., 2006). The customized textbook embedded interactive glossary term flashcards in each chapter using the original textbook's terms. Flashcards were built with Quizlet, a free, online, effective (Wright, 2016) flashcard application. Flashcard use was optional, and not recorded.

Chapter Due Dates

Consistent pre-class assignments prepare students for a flipped class (Baepler et al., 2014) and contribute to increased outcomes (Gross et al., 2015). Flipped classes should incorporate preferred features of online classes including clear structure, easy navigation and scheduling milestones (Bergstrand & Savage, 2013; Crews & Butterfield, 2014; Rabbany et al., 2011; Wanner & Palmer, 2015). It is important for flipped students to know what they need to do prior to class (Rotellar & Cain, 2016), as self-regulation is often a challenge for students in technology mediated environments (Shyr & Chen, 2018). This can be communicated to flipped class students by providing a study schedule (Mason et al., 2013).

As displayed in Figure 3, the redesigned textbook used a calendar-like format that organized chapters by their due dates rather than topic. This Due Dates page was shown upon logging into the text.

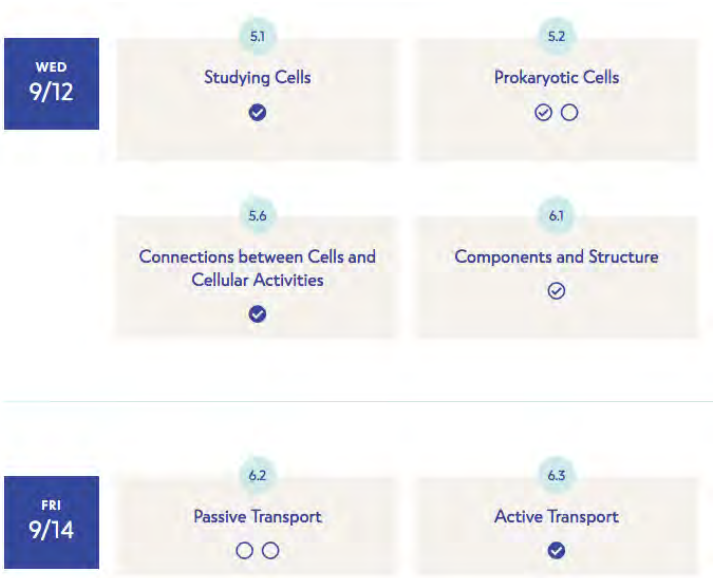

Figure 3: Chapters organized by due dates with quiz status icons

Each chapter was displayed as a single webpage. Groups of chapters due on the same date were displayed as circular icons at the top and bottom of each chapter page. As displayed in Figure 4, rolling over a chapter icon displayed the chapter's title and quiz status. Clicking on a chapter icon would take a student to that chapter.

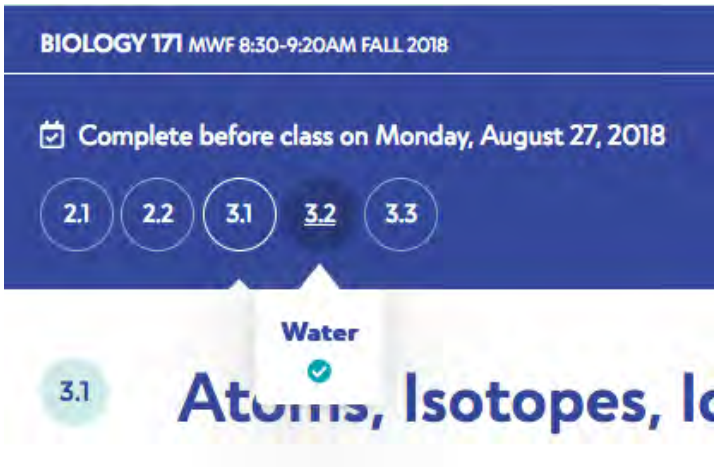

Figure 4: Rollover feature displaying chapter title and individual student's quiz status

Quiz Status Icons

Students are often not aware of how they are doing in a course until it is too late (Pistilli & Arnold, 2010). An online student dashboard "provides a visual display of the important information needed to achieve one or more goals, consolidated and arranged on a single screen so the information can be monitored at a glance" (Teasley, 2017, p. 378). Quiz status icons were displayed with each chapter depicting student progress. As seen in Figures 3 and 4, each quiz was represented by a circle. At a glance, a student could see their quiz status.

Figure and Text Rollovers

In the original textbook, when clicking on a figure reference would take readers back to the original figure's location. To reduce clicks and keep readers in their location, the redesigned

textbook added a rollover feature that popped a figure up in place any time it was referred to in the text. The figure rollover feature is seen in Figure 5.

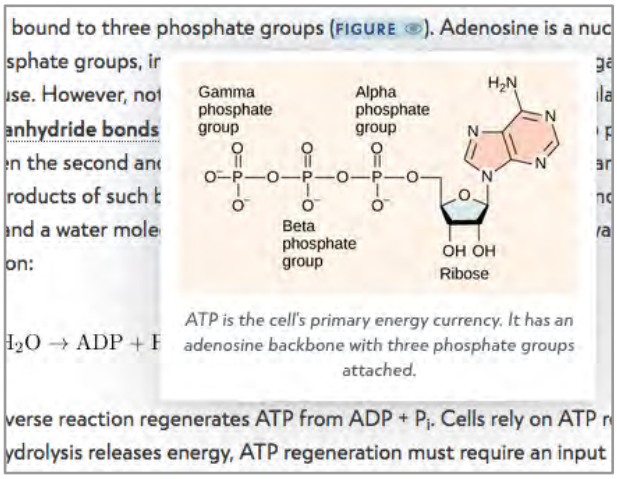

Figure 5: Figure rollover feature

As seen in Figure 6, a glossary term in-text rollover feature was also added. Terms appeared as underlined text, indicating that they could be rolled over to display their definition.

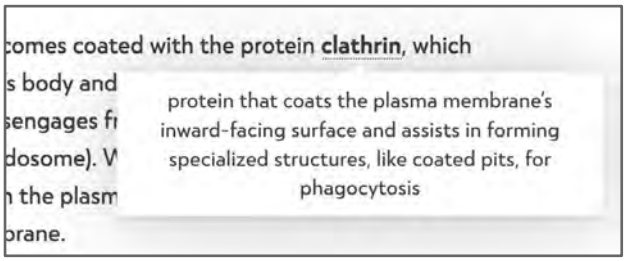

Figure 6: Text rollover feature

Chapter Feedback

At the end of every chapter, students were able to provide comments and ratings on a 1 to 5 "star" scale, see Figure 7. Feedback could be given a descriptive tag to identify it as a compliment, fix or recommendation. The feedback was then displayed to instructors in their dashboard.

Figure 7: Student feedback feature

Additional Chapters

A comprehensive course orientation may help reduce confusion for online students regarding course layout and expectations (Morris & Finnegan, 2008). For flipped students it may additionally reduce fear or resistance to a new method (Lee et al., 2017). To orient students and provide tips on being a successful online learner, two additional chapters, Start Here and Online Learning Success, were added. Start Here included a video detailing logging in, taking quizzes and monitoring progress. Online Learning Success provided online learning tips.

Method

The purpose of this study was to examine students' perceptions of the customized textbook. All methods and instruments were approved by the University's institutional review board on human subjects research. Data were collected using an anonymous, online survey consisting of 16 Likert scale, three open-ended, and three demographic questions. As the textbook's redesign had been conceptually guided Gagne's Theory of Instruction and the Self-Determination Theory, the survey asked students to rate the features added to provide learner guidance, practice with content, and feedback as well as questions about satisfaction and motivation with the text. The survey was distributed in week 14 of the 16-week fall 2018 semester. Quantitative data were analyzed using SPSS 25.0. Qualitative data were quantified for frequency of favored features and improvement suggestions.

Findings

Participants

The majority, 96.3% (n = 446) of the 463 fall 2018 BIOL 171 students invited to participate completed the survey. Students ranged from 17 to 38 years old, 70% (n = 312) were female, 29% (n = 131) were male and 3 opted to not identify gender.

Students' Perceptions of the Design Features

Text and video quizzes. Students were positive about the text and video quizzes. As summarized in Table 1, the overall mean score (*M*) for quizzes was 3.8, above the midpoint on a scale of 1 (strongly disagree) to 5 (strongly agree) with a standard deviation of .870. Specifically, 59% found the quizzes engaging, 62.3% agreed that the questions in the videos helped them learn the content in the video, and 68.6% agreed that the text quizzes reinforced the chapter content. In addition, 16.6% listed the embedded quizzes as the feature they liked best about the customized textbook. Student 327 explained, "the quizzes encouraged me to review and study the information being taught." Student 345 said, "the textbook had...video quizzes so that I could be engaged in my homework."

Table 1: Text and video quizzes

Text and Video Quizzes (*M* = 3.8, *SD* = .870)	**1-2 (%)**	**3 (%)**	**4-5 (%)**	***M (SD)***
1. The text and video quizzes in the online textbook were engaging.	10.7	30.3	59	3.72 (1.008)
2. The questions embedded in the videos helped me learn the video content.	11.5	26.2	62.3	3.78 (1.042)
3. The text quizzes reinforced the chapter content.	8.1	23.3	68.6	3.94 (0.980)

(1-2: strongly disagree - disagree; 3: neutral; 4-5: agree - strongly agree)

The results also revealed students with neutral or negative perceptions toward the quizzes. As seen in Table 1, 23.3% to 30.3% of the students indicated neutrality about the benefits of the text and video quizzes to their learning, and 8.1% to 11.5% indicated negative perceptions of the quizzes. Some students suggested adding more questions to the text and video quizzes. For example, Student 372 wrote, "More content on the quizzes that better reflect exams questions i.e actual questions from the exams." Student 137 said, "the quizzes more in depth because they were very easy and i feel quite a few of them didn't cover main ideas of certain sections." Student 159 suggested fixing the questions saying, "Some of the quizzes had answers that did not make sense."

Glossary term practice flashcards. As displayed in Figure 8, slightly over half (52.9%) of the students reported using the flashcards in most, or every chapter while 28.1% of the students did not use them in any, or in very few chapters.

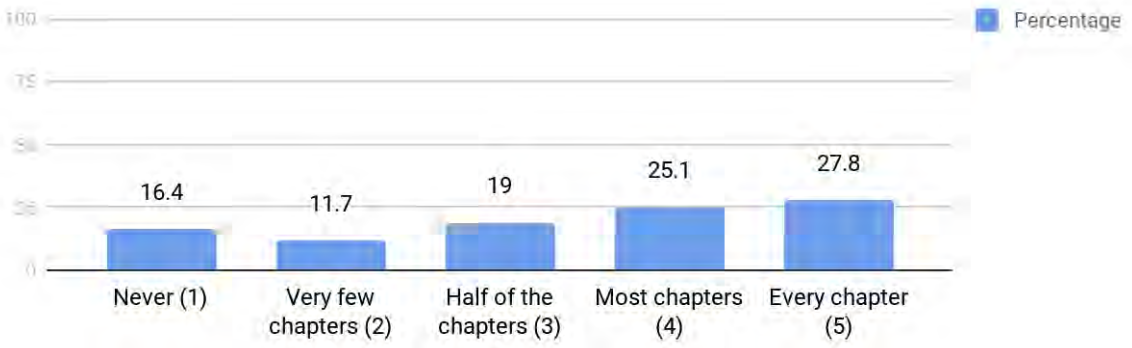

Figure 8. Reported frequency of use of glossary term practice flashcards.

Additional design features. The majority of students were positive about the additional design features. The overall mean score for these 5 questions was 4.2 with an *SD* of .653. As shown

in Table 2, the quiz status icons (item 6) were rated most highly (approximately 90%) with a mean value of 4.59 and an *SD* of .781. Organization of the textbook (item 5) was second, with 82.5% (M = 4.35, *SD* = .894). The remaining questions regarding redesign elements (rollovers, chapter due dates, and feedback option) received a smaller number of positive responses. In order of highest to lowest, 78.7% of the students liked the rollover feature (*M* = 4.27, *SD* = .880), 76.2% preferred the text organized by chapter due dates (*M* = 4.26, *SD* = 1.062) and the feedback option scored lowest with 33.6% of the students neutral and 13.5% negative on this item (*M* = 3.64, *SD* = 1.112).

Table 2: Additional design features of the customized OpenStax Biology textbook

Additional Design Features (*M* = 4.2, *SD* = .653)	**1-2 (%)**	**3 (%)**	**4-5 (%)**	***M (SD)***
5. The organization of the online textbook was logical and easy to follow.	3.2	14.3	82.5	4.35 (0.894)
6. The online textbook quiz status icons (checkmarks in circles representing each quiz in a chapter) helped me track my progress.	2.7	7.6	89.8	4.59 (0.781)
7. I liked the rollover feature that allowed me to see the figures in a chapter.	2.7	18.6	78.7	4.27 (0.880)
8. Given the choice, I would rather have the online textbook chapters organized by when chapters need to be read versus a traditional table of contents.	6.1	17.7	76.2	4.26 (1.062)
9. Having the option to	13.5	33.6	52.9	3.64 (1.112)

provide feedback at the end of each book chapter made me feel more involved in my learning process.				

(1-2: strongly disagree - disagree; 3: neutral; 4-5: agree - strongly agree)

Additional chapters. The Start Here and Online Learning Success chapters added to the textbook were rated positively by approximately 60% of students. The overall mean for the two chapters was 3.8 with an *SD* of 1. As displayed in Table 3, 63.2% of students agreed that the Start Here chapter helped them navigate the textbook, and 61.2% found the Online Learning Success chapter helpful.

Table 3: Additional chapters

Additional Chapters (*M* = 3.8, *SD* = 1.000)	**1-2 (%)**	**3 (%)**	**4-5 (%)**	***M (SD)***
10. The Start Here: Textbook Orientation chapter helped navigate the textbook.	10.8	26	63.2	3.84 (1.111)
11. I found the information in the Online Learning Success chapter helpful and would advocate keeping it in the online textbook.	11	27.8	61.2	3.78 (1.112)

(1-2: strongly disagree - disagree; 3: neutral; 4-5: agree - strongly agree)

Format. As displayed in Table 4, 90.8% of students reported that they preferred an online, free version of the text over a hard copy for purchase (M = 4.7, *SD* of .918). Fewer than 10% of students indicated otherwise.

When asked specifically about the customized textbook (item 13), a smaller number of students (70.4%) indicated their preference for the online version (*M* = 4.09, *SD* = 1.253). More students (15.9%) indicated their neutrality on item 13 and 13.7% reported not preferring the online textbook over a hard copy. Agreement dropped 20.4% between item 12 and 13 when students were asked about a general preference for a free online textbook and this textbook in particular.

Table 4: Free online vs hard copy format

Format (*M* = 4.4, *SD* = .918)	**1-2 (%)**	**3 (%)**	**4-5 (%)**	***M (SD)***
12. I preferred having a free online textbook over a hard copy book I have to purchase.	3.6	5.7	90.8	4.7 (0.805)
13. I preferred having this online textbook over a hard copy textbook.	13.7	15.9	70.4	4.09 (1.253)

(1-2: strongly disagree - disagree; 3: neutral; 4-5: agree - strongly agree)

Favorite features. To the optional, open-ended question, "What did you like best about the textbook?", "No cost" and "Online" were the two most frequently given answers, mentioned by 31.6% and 24.9% students respectively. Student 298 said "It was easy to access anywhere I was because I found myself forgetting to do my reading but I could still do it in my spare time when I was out just on my phone!" Student 430 commented:

> Having easy access to this textbook was amazing. I could complete readings and hw on the bus which helped me stay on top of my work. Also, the interface was intuitive and very organized. Not having to pay and carry around a textbook was very nice. I wish all my classes adopted this system. Having the hw integrated into the textbook made my life much easier.

Student 250 reported:

> I love this book! It is the best bio book I have ever read! I really like how easy it is to keep track of assignments and to know if I turned them in or not. I also like how at the start of every assignment, there was a learning objective center for me to know what to focus on. Above all else, I LOVED the flashcards, quizzes and matching game. I wish all my classes used books like this. BEST BOOK EVER!

In referring to no cost, student 345 said, *"*I like that this textbook was free especially because biology textbooks are very expensive.*"* Student 154 stated that a no cost textbook "lowers the cost of going to school for the student" and Student 353 said "even students like me who struggle financially could still have the opportunity to use it.*"*

Other favorite aspects cited included organization (21.7%) ease of access (10.1%), practice flashcards (4.5%), chapter due dates (3.4%), glossary (2.9%), and chapter summaries (1.1%). A few students, 2.7%, mentioned the search feature with Student 181 saying "There is also a "search" button, where I could look-up topics whenever I don't know what chapter they belong to."

Motivation and Satisfaction

As shown in Table 5, the mean value for the textbook motivating students to study was 3.38 (SD = 1.213), slightly above the midpoint.

Table 5: Influence of the textbook on student motivation

	1-2 (%)	3 (%)	4-5 (%)	*M (SD)*
14. The online textbook motivated me to study for this course.	21.7	32.7	45.6	3.38 (1.213)
16. Other courses should adopt similar online textbooks.	6.7	11	82.3	4.27 (1.016)

(1-2: strongly disagree - disagree; 3: neutral; 4-5: agree - strongly agree)

Item 16 asked students to respond to the statement: "Other courses should adopt similar online textbooks." The majority of students (82.3%) agreed or strongly agreed with this statement (*M* = 4.27, *SD* = 1.016).

Suggested Improvements

Sixty three percent of students made suggestions for improvements, summarized in Figure 10. Frequencies are based on the number of times a suggestion was made, one student often had more than one suggestion.

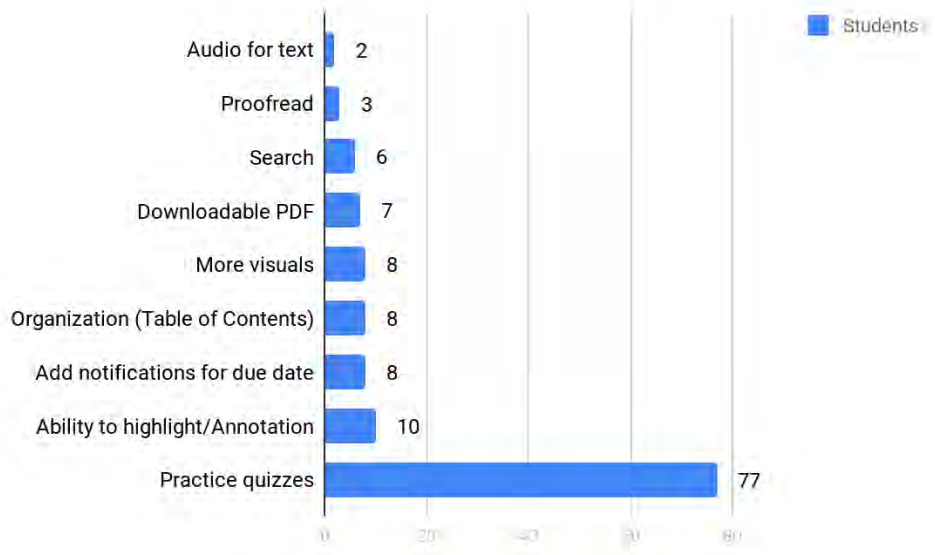

Figure 10. Student suggestions for improvement.

Eight students recommended having more visuals and the same number suggested having a traditional table of contents. Student 371 stated that "More pictures would be helpful." Student

366 preferred to "have a table of contents available for the chapters for easy navigation while studying, looking back over content, etc." Six students made suggestions about the search feature.

Students also suggested four features to add to the textbook: 1) audio in addition to text (2 students), 2) a PDF download for the textbook (7 students), 3) due date notifications sent via email (8 students), and 4) adding a highlight/annotation feature (10 students).

Discussion and Recommendations

The elements added to the textbook intended to provide learner guidance, practice with content and feedback on performance were all well received by students. The textbook appears to have addressed students' need for autonomy and competence as evidenced by their overall satisfaction with the book and their motivation to use it to study for the course.

The two most favored aspects of the text were no cost and the affordances of it being online. Others have also found no cost and online to lead to student satisfaction with OER (Feldstein et al., 2012; Hilton et al., 2013; Petrides et al., 2011). The majority, (90.8%) agreed with the statement: "I preferred having a free online textbook over a hard copy book I have to purchase." This aligns with previous studies in which students reported preferring OER texts due to low or no costs (Lindshield & Adhikari, 2013; Petrides et al., 2011). Students may not purchase costly textbooks when enrolled in a course, despite decreased learning outcomes (Allen, 2011). No cost textbooks address equitability and students may feel more competent when they can equally access learning materials. Online access may also have contributed to feelings of autonomy given that students appreciated anywhere, any time access.

While using unmodified OER resources has proven successful, customized OER has also been shown to increase student learning outcomes (Mathew & Kashyap, 2019). The redesigned textbook customizations were cited as favorite aspects of the text. Students were positive when rating features incorporated to enhance learner guidance including the chapters viewed by due dates, glossary term practice flashcards and the new rollover feature. The majority of students (89.8%) felt the quiz status icons helped them monitor their progress. The ability to monitor progress is an important part of self-regulated learning (Zimmerman, 2002) and students have been shown to be more self-regulated when they feel more autonomous in their learning (Sierens et al., 2009).

The text and video quizzes in particular were the third most favored aspect of the text. This is encouraging as ungraded test-enhanced learning has been shown to have learning benefits. In particular, completing ungraded tests prior to an exam can increase active information retrieval on exams (Karpicke & Roediger, 2008; McDaniel & Masson, 1985) which has been associated with higher final exam scores (Khanna, 2015).

Students also had suggestions for improving the quizzes. These included more quizzes, more questions, and better alignment with the exams. That students highly rated the quizzes and wanted more may have been due to them supporting feelings of competence with the course content, perhaps because quizzes have been found to be more beneficial to students in content-focused courses versus skills-focused courses (Khanna & Cortese, 2016). Aligning quizzes more closely to exams may also improve student confidence with the content.

Requests for additional and more comprehensive quizzes suggests that students are willing to engage even further with the textbook. This is significant as out-of-class work is a key factor in students' success in flipped classes (Hwang et al., 2015) and students typically do not spend enough time on out-of-class work (Akçayır & Akçayır, 2018; Lai & Hwang, 2016).

The two new chapters were less well received by students. Over a third of students, 36.8%, disagreed or were neutral that the Start Here chapter was helpful. Additionally, 38.8% were neutral or disagreed that the Online Learning Success chapter was helpful. Specific features of these chapters may have led to students' attitudes toward them. First, neither were directly related to the course content. Second, while encouraged, they were not required and did not have quizzes that impacted students' grades.

Student response to the chapter feedback feature was also mixed. Only half agreed that "Having the option to provide feedback at the end of each book chapter made me feel more involved in my learning process." This may have been due to instructors not reading or responding to student feedback. It may also have been due to lack of student use of the feature. Despite the opportunity, students often do not provide feedback. Common reasons include skepticism about the possibility for change or a lack of skill in how to provide meaningful feedback (Svinicki, 2001). If receiving feedback is a goal, it should be more thoroughly incorporated into the teaching and learning process because "giving feedback is a skill that can be learned" (Svinicki, 2001, p. 1). The design team suggests that future instructors emphasize feedback's importance and respond to it more regularly. Enhanced communication with the instructor may also increase students' intrinsic motivation to use the textbook. When looked at through the lens of SDT, in addition to competence and autonomy, learners also have a need for relatedness or the feeling of being connected to others (Deci & Ryan, 2012). Students that engage in more dialog with their instructor may feel more connected to them.

Other suggestions for improvement included the ability to download an offline copy of the text to reduce eye strain and enable highlighting and annotation. This result is not surprising as the lack of annotation ability and eye strain associated online texts were complaints in a study using the original OpenStax Biology textbook (Watson et al., 2017) and "computer vision syndrome" (Akinbinu & Mashalla, 2014) is a known effect of increased screen time. In fact, almost a third (29.6%) of the students in this study disagreed with or were neutral on this statement: "I preferred having this online textbook over a hard copy textbook." The complaints regarding eye strain and lack of ability to highlight and annotate may be associated with this result. In response, students are now provided with a PDF file of the textbook upon request but are still encouraged to use the online version in order to have their quiz results recorded.

In conclusion, implementing the new features to the textbook enhanced students' experience and supported the efforts to incorporate the flipped learning model into the course. Students appreciated the customized text, specifically cost reduction, online availability, and the embedded quizzes. However, the new features added complexity to the implementation process, which in turn led to additional development time and increased need for technical support. Institutions considering similar endeavors should be prepared to provide ongoing support to students and instructors, and to be responsive to technical and performance issues that may arise.

Viewing future textbook developments through the lens of motivation theory may also prove beneficial to retain focus on student engagement, especially if part of a flipped classroom design. While this textbook development and study focused primarily on students' need for

competence and autonomy, future textbook developments might benefit from also incorporating features that foster students' need for relatedness. Features to enhance relatedness might include increased student-to-student or student-to-instructor communication directly in the textbook platform or leveraging the inherent social affordances of mobile devices to encourage collaborative learning through student sharing, peer assessment, and intentional community building activities.

Limitations

The scope of this study presents limitations to transferability of the results. Only one textbook in the specific field of Biology was redesigned and tested with students enrolled in a single semester. Additional textbooks in various fields, tested with a larger pool of students would result in more transferable results. In addition, a goal of the textbook was to motivate students to engage in out-of-class content. However, only one survey question specifically asked if the redesigned textbook motivated them to study. Future research by the authors on redesigned textbooks will address student motivation and satisfaction on a more comprehensive level.

Conclusion

In conclusion, implementing the new features to the textbook enhanced students' experience and supported the flipped learning model in the course. Students appreciated many aspects of the customized text, specifically cost reduction, online availability, and the embedded quizzes. However, the new features added complexity to the implementation process, which in turn led to additional development time and increased need for technical support. Institutions considering similar endeavors should be prepared to provide ongoing support to students and instructors, and to be responsive to technical and performance issues that may arise.

Viewing future textbook developments through the lens of motivation theory may also prove beneficial to retain focus on student engagement, especially if part of a flipped classroom design. While this textbook and study focused on students' need for competence and autonomy, future textbook developments might benefit from incorporating features that foster students' need for relatedness. Features to enhance relatedness might include increased student-to-student or student-to-instructor communication directly in the textbook or leveraging the inherent social affordances of mobile devices to encourage collaborative learning through student sharing, peer assessment, and intentional community building activities.

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Corresponding author: Ariana Eichelberger
Contact email: ariana@hawaii.edu