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STUDENT SATISFATION WITH A STUDENT-WRITTEN TEXTBOOK IN AN
INTRODUCTORY COLLEGE BIOLOGY COURSE

By

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Thesis presented in partial fulfillment of the requirements for the degree of

Master of Arts
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ABSTRACT

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Student Satisfaction with a Student-Written Textbook in an Introductory College Biology Course

Chair: David R. Erickson

Textbooks are ubiquitous tools in college classes, particularly in the sciences. Regular use of textbooks to complement science coursework can foster academic achievement and scientific literacy. Textbooks are chronically underused in college study due to high costs, challenging and time-intensive content, and perceived low value. In response, professors are increasingly using textbook alternatives including open textbooks, etextbooks, and wikis. Each has unique strengths and weaknesses.

Student-written textbooks are a less common, but growing, resource used to offer a low-cost alternative to publisher textbooks using collections of student research and writing. Student-written textbooks carry the possible benefits for students of supporting engagement and ownership in their coursework while enhancing writing and collaborative skills.

Student satisfaction is one critical indicator of textbook value. Other important features of quality textbooks include readability, quality images, ancillary perks, and pedagogical aids such as summaries and glossaries. This project explored student satisfaction with a student-written textbook in one general education biology course at a two-year college in Missoula, Montana. Anonymous survey responses from two sections of this course informed specific additions to one chapter of the textbook to test for changes in student satisfaction in subsequent classes. A second anonymous survey explored chapter-specific student preferences alongside additional questions related to student use of the textbook.

In spite of survey-inspired, research-supported additions to the student-written textbook, students in the second survey showed no disproportionate preference for the augmented chapter. Students might experience their reading on a more whole-textbook level or their preferences might be more strongly influenced by features other than those added to the textbook chapter, such as content, perceived utility, and readability. Survey responses suggest a high degree of satisfaction with the student-written textbook, to the point that differences in student responses between separate questions were not discernable. The continued use of the student-written textbook is supported by the review of literature and the research findings. Specific strategies for future research and improvements to the student-written textbook are discussed in detail.

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CHAPTER 1. INTRODUCTION

Science courses are commonly required for degree completion in colleges throughout the nation. Modern technological lifestyles and careers underscore the goal of fostering scientific literacy, wherein an educated citizenry understands the process of science as a method of exploring the world, can accurately interpret findings, and participates in the process of science throughout their lives (Liu, 2009). Despite this commitment to science education, there is persistent concern that colleges are not successfully cultivating scientific literacy (Gonzalez-Espada, 2009; Goodstein, 1992). The completion of general education science courses produces only marginal improvement in scientific literacy (Impey, Buxner, Antonellis, Johnson, & King, 2011). College students may view required, general education science courses and their entire programs as irrelevant, uninteresting, or meriting less effort than more desired courses (Rutledge & Lampley, 2017).

Textbooks are one of the most commonly used resources to support general education science coursework (Burton, 2014). Textbooks provide a guiding framework and a reference of uniform content to support student connection to core knowledge in a field (Skinner & Howes, 2013). Regular reading of a textbook can improve achievement in introductory college science education (French, Taverna, Neumann, Paulo Kushnir, Harlow, Harrison, & Serbanescu, 2015), and affect student attitudes about science (Kloser, 2013). Textbooks can also present impediments to learning, ranging from overreliance by instructors, errors, and too much detail (Kirk, Matthews, & Kurts, 2001) to supporting rigid, top-down instruction that fails to support inquiry (Alberts, 2009). Many college students' reading comprehension is inconsistent with the readability and vocabulary presented by typical college science textbooks (Crow, 2004). College students can perceive required courses as having lower

value to their education (Rutledge & Lampley, 2017), a challenge often compounded by dissatisfaction with and underuse of textbooks (Skinner & Howes, 2013; Swanson, 2014). Student satisfaction with coursework and educational resources is an important and reliable factor influencing learning success (Altman, Ericksen, & Pena-Shaff, 2006; Bliss, 2013; Durwin & Sherman, 2008).

This project explores one strategy to improve student satisfaction with college-level general education science by addressing students' experiences with their textbooks. The use of a student-written textbook was initiated two years in advance of this study, setting the stage to explore its impact on student satisfaction with their required readings. An action research investigation examined the use of this textbook in one introductory, college-level, general education biology course. Given this context, special attention in the review of literature was paid to textbook issues related to the sciences and two-year schools, when available. The primary goal was to inform further development of the student-written textbook to increase student satisfaction. This project used student surveys to inspire changes to the student-written textbook and then explore student reactions to those changes, collectively guided by the following research question:

How can a textbook created largely through student contributions best be written and structured in an introductory science course to enhance student satisfaction?

Two important corollary questions are:

- 1) Is it in the students' best interest to be using student-written textbooks, or would students be better served by traditional published texts?
- 2) In what ways do published research and student feedback share implications for improving student-written textbooks, and in what ways do they differ?

CHAPTER 2. LITERATURE REVIEW

Textbook use in college courses

Textbooks are a nearly ubiquitous tool used in college courses throughout the United States, and are particularly common in science courses (Burton, 2014; French et al., 2015). The use of textbooks began centuries ago with the intention of benefitting student learning by providing course-specific content and vocabulary in an organized, cohesive reference (Brandt, 1964; Sala, 1963). The use of textbooks in college courses remained high through the early 20th century (Lichtenberg, 1992), declined temporarily in the 1960s, and grew again in the 1970s with particularly common use in science courses as class sizes grew alongside economic challenges (Whitten, 1975). Textbook use in college courses remained pervasive on many college campuses into the 1990s (Lichtenberg, 1992). In college education today there is growing interest in shifting the structure, content, and use of textbooks in response to new technologies and diverse demands. Professors and students are now expecting more dynamic, interactive, and flexible educational resources (Bierman, Massey, & Manduca, 2006), and even traditional print textbooks are becoming more customizable (Seifert, 2010).

In spite of this shift, college professors today continue to require textbooks because they are seen as containing foundational content that supports success in class lectures and activities (Skinner & Howes, 2013). Many professors even refer to textbooks to guide development of course content (Kortz, Grenga, & Smay, 2017). Students rely on textbooks as a reference to guide and supplement their learning (Bierman et al., 2006). Textbooks in college courses are presumed by students and professors alike to benefit learning by providing organized, reliable, topic-specific content in an easily-accessed reference (Skinner & Howes, 2013). Students believe that over half of their college-based knowledge comes

from textbooks (Lichtenberg, 1992), and there is a persistent assumption that textbook reading supports learning (French et al., 2015).

Given the perceived strengths of college textbooks, there is surprisingly limited research on the relationship between reading textbooks and achievement in college science courses. Research concerning textbooks over the past several years has focused largely on instructional resources, costs, digitization, and perceived publisher exploitation (Swanson, 2014). One study found that students in a college science course who regularly read an assigned textbook displayed higher achievement, although this was tempered by findings that some who read rarely performed equally well on exams as those who read frequently (French et al., 2015). Others found that textbook reading coupled with surprise reading quizzes was associated with higher exam scores (Sappington, Kinsey, & Munsayac, 2002). In a study focused on textbook aids in a general psychology course, Landrum, Gurung, and Spann (2012) reported a relationship between reading completion and higher grades on quizzes and exams. Henderson and Rosenthal (2006) documented higher test scores in college science following incentivized textbook reading. Others have found no correlation between reading frequency and grades across several courses (Podolefsky & Finkelstein, 2006).

The challenge of interpreting research concerning the efficacy of textbooks is compounded by the diversity of ways they are used by students. Assuming value from student use of textbooks, a substantial problem exists in their chronic underuse. College students' self-reported rates of regular textbook use are variable, ranging from 20% to 70% (French et al., 2015). In one study of college textbook use only 18% of students reported regularly reading their textbooks despite believing that doing so would benefit their learning and course grades (Berry, Cook, Hill, & Stevens, 2010). Reasons for underuse of textbooks

include the high cost, their lack of perceived usefulness for successful learning, time investment, lack of interest, and low student confidence in reading comprehension (Skinner & Howes, 2013; Swanson, 2014). Textbook ownership is not a reliable indicator of use; for example, in one college physics course 97% of students purchased the textbook but only 37% reported regularly reading it (Podolefsky & Finkelstein, 2006). These reading levels themselves may be inaccurate if self-reported rates of reading are exaggerated (Sappington et al., 2002). Furthermore, the act of reading alone may not indicate quality reading, as many students might read a textbook but not do so adequately or carefully enough to benefit their learning (Clump, Bauer, & Bradley, 2004), and many students are likely to only read the parts of a textbook they believe directly relate to their academic goals (Baker et al., 2009).

In addition to the possibility that student underuse of textbooks hinders achievement, there are also important ways that textbooks themselves may be inadequate to support learning. College biology textbooks can be rife with challenging vocabulary embedded throughout dry, fact-based writing that is disconnected from science as a method of inquiry (Crow, 2004). Alberts (2009) mirrors these concerns by suggesting that modern science textbooks are disruptive to learning because they rely too strongly on vocabulary at the expense of guiding the skills of interpreting evidence and understanding the process of scientific investigation. Pinto (2007) offers an even more biting criticism, suggesting that the overuse of textbooks leads to close-mindedness and indoctrination of students by limiting diverse perspectives in favor of specific cultural values. Consistent with such professional critiques, students often feel that textbooks, especially in the sciences, are inconsistent with their academic goals and so dense and difficult to read as to decrease motivation for reading (Kirk et al., 2001).

Textbook costs

As the study of the value of textbooks and their use continues, one issue of near universal agreement is that the increasing costs of textbooks is a problem in higher education. Over the decade from 2006 to 2016, the cost of a college textbook increased by 73%, four times the rate of inflation, with many individual textbooks costing over \$200 (Senack & Donoghue, 2016). In recent years, the College Board has found undergraduate students' average annual expenditures on textbooks and supplies to exceed \$1,000 (Baum, Ma, Bell, & Elliott, 2014). The dramatic increase in textbook prices began decades ago as used textbooks became more accessible, faculty began demanding more amenities, and market competition grew (Lichtenberg, 1992). Publishers contributed to rising costs as they began including more ancillary materials with required content and frequently releasing new editions (Stevens, Silver, Clow, & McConkey, 2010). The result has been an unmistakable increase in the cost of textbooks. The continuing rise in textbook cost is one substantial piece of a broad trend of rising college expenses (Privateer, 1999).

The high cost of textbooks negatively affects students by limiting their ability to access necessary resources. Although many college students believe owning a required textbook will enhance their learning and improve their grades, as many as 65% choose not to purchase at least some textbooks due to the high cost (Martin, Belikov, Hilton, Wiley, & Fischer, 2017; Senack, 2014). Students also respond to the high cost of textbooks by using digital options, sharing, or renting books. Textbook prices even been shown to influence student choice of which and how many college courses to take (Senack, 2014). The high cost of textbooks disproportionately affects the students of community colleges (Senack & Donoghue, 2016). Potential students of low socioeconomic standing are more likely than

wealthier peers to put off college and are more likely to attend a community college when they pursue post-secondary education (Provasnik & Planty, 2008). Community colleges generally have lower tuition relative to textbook costs, so textbook costs can disproportionately contribute to financial challenges and lower grades (Smith, 2011). Financial limitations mean that appropriate textbook choice is essential in introductory courses at two-year institutions (Baker, Thierstein, Fletcher, Kaur, & Emmons, 2009).

Because the high cost of textbooks can negatively affect student success, it is not surprising that cost is an important factor in professor textbook selection (Petrides, Jimes, Middleton-Dezner, Walling, & Weiss, 2011). Cost is not, however, consistently the most important factor mentioned by professors for textbook selection (Silver, Stevens, & Clow, 2012). Several other considerations influence an instructor's choice of textbook, including student knowledge, course challenge level, course content, and features such as such as detail, readability, and organization (Durwin & Sherman, 2008). In general, K-12 teachers select textbooks with similar priorities to college professors, with particular attention paid to cost and additional consideration given to content, cultural issues, readability, and ancillary aids (Bliss, 2013). Student feedback is also a factor in faculty textbook selection (Bliss, Hilton, Wiley & Thanos, 2013; Durwin, & Sherman, 2008). Other factors less thoroughly researched include considerations of format, value, and pedagogical utility (Bliss, 2013).

Publisher competition and the resulting standardization of textbooks means that textbook selection may not be as important as implied by the many criteria cited by professors. In a comparison of different psychology textbooks there was no significant difference in student understanding after reading similar passages, suggesting limited differences in effectiveness between mainstream textbooks in any one field (Durwin &

Sherman, 2008). This is likely due to the fact that published textbooks in a given field of study share similar content and organization (Seifert, 2010). Nonetheless, textbook selection merits careful attention because professors tend to stick with a textbook once they have made a choice (Durwin, & Sherman, 2008) and textbooks often influence the content and teaching approach used in a classroom (Reys et al., 2004).

Alternatives to publisher textbooks

In light of the high costs and potential pedagogical limitations of textbooks, many professors are increasingly choosing alternative resources to traditional textbooks. Novel resources are made more readily available with changing technology and publisher responses to student and faculty demands. Educators increasingly envision a customizable, affordable, and responsive set of resources for students. These expectations include concise content, web links to related materials, and the ability to select modular, customizable content for specific courses and place-based learning (Bierman et al., 2006). There is a growing array of possible solutions to the high cost, dissatisfaction, and underuse of college textbooks; examples include digital texts, custom texts, careful textbook selection, writing one's own text, or not requiring a textbook at all (Skinner & Howes, 2013). One study highlights cost and learning benefits from abandoning a textbook entirely to use student cell phones as resources in a college science class (Tessier, 2014). Others have proposed the use of podcasts as effective and inexpensive tools to develop listening skills in language learners (Selwood, Lauer, & Enokida, 2016). A well-maintained course website can substitute for a formal textbook (Simon, 2001). Multimedia supplements such as interactive online activities and videos can complement textbook use and contribute to student success (Rackaway, 2012). Solutions that

retain traditional textbooks include reducing the numerous supplements and software that accompany many modern texts or using campus-wide rentals and shared texts (Carbaugh & Ghosh, 2005).

Among these innovative substitutes for and amendments to traditional textbooks, the three most commonly used alternatives are explored in more detail below before discussing the use of student-written textbooks. Published research specifically focused on student-written textbooks is sparse; the inclusion of additional textbook alternatives with shared features helps establish a broader context for the benefits and limitations of student-written textbooks. Most of these alternatives can be offered online, available for download, or both. These three strategies have overlapping characteristics, but are defined hereafter as follows:

- 1) Etextbooks, which can include embedded videos and web links, but are usually simply digitally available versions of textbooks. Etextbooks are often offered by publishing companies for a lower cost than print versions of the same textbook. Etextbooks are growing in their use in colleges, but more slowly than some other textbook alternatives (Miller, Nutting, & Baker-Eveleth, 2013).
- 2) Open textbooks, which differ from etextbooks by being mostly instructor-written, free, and frequently updated online collections of diverse resources. A growing number of college courses are using open textbooks because of their accessibility, customizability, and presumed high quality (Ozdemir & Hendricks, 2017).
- 3) Wikis and related web-based resources, which differ from open textbooks by integrating student contributions. Wikis are commonly more interactive and collaborative than etextbooks and open textbooks, and are also readily updated and free (Altanopoulou, Tselios, Katsanos, Georgoutsou, & Panagiotaki, 2015). The focus of this research is student-written textbooks, in which an instructor guides and edits the synthesis of student contributions to a

free, updatable collection of writings into one document to serve as an alternative to a published textbook. Such resources can also be offered either in print, electronically, or both. Student-written textbooks are examined in greater detail following the discussion of the three dominant textbook alternatives below.

Etextbooks

Etextbooks are increasingly common offerings from publishers (Miller et al., 2013). Students and faculty are becoming more open to etextbooks while students are also gaining more access to the devices needed to use them. Commonly cited reasons for growing use of etextbooks are portability, searchability, accessibility, and cost (Baek & Monaghan, 2013). Although cost is the clearest of these advantages and certainly does affect etextbook adoption, it may not be the most important factor in their increased use because of other advantages over printed textbooks (Gerhart, Peak, & Prybutok, 2015). Etextbooks are easier to update with new information through quicker editing (Miller et al., 2013). Etextbooks support student engagement with materials differently from printed texts. Most digital books are searchable and can enable personalized features such as highlighting, commenting, and personal annotations in diverse ways (Ravid, Kalman, & Rafaeli, 2008). The use of etextbooks in university coursework has been shown to be as effective as print textbooks at supporting learning (Rockinson-Szapkiw, Courduff, Carter, & Bennett, 2013). Student satisfaction with etextbooks is difficult to discern from existing literature. Some studies have indicated marginal student satisfaction with etextbooks, with positive feedback related largely to cost, ease of use, light weight, and searchability (Baek & Monaghan, 2013). Students reported leisurely reading, ease of research, convenience, and mandatory use as the

most likely factors supporting their satisfaction with or purchase of an etextbook (Walton, 2014). Etextbooks are perceived as being more available when needed because they can be less cumbersome to carry than large printed textbooks (Rod-Welch, Weeg, Caswell, & Kessler, 2012). When supplemental tools are included, students value the ease of annotation, control over font size, quality images, embedded web links, and in-text quizzes providing immediate feedback (Bliss, 2013). Other factors that can contribute to higher etextbook use are lower student income, enrollment in more business- and technology-oriented courses, and positive teacher communication about the etextbooks (Miller et al., 2013).

There are important concerns from students, professors, and researchers regarding the increasing use of etextbooks. Overall, students consistently indicate a preference for using printed books even though today's college students are generally skilled at using electronic devices (Nelson, 2008; Miller et al., 2013; Rod-Welch et al., 2012; Walton, 2014). Students have been slow to adopt etextbooks despite the increased access to other digital media and lower costs (Gerhart et al., 2015). Several factors are involved in the resistance to etextbooks, most of them related to their digital format. The need for a computer or tablet and related computer skills can be limiting for some, reading electronically can be clumsy or difficult to track, and many readers prefer a more tactile experience (Gerhart et al., 2015; Walton, 2014). Reading etextbooks can increase reported frustration with eye strain (Dobler, 2015). Etextbooks do not always permit marginal annotations, they may not work on all devices (and thus require additional technology expenditures), they can be susceptible to errors or viruses, and they can include images that are difficult to view (Miller et al., 2013). Some students especially dislike the difficulty of finding one's location in etextbooks (Walton, 2014). These challenges collectively help explain why many students consider printed books

as easier and more pleasurable to read (Rod-Welch et al., 2012). The ease of reading can be especially important to supporting positive classroom interactions when students are asked to read aloud (Walton, 2014). Requiring an etextbook with no print alternative does increase their use (Walton, 2014), but many students strongly dislike being required to use etextbooks with no available print option (Baek & Monaghan, 2013). Students appreciate having the choice of selecting an etextbook or a print copy (Bliss, 2013).

Open textbooks

The use of open textbooks is also growing across many levels of education. Open textbooks are used to offer easily-navigated, free, online substitutes to publisher textbooks (Baker et al., 2009; McKerlich, Ives, & McGreal, 2013). Open textbooks offer free educational resources such as textbook content, research articles, videos, and simulations through an open copyright license or in the public domain (Wiley, Green, & Soares, 2012). There are several reasons for the growing use of open textbooks. The free content eliminates the textbook contribution to financial barriers in education (Caswell, 2012). Even though they are typically offered online, open textbooks can be printed for far less than the price of most textbooks while still offering easy access to supplemental digital resources (Bliss et al., 2013; Ozdemir & Hendricks, 2017). In addition to the clear cost savings, there are other advantages to open textbooks that explain their increased use, some of which distinguish them from etextbooks. Open textbooks create ready opportunity for revision, customization, and sharing of course content (Wiley et al., 2012). Open textbooks are more flexible than etextbooks, and can therefore accommodate specific course objectives, local contexts, and personalized resources for students with particular needs (Voss, 2015). Open textbooks are

often coordinated by professionals in specific fields; as a result, they tend to have dependable quality while supporting teachers' preferred educational methods. They can concurrently support teacher collaboration and interactive materials (Petrides et al., 2011). Because many open textbooks are written or edited by the course instructor, there is greater consistency between course content and its supporting resources (Baker-Eveleth, Miller, & Tucker, 2011). A synthesis of several studies support the conclusion that student learning is not negatively affected by use of open textbooks (Hilton, 2016; Hilton & Wiley, 2011). Other research suggests higher student achievement with the use of open textbooks. Open textbooks can improve student progress and class preparation (Bliss et al., 2013). The use of open textbooks was associated with higher exam scores, grade point averages, and retention rates in a college psychology course (Hilton & Laman, 2012).

Student and faculty experiences with open textbooks are generally positive. Faculty reported that cost savings was the most important motivation for adopting open textbooks, and that students most often reported this as what they appreciated as well (Ozdemir & Hendricks, 2017). Majorities of faculty and students have described open textbooks as equal or superior in quality and ease of use to print textbooks in many studies (Bliss et al., 2013; Hilton, 2016; Illowsky, Hilton, Whiting, & Ackerman, 2016). Faculty have reported improvements in student learning and ease of teaching when using open textbooks compared to traditional textbooks, and tend to prefer them enough to continue using them over the long term (Delimont, Turtle, Bennett, Adhikari, & Lindshield, 2016). Students have reported open textbooks as being of high enough quality that alongside cost considerations they would appreciate having more open textbooks offered (Voss, 2015).

Open textbooks present some of the same challenges as etextbooks, such as student preference for tactile reading and the need for computers and computer skills, but these concerns can be partially alleviated by the capacity to print many of these resources at lower cost relative to traditional textbooks (Voss, 2015). Two concerns specific to open textbooks are the need for professor content contributions and the ongoing maintenance requiring time and computer proficiency (Petrides et al., 2011). Supporting a quality open textbook requires clear objectives, professional contributions, reflective analysis, and maintained connections between content and learning goals. This means that an effective open textbook is a never-ending project demanding sustained teacher commitment (Voss, 2015).

Wikis

The use of wikis and blogs has grown dramatically in educational settings in recent years (Altanopoulou et al., 2015). Wikis are fully editable websites; users can visit, read, reorganize, and update the structure and content of a wiki at any time (Leuf & Cunningham, 2001). Wikis present great potential as a tool to support online, interactive education because a user only needs access to the internet through a reliable web browser to edit and read a wiki (Augar, Raitman, & Zhou, 2004). This open nature of the wiki technology creates significant opportunities for learning (Wheeler & Wheeler, 2009). Possible applications include group writing projects, updated glossaries, online discussion, and reflective journaling (Ben-Zvi, 2007). As with open textbooks, wikis do not incur any cost to students beyond the requisite technology (Ravid et al., 2008). Distinguishing wikis from etextbooks and open textbooks, a commonly cited strength of using wikis as textbook substitutes is the potential for student-generated class content involving collaborative exercises (Lazda-Cazers, 2010). Most

research citing benefits from wikis includes this theme of the potential for collaborative learning.

By their nature of being readily updated, wikis create potential for collaborative problem-solving and analyzing resources, helping to model the value of self-reflective editing through the experience of content creation (Ferris & Wilder, 2006). By enabling multiple participants to improve content, wikis can help students develop stronger writing skills (Mak & Coniam, 2008; Wheeler & Wheeler, 2009). Through this process, students are also exposed to multiple sources that can deepen their appreciation for diverse perspectives (Lazda-Cazers, 2010). Collectively, these benefits foster a more equitable and learner-centered educational environment relative to the top-down information distribution reinforced by a traditional textbook (Hu & Johnston, 2012). The process of content development through wikis provides valuable information to professors. Instructors can make editorial changes as needed while monitoring and providing feedback on the development of individual and group contributions to a project (Duffy & Bruns, 2006). Wikis add a benefit to science education with opportunities to develop skills seeking evidence and refining explanations as a model for scientific inquiry (Bogiages & Lotter, 2011).

Consistent with these opportunities, several studies have demonstrated educational success from the application of wikis. The commonly cited benefit of collaboration supports the findings that group wiki work can improve academic achievement (Ben-Zvi, 2007). Unlike collaborative work in a shared physical space, wikis are open to each individual's pace while they follow others' progress (Coyle, 2007). This is one example of how wikis support diverse student abilities and contribute to their learning (Lai & Ng, 2011). Learning has been shown to be unrelated with the student role in wiki development, and the relative

benefits to learning from using wikis can be higher for students with low early achievement (Altanopoulou et al., 2015). Wikis may also support diverse learners because aside from core computer skills, the use of wikis does not require complex programming abilities (Duffy & Bruns, 2006). Furthermore, the use of wikis can assist developing some technology skills (Ravid et al., 2008). After using wikis, students have reported high satisfaction from their support for collaboration and shared their plans to use wikis in future coursework (Chao, 2007).

Wikis are one of several online educational tools that can be used as textbook substitutes. Blogs and other web-based tools share some of the benefits of wikis, including minimal cost, ready editing, and interactivity. Through a class blog, students can creatively contribute to class content, work at their own pace and with others, and deepen their skills through reading, writing, and analyzing sources (Duffy & Bruns, 2006). Simon (2001) explored the use of a class website in a college biology course with diverse, up-to-date content and space for student contributions, a glossary, practice questions, animations, and links to access to remedial content. Students reported that the website created for their class was more valuable to their learning than a textbook. Blogs and webpages maintained by instructors are generally not as dependent on student contribution and collaboration. When blogs and wikis were compared in one college course, both were found to benefit learning, but the consistent differences favored wikis. The researchers propose that the preference for wikis relates to its nature as more flexible and collaborative (Avci & Askar, 2012).

Wikis and blogs share some limitations with e textbooks and open textbooks. The need for computers and some degree of computer proficiency can create barriers for some students (Ren, Baker, & Zhang, 2009). Student and professor experiences with these web

tools include additional factors that create resistance to their successful application in college education. By their nature, accuracy is not guaranteed and wikis may be susceptible to viruses or intentional malware (Wheeler, Yeomans, & Wheeler, 2008). In spite of the asynchronous contributions, some students expressed their frustration with group work (Hu & Johnston, 2012). Students have also expressed frustration with the lack of authorship for their work and the capacity for others to change their contributions (Wheeler et al., 2008). Face-to-face collaboration enables efficient communication among group members and may be preferred for its familiarity (Coyle, 2007). Regardless of the potential for success with wikis, student preference for face-to-face collaborative work may impede progress and satisfaction with wikis (Witney & Smallbone, 2011). Students in a group creating a wiki might not all actively participate in sharing resources and development duties; interaction does not guarantee collaboration (Hu & Johnston, 2012).

Additional challenges with wikis in college education relate largely to the extensive instructor responsibilities relative to the simple adoption of a textbook. Instructor vigilance is critical because wikis foster rapid changes in content and organization, generating the possibility of opinions and inaccuracies in class content (Altanopoulou et al., 2015; Ferris & Wilder, 2006). Instructor input is necessary for establishing the wiki framework, defining the activity, and monitoring content; maintaining an effective wiki can require significant time investment (Hu & Johnston, 2012; Parker & Chao, 2007). Managing wikis requires guidance of group work toward reliable sources because students might perceive wikis as requiring less academic rigor (Elgort, Smith, & Toland, 2008). A challenge with assessment can be the concern that with a dynamic product it can be difficult for instructors and students alike to monitor ongoing changes, reduce plagiarism, and connect meaningful feedback to individual

contributions (Ben-Zvi, 2007; Elgort et al., 2008; Hu & Johnston, 2012). These challenges necessitate deliberative development of the platform, clear communication of expectations, and careful monitoring by instructors (Duffy & Bruns, 2006; Wheeler et al., 2008). Given that challenges with accuracy and detail may persist, web-based resources like wikis may be most appropriate for introductory and general education courses (Simon, 2001).

Wikis can range from highly instructor-controlled to mostly student-driven and from a dependency on individual contributions to largely collaborative. Wikis share with student-written textbooks the key feature of depending on student contributions for content in a textbook alternative, and therefore share overlapping educational strengths. For example, the student contributions to a college biology web page (Simon, 2001) and the use of wikis to develop online textbooks for college courses (Kidd, O'Shea, Baker, Kaufman, & Allen, 2008; Ren et al., 2009) all illustrate the possibility of overlapping characteristics between wikis and student-written textbooks. This overlap is perhaps best illustrated by the small but growing use of wikipertextbooks, in which wiki platforms are specifically used to build student-written electronic textbooks (Kidd et al., 2008; Ravid et al., 2008).

Student-written textbooks

The research and use of student-written textbooks in college education are lower than for etextbooks, open textbooks, and wikis. Student-written textbooks are built from either individual or collaborative student contributions to create a dynamic, affordable class resource. Student-written textbooks can incorporate characteristics of other textbook alternatives. For example, student-written textbooks can be offered electronically to include advantages of etextbooks with the instructor review and minimal cost of open textbooks

alongside the collaborative and skill-building opportunities of wikis. The clearest commonalities for student-written textbooks are with wikis, but student-written textbooks are distinguished by the end product being a printed or digital book, similar to a traditional textbook or etextbook. A student-written textbook can be offered as a printed textbook, an open textbook, or an etextbook, and includes the important benefit of low cost.

Student-written textbooks present an opportunity for student empowerment through active participation in the production of class resources (Nahornick, 2014). Traditional publisher textbooks are typically selected by their instructors and rarely have student input into their content and structure (Seifert, 2010). This exclusion of student voices, typical in college courses, can diminish motivation, enthusiasm, and self-directed learning (Shibley, Dunbar, Mysliwiec, & Dunbar, 2008). Interest in student-written textbooks is growing in part because of the benefits of including students in the creation of their own learning tools. Student-written textbooks are one of a growing set of learning tools co-created by faculty and students, ranging from curriculum design to assessment, with a common goal of deepening student responsibility for their own learning (Bovill, Cook-Sather, Felten, Millard, & Moore-Cherry, 2016). Collaboration between students and professors can contribute to a more democratic learning environment while benefiting the entire class from the underused resource of student contributions (Gärdebo & Wiggberg, 2012).

As one tool to access student talent and enhance satisfaction and engagement, student-written textbooks are consistent with constructivist methods of teaching and the development of metacognitive skills. Two key constructivist learning approaches made possible with student-written textbooks are the connection of student experiences and background knowledge to their content and assignments, and the potential for students to

build their knowledge in a social context (Straits & Wilke, 2007). Furthermore, students can develop more positive attitudes and self-motivated learning strategies when encouraged to ask and explore their own questions. Viewing learning as an ongoing process instead of seeking fixed knowledge supports sustained, independent learning (Ren et al., 2009). This appreciation is reinforced through metacognitive skills, in which students reflect on and understand their own thinking and learning. Development of metacognitive skills has been shown to produce positive outcomes in college science education (Zhao, Wardeska, McGuire, & Cook, 2014). Students with greater accountability for their own learning can strengthen metacognitive skills while becoming more active creators in their learning instead of passive recipients of information (Bovill et al., 2016). The responsibility generated by student-written textbooks shows promise in fostering these abilities through offering students greater ownership, choice, self-directed learning, pride in contributing to a collaborative project, and improved critical thinking from asking deep questions and analyzing multiple sources (Nahornick, 2014; Ravid et al., 2008; Sosenke, 1994). These opportunities can collectively help students see themselves less as consumers of information and more as creators of meaningful knowledge (Seifert, 2010). Furthermore, student-teacher co-creation of class materials enables professors to better understand their students and how they learn, regardless of benefits to content knowledge (Allin, 2014).

Other educational benefits complement the potential cognitive learning value from student-written textbooks, many of which relate to student satisfaction. Glossaries, summaries, and practice questions can be readily incorporated into student-generated content (Simon, 2001). Textbooks can be custom-made to meet specific class goals, highlight student priorities, and connect to local cultures and environments. Student-written textbooks are

often shorter than publisher textbooks and offer greater control over formatting and content. The result is a resource with minimal distracting or unrelated content that is more likely to be viewed as useful by students (Seifert, 2010). The process of writing content for a textbook presents students with opportunities to strengthen technology skills (Nahornick, 2014) and writing skills, especially when contributing to a product with meaningful stakes and ownership (Sosenke, 1994). Writing skills are enhanced with chances for repeated revision guided by teacher and classmate feedback wherein writing is treated as a process of discovery and creation (Galbraith, 1999). With instructor guidance, such writing can even be more engaging when allowing for creative self-expression with a goal of having fun while sharing content in novel ways, even in science courses (Killingbeck, 2006). Ultimately, these opportunities mean that involving students in the research and production of textbooks can improve their overall readability and attractiveness (Knecht & Najvarová, 2010).

In light of these apparent benefits from student-written textbooks, the essential question that follows is whether or not they meet their goals. While exploring student satisfaction with student-written textbooks (the focal point of this research) it is also worthwhile to visit their effectiveness in meeting learning goals. There are a handful of published works that suggest generally positive impacts from student-written textbooks on learning outcomes. Teachers incorporating textbooks with student contributions have reported improvements in areas ranging from understanding content to research methods (Frye, 1999). Student-written textbooks can be as effective as traditional texts in college study (Seifert, 2010), associated with higher academic performance (Ravid et al., 2008; Russo, 2016), and foster more engaged and thorough learning (Evans, 2006). Other resources using student contributions such as blogs and wikis with positive results reinforce the

encouraging outcomes from using student-written content (Altanopoulou et al., 2015; Avci & Askar, 2012; Ben-Zvi, 2007; Simon, 2001). Researching and writing are part of a valuable learning process, showing positive results in meeting challenging learning goals (Hand, Hohenshell, & Prain, 2007) while contributing to the development of writing skills (Frye, 1999).

Students report generally high satisfaction with the use of and contribution to student-written textbooks. In response to their contributions, students cite positive experiences with being pushed to explore a topic in greater depth and the sense of ownership from creating a resource to help teach others (Ravid et al., 2008). Students contributing to a textbook replacement have reported feeling more engaged in the course through the participation in creating the book and choosing to spend more time reading (Kidd et al., 2008). The use of student contributions to content in realms other than textbooks supports this pattern of satisfaction. Faculty and student co-creation of content in a math course inspired more positive attitudes and feelings of ownership and freedom (Russo, 2016). The reported positive outcomes are not limited to student responses; faculty find that through co-creation they discover a broadened perspective and improved teaching practices that encourage them to explore additional collaborative projects (Cook-Sather, 2014). Shane (2008) reports high satisfaction from using journalism-style student contributions that connect students to the broader community and make the class easier and more enjoyable to teach. Although there are important concerns with implementing student-written textbooks, this literature review found no consistently reliable reports of student or faculty dissatisfaction when they were used.

The most important challenges with student-written textbooks can be grouped into four categories: the student experience, the professor experience, the textbook product, and the student-teacher dynamic. The student experience of contributing to a student-written textbook is generally positive, but can present special challenges that merit careful attention. For example, some students may choose topics that they already understand well, or believe they understand well, and fail to push themselves to engage with new material and support deep learning (Ravid et al., 2008). Students contributing to a group project may focus more on their own contributions and less on the contributions of others (Bonk, Lee, Kim, & Lin, 2008). When the desired product from student contributions is not clearly defined, students can feel less motivated by a process they experience as ungrounded in their educational or professional goals. This can lead to contributions modeled on existing notions about textbooks instead of supporting a more engaging writing process (Seifert, 2010). Such challenges can be exacerbated by student concerns about time investment, especially when positive results are not felt immediately (Wolf-Wendel, Ward, & Kinzie, 2009). This relates to the need for faculty to invest ample time and energy supporting the process. Many professors are resistant to co-creating content with students because of real or believed challenges (Allin, 2014). Some professors feel risk to their profession from encountering resistance in their institution or concern for failing to meet academic standards when using student contributions to class content (Bovill et al., 2016).

A student-written textbook also presents risks to overall quality, such as inadequate or inaccurate content coverage, poor writing quality, and excess focus on individual topics. As presumed novices in course content, students are not experts in a field of study they are writing about, which can create misconceptions interpreting more advanced vocabulary and

concepts (Seifert, 2010). Professors must provide guidance while supporting genuine student self-expression. When empowering students by incorporating their voices into class content, there is still a pronounced power imbalance inherent to the student-teacher dynamic. It is particularly important to be aware of this imbalance in science courses where students may feel less capable of making valid contributions than in other content areas (Allin, 2014).

Quality textbooks

This project explores student satisfaction with student-written textbooks in an introductory two-year college biology course. A guiding goal, therefore, is to assess which features are common to effective and satisfying textbooks. Many of the features of a quality textbook are applicable to etextbooks, open textbooks, wikis, and student-written textbooks alike. The broader body of research concerning quality traditional textbooks relative to their more recent alternatives provides valuable insight into how all of these resources can best support student education. The features of a quality textbook are particularly important considerations in this study in light of the challenges discussed above with using student-written textbooks. There is more published research concerning professors' perspectives than student experiences and satisfaction with textbooks (Bliss, 2013). Textbooks have a history of being written from a professor perspective as resources of information to be memorized, and less from a goal of accommodating how students learn and create meaning (Carpenter et al., 2006; Tulip & Cook, 1993). Research into quality textbooks has highlighted several common themes including comprehensive content coverage, clear organization, quality writing, readability, visual appeal, and appropriate aids and supplements which can be viewed in concert to inform quality textbook selection (Durwin & Sherman, 2008; Griggs &

Marek, 2001; Seifert, 2010). These features are shared below in more detail to highlight common patterns of quality and satisfying textbooks.

As discussed earlier, the cost of textbooks is a limiting factor for college student success. The increasing costs of textbooks can limit textbook purchasing (Martin et al., 2017), negatively impact learning (Petrides et al., 2011) and even influence course selection and degree of participation in college (Senack, 2014). Although not inherently an indicator of textbook quality, special consideration should be given to reduce cost whenever possible because of its influence on student success and its relationship with the frequency of new editions, delivery format, and ancillary materials (Stevens et al., 2010).

A core need of any textbook is the presentation of appropriate, course-specific content (Silver et al., 2012). The structure of introductory college science textbooks tends to share common themes of similarly-organized units, similar chapter length and content, similarly-labeled images, a glossary, and a fact-based sequential presentation of material. Textbooks in a given field may be growing even more similar due to professor demands and publisher competition, and the effect of differences in text design on student success is unclear (Durwin & Sherman, 2008). The apparent similarity in college textbooks in any one course of study may be superficial, with more meaningful differences found in the vocabulary, specific content, and sources (Griggs & Marek, 2001). As textbook structures continue to converge, there is some evidence that textbook design can impact learning. For example, independent modules that can be adjusted for professor preference of content and organization have shown moderate improvements in student achievement (Nevid & Carmony, 2002). The length of a portion of a textbook devoted to a particular subject can suggest its value to students (Rosenthal, 1985). Even the order and interconnectedness of

content can convey messages of relative importance to students that affect their attention to certain topics. For example, biology textbooks often place ecology concepts at the end of a text, possibly serving to diminish their perceived significance (Kuechle, 1995). The presentation of evolution as a separate textbook unit instead of an integrated theme in college biology texts might contribute to inadequate understanding of evolution as a unifying theme in biology (Nehm, Poole, Lyford, Hoskins, Carruth, Ewers, & Colberg, 2009).

Textbook content also influences student satisfaction. Students appreciate shorter textbooks with distinct sections that focus on essential content without distracting details (Baker et al., 2009; Kortz et al., 2017; Seifert, 2010). A frequently cited content-based benefit to student learning and satisfaction is including real-world application in textbooks (Gentry, Becker, Lamb, & McGregor, 2009; Moravcsik & Kintsch, 1993). Students' existing knowledge and perspectives influence their capacity to develop meaningful understanding when reading new material (Willingham, 2003). A textbook is more effective and more likely to be used by students when it does not require extensive background knowledge and connects to students' interests and goals (Durwin & Sherman, 2008). Students respond positively to textbooks that illustrate scientific inquiry through up-to-date connections to their daily lives, such as how things work, the natural world, or the human body (Gonzalez-Espada, 2009). Students value locally relevant, practical textbook content (Seifert, 2010). Textbooks that honor the experiences of diverse students with culturally relevant materials are particularly important for community college students (Baker et al., 2009).

Accompanying the structure and content, textbook quality is further influenced by embedded pedagogical aids and ancillary perks. Commonly-cited and student-valued textbook aids include embedded questions, chapter summaries, and bolded terms and

glossaries to assist with vocabulary (Bliss, 2013; Weiten, Guadagno, & Beck, 1996). These ancillary resources in particular can be customized to benefit diverse student needs (Moravcsik & Kintsch, 1993). Although research shows educational benefits from including student feedback in textbook selection and supplements (Altman et al., 2006; Bliss, 2013), student preferences for these resources are not always considered by publishers (Marek, Griggs, & Christopher, 1999). Feedback could be particularly important with assisting vocabulary comprehension, because in spite of the generalization that textbooks in a given field are similar, they can differ greatly in their glossaries (Griggs, Bujak-Johnson, & Proctor, 2004). Traditional textbooks reinforce the notion of students as recipients of information; raising questions in a textbook can help shift the student role to more active construction of new knowledge (Seifert, 2010). In-text questions can promote interaction with a textbook that deepen student connection to content (Bliss, 2013). Embedded textbook questions best serve students when they are diverse, challenging, and ask students to synthesize, evaluate, and extrapolate their knowledge to new contexts. Such deep-thinking questions are rare in currently published textbooks (Davila & Talanquer, 2009).

In-text questions are not the only tool that can increase student interaction with a textbook. In one computer programming course, researchers found improved grades and exam scores for students using a textbook with less text and several animations instead of embedded questions (Edgcomb, Vahid, Lysecky, Knoesen, Amirtharajah, & Dorf, 2015). Textbooks with marginal inserts to focus attention on key concepts have shown positive results on achievement and student satisfaction (Nevid & Lampmann, 2003). As interactive features become more common additions to textbooks, special care must be taken to ensure quality imagery, smooth navigation, and reliable technological performance to maintain

student satisfaction (Bliss, 2013). Students appreciate and use online activities that accompany a textbook when they function properly and are required resources that relate directly to course learning goals (Sellnow, Child, & Ahlfeldt, 2005).

Textbooks can be written with creative approaches and styles to engage student interest and help them build new knowledge. Incorporating the history of science in teaching materials can help students understand science content and the process of scientific investigation (Fulford & Rudge, 2016). Many college biology textbooks include a few standard and cursory historical references, but little space concerning the nature of science as an ongoing process of discovery. Sharing historic discovery can help students understand science as a process instead of a set of facts (Eichman, 1996). Incorporating primary journal articles and their diagrams into reading assignments presents students with direct exposure to sound hypothesis testing, data analysis, and communication of findings (Rybarczyk, 2011). One limitation to these strategies is that students may be less interested in readings with biographies, history, and journal articles (Gonzalez-Espada, 2009; Hobson, 2000).

Popularizations of science such as fictional novels can connect science to students' lives while demonstrating appropriate data synthesis and interpretation. Students often feel less intimidated and more responsible for their own learning when reading about science through popular literature (Shibley et al., 2008). Counter to a common concern about diminished learning, the use of science popularizations has shown increased student motivation and development of critical knowledge in college science (Lynd-Balta, 2006). Some of this success may be attributable to the value of storytelling. Learning through stories can foster wonder and involvement in students while supporting more creative curriculum

development for teachers (Dietiker, 2016). No major published college biology textbooks include a consistent use of storytelling, even though this approach can deepen student appreciation of biology as both a process of inquiry and a part of their current lives and not just a set of facts in a reference book (Crow, 2004). The use of materials with a narrative style in a college psychology course resulted in higher exam scores and student satisfaction relative to reading materials without the storytelling style (Fernald, 1989).

The writing style of a college textbook can affect student comprehension (Moravcsik & Kintsch, 1993). While coherent and accurate writing are essential, the most important considerations in writing style relate to vocabulary and readability. Students struggle with challenging vocabulary in textbooks (Crow, 2004), to the point that students receiving readings with less technical terminology have displayed improved academic performance (Burton, 2014). Many have suggested that a college biology textbook has more new vocabulary than a foreign language textbook (Penick, 1995). Students often find textbooks to be jargon-rich and impersonal (Shibley et al., 2008); guidance with new vocabulary is essential for student success (Gentry et al., 2009). Quality textbooks use age-appropriate language and do not require extensive background knowledge for comprehension (Durwin & Sherman, 2008; Griggs & Marek, 2001).

Because they are generally written by experts in their fields, textbooks can be so dense with new concepts as to overload student cognitive processes (Kortz et al., 2017). Without prior knowledge in a field of study, students struggle to successfully read textbooks that frequently demand abstract inferences (Pyburn & Pazicni, 2014). Furthermore, regardless of the richness of content, technical vocabulary and complex sentence structure can make college science textbooks more challenging for students to read, and even

successful comprehension of new words does not guarantee comprehension of the complex concepts they describe (Burton, 2014). In other words, college science textbooks present their readers with the concurrent challenges of abstract thinking about novel concepts alongside a high frequency of new vocabulary often presented in an unfamiliar writing style (Huffman-Kelley, Perin, & Liu, 2015).

Readability can be determined in different ways, but is usually a calculated indicator of the skill or grade level required to comprehend written content. Textbooks with readability above a student's level can disrupt learning (Kortz et al., 2017). Less research has focused on college level textbook readability than in K-12 education, but a common theme is that readability bears little concern in professors' textbook selection relative to other factors (Hippensteel, 2015). A large proportion of college textbooks have a readability level more demanding than the college freshman level (Schneider, 2011). In the sciences, it may be the conceptual and vocabulary challenges that are of greatest importance because some science textbooks are rated as more readable than other college textbooks due to having shorter and more descriptive sentences (Hartley, Sotto, & Fox, 2004). Readability is an essential factor when considering the use of scientific journals in class readings because peer-reviewed journals often have readability at multiple grade levels above college students (Hippensteel, 2015). Student feedback reinforces the conclusions from other research regarding quality textbook writing; students dislike textbooks that are complex and difficult to read with disconnected content and highly technical vocabulary (Gonzalez-Espada, 2009; Sadoski, Goetz, & Fritz, 1993). Some educators fear that catering to these concerns could diminish the quality of textbooks (Armbruster, 1985), but careful creation of shorter, more readable

textbooks with attention to core concepts does not necessarily reduce academic rigor and growth (Edgcomb et al., 2015).

Images are an often overlooked factor affecting the quality of a textbook, despite the likelihood that appropriate textbook images can improve student comprehension (Sadoski et al., 1993). Professors and publishers would benefit students with more attention to the quality of textbook diagrams and photographs (Gurung & Martin, 2011). Effective integration of images requires quality imagery, concise and informative captions, and clear connections to written content so that the images are truly helpful in making sense of the written words (Leivas Pozzer & Roth, 2003). Textbooks are problematic for students when they display abstract images without clear descriptions (Roseman, Kulm, & Shuttleworth, 2001). Images should be incorporated into text carefully; students benefit when images are concrete, clearly labeled and presented at natural breaks in the text (Kortz et al., 2017). The appropriate use of images can be particularly important in science textbooks, where many abstract concepts have a visual component and can be overly reliant on background knowledge. The skills of visually interpreting scientific data can benefit learning while promoting scientific literacy, and textbooks fail to support these benefits when images represent simple facts instead of ongoing processes (Rybarczyk, 2011). Less than five percent of introductory college biology textbook images relate to scientific investigation, contributing to the misconception of science as simply a collection of information (Duncan, Lubman, & Hoskins, 2011). Of the many factors affecting the quality of textbook images, students have reported dissatisfaction with images that are overly complex or mislabeled (Gonzalez-Espada, 2009).

Some attention is given in textbook writing and selection to diversity of cultural perspectives (Griggs, Jackson, Christopher, & Marek, 1999; Seifert, 2010). Textbooks have a

long history and ongoing issues with sexism and cultural bias (Whitten, 1975). Sensitivity to diversity is as essential in science textbooks as in any other realm, and the presumed norm of scientific investigation itself has western cultural biases. Multicultural perspectives in sciences benefit all students when they honor students' cultural backgrounds and individual orientations (Aikenhead, 1997). The satisfying, engaging nature of inquiry-based science activities in place of an overreliance on textbooks may be particularly beneficial for students with learning disabilities (Mastropieri, Scruggs, & Magnusen, 1999). Scientific investigation that celebrates students' connection to the natural world could aid all students, with particular encouragement for native students (Aikenhead, 1996). Women are underrepresented in textbook writing and images, and when represented are often in stereotypical roles. Female comprehension of textbook content improves when women are deliberately represented in counter-stereotypical roles, and all students display similar comprehension when men and women are portrayed in science textbooks working together (Good, Woodzicka, & Wingfield, 2010). Textbook alternatives such as wikitextbooks have the potential for empowering underprivileged individuals through their democratic process, but more research is required and care should be taken with professor guidance to ensure diverse voices are honored (Ravid et al., 2008).

Effective use of textbooks

There are other considerations for the use of textbooks in a college course that can impact student success. For example, how the textbook is used in the classroom, how students are guided to use it at home, and how the textbook is integrated in course responsibilities all influence learning in ways not directly related to the textbook content

(Gentry et al., 2009). Some propose that it is best not to use a textbook at all (Simon, 2001). Beyond their commonly cited intended uses as references and content guides, textbooks are often used to inform assignments and in-class activities (Tulip & Cook, 1993). The instructor role in guiding textbook use can impact students in many ways. Students generally view textbook readings as more important to their learning when some assessment depends primarily on readings (French et al., 2015). Students are also more likely to read textbooks when professors directly relate assignments, lectures, and in-class activities with readings (Gurung & Martin, 2011). Professors can share their own experiences with textbooks to the students, connect readings with brief supplements, and personally highlight key components (Kirk et al., 2001). Interventions that recognize reading difficulties can include group activities to support collaboration and self-reflection to promote metacognition (Huffman-Kelley et al., 2015). Teachers can also encourage students to ask specific questions from their textbook experiences, reference specific textbook passages as inspiration for class discussion, and connect textbook readings with class writing assignments (Weinberg & Wiesner, 2011).

How students read their textbooks outside of class is also critical to success. Active annotation during reading can help students restructure their reading practices from memorization that reinforces passive reception of information to a more active creation of knowledge (Simpson & Nist, 1990). Such practices are not limited to pen and paper as annotation resources are increasingly functional in e-textbooks (Ravid et al., 2008). Reflective writing is another strategy to increase student interaction with textbook readings and improve knowledge building. Reflective writing helps students connect existing knowledge with new concepts to provide insight into what they do and do not yet understand (Kalman, Aulls, Rohar, & Godley, 2008).

Our understanding of student attitudes towards textbooks is limited because research has focused more on content, structure, and professors' perceptions of value (Gentry, Fowler, & Nichols, 2007; Gurung & Landrum, 2012). This is in spite of the fact that students are the consumers most affected by textbook content (Bliss, 2013) and are reliably accurate in their assessments of which textbooks benefit their education (Britton, Van Dusen, Gülgöz, Glynn, & Sharp, 1991; Durwin & Sherman, 2008). Research into student satisfaction and feedback concerning textbooks is limited but supports the notion that including student voices is valuable to both students and professors (Altman et al., 2006; Bliss, 2013). The shift from teacher-centered to learner-centered science education in some college settings underscores the need to develop deeper understanding of how best to offer resources such as textbooks (Shibley et al., 2008). Exploring student satisfaction with a textbook can provide valuable insight into improving their learning experiences. This project explores student satisfaction with student-written textbooks with the goal of informing the development of a more valuable textbook alternative. The student feedback collected in this research can be coupled with existing knowledge regarding quality, satisfying textbooks in college science courses.

CHAPTER 3. METHODS

Overview

The core research question was explored using action research to inform changes to a student-written textbook and examine student reactions to those changes and other features of their textbook. Research followed a mixed-methods design in which the data collection was partly qualitative (open-ended survey questions) and partly quantitative (scaled survey responses). Action research in education is a process for teachers to examine their teaching practices to inform practical improvements in their own classes. Although action research often generates valuable findings for the field of educational research, its primary purpose is to seek solutions to individual teachers' problems and questions (Mertler, 2017). The problem that inspired this research is the chronic underuse of textbooks in college science courses and its probable negative influence on learning. Offering the student-written textbook successfully reduced cost, but high cost is not the sole cause of the broad problem of underuse of textbooks (Skinner & Howes, 2013; Swanson, 2014). This study collected student survey responses to inform the researcher how to structure a student-written textbook to help address issues with textbook use that are influenced by student satisfaction.

The research setting was one general education biology course at Missoula College, a two-year college embedded in the University of Montana offering professional training programs and an Associate of Arts degree. The biology course is offered both as a moderately-sized (between 30 and 40 students) face-to-face course accompanied by smaller lab sections and as a slightly smaller (25 students) online course. The content, learning goals, and textbook are identical between the face-to-face and online sections. The primary differences in the online sections are the use of chat-based discussion and short quizzes

instead of lecture instruction and the substitution of web-based activities for hands-on lab investigations.

The adoption of a published textbook ended in fall semester 2015 and the use of a student-written textbook began in spring semester 2015. Throughout this document, the student-written textbook will be referred to simply as the textbook. The textbook began as a class assignment designed to produce a collection of short chapters submitted by students to help replace a traditional textbook. The content and organization were developed by the professor to create a document similar to but shorter than existing introductory college biology textbooks. Students were asked to select a topic from a list of possible content areas. They were then instructed to write a short chapter of between 3-4 pages (roughly 1000 to 1500 words) citing multiple sources and incorporating images of their own creation or from open-source resources. The resulting collection of chapters required substantial professor editing for writing quality and content accuracy. In subsequent semesters, each student selected an individual textbook chapter to add to and refine. This process continued for three semesters as the product became more reliably readable, visually satisfying, comprehensive, and accurate. Although the modification each semester has benefited the quality of the textbook, errors and confusing content persist; the textbook is still relatively new and in need of continued editing.

At the initiation of this study, the textbook was an approximately 150-page word-processed document consisting of 43 short chapters ranging from 3-6 pages each. It included an introductory description of course content, an explanation of the student-written textbook, and a table of contents. All chapters included introductory paragraphs, several content-connected images, and one or more of the short sections titled “Biologists at Work,”

“Connections to Daily Life,” or “Just for Fun.” The textbook was organized in a commonly used scheme in published biology textbooks by presenting content ranging from the chemical to the ecological. The textbook is organized into four units that correspond to class content: 1) The chemical and cellular basis of biology, 2) Energy transformations and genetics, 3) Evolution and biodiversity, and 4) Ecology. At the time of this study, the textbook did not include a glossary. The textbook is offered to students at the university bookstore in a spiral-bound, black-and-white printed book costing approximately \$20. The textbook is also offered to all students, both online and face-to-face, as a free, color .pdf etextbook through the learning management system Moodle maintained by the University of Montana. Over the course of the past two years, students in the online class have largely chosen to read the etextbook over the printed textbook. Students in the face-to-face classes have shown diversity in textbook format choice, with most students choosing to purchase the printed textbook.

Early student feedback (spoken and shared in instructor evaluations prior to this study) suggested appreciation for the accessible language, manageable chapter length, and low cost of these textbooks. During the first two semesters of using the textbook, negative student feedback was largely related to writing quality and clarity. Some of these issues have been addressed in newer versions of the textbook, but the editing process has not been done in a deliberate, data-driven manner to guide improvements in ways best suited to support student learning and satisfaction. Too little was known about the students’ interactions and satisfaction with the textbook to inform a meaningful understanding of its value to students or the most effective ways to improve it for future use.

Data collection

Student perspectives were collected from two separate and similar anonymous surveys to inform changes to the textbook and explore student responses to those changes. Both surveys were offered through the survey program Qualtrics. The surveys were designed for completion in under ten minutes and included dichotomous, Likert-type, multiple-answer checkbox, and open-ended questions. Several Likert-type questions were phrased in negative terms to reduce the potential for acquiescence bias. For example, negatively-phrased statements such as, “I often get bored reading my Biology textbook” were interspersed with positively phrased statements such as, “The Biology textbook is well written.”

The details of the surveys were included in an approved application with the UM Institutional Review Board in June 2017 to verify minimal harm for student participants. Participation was strictly voluntary and anonymous. Students were invited to participate in the survey through a series of three emails distributed at one-week intervals. Students from spring semester 2017 were invited to complete Survey 1 through email accounts offered voluntarily at the end of the semester to increase the likelihood of participation over the summer. Students in fall semester 2017 were invited to complete Survey 2 through university email accounts under the assumption that students were more likely to read these during an active semester of study. The first email in each survey included a request for participation with a description of the research. Students were informed that the survey was voluntary, anonymous, helpful, and would in no way influence their academic success, with an accompanying link to the online survey. Subsequent emails included a brief expression of gratitude for the students who had completed the survey and a reminder with the link to the survey. Both surveys were left active for approximately one month.

Survey 1 was offered to students from spring semester 2017 shortly after completion of the course. The first purpose of Survey 1 was to provide qualitative and quantitative data about student satisfaction with the textbook to address the research question by exploring which textbook features were appreciated and disliked by students. The second purpose of Survey 1 was to recommend specific changes to the textbook to explore in the second survey. Specific changes to one chapter in the first unit of the textbook were informed by student responses in Survey 1 to the questions “Which of the following features would most improve the textbook?” and “Please share one or two specific suggestions for improving the class textbook.”. These results were compared with themes from the literature review for patterns or disparities of what could guide an improved, quality textbook. Survey 1 posed the prompts and questions listed in Table 1. Included with the Likert-type questions in Table 1 are the abbreviated statements used for each in the remainder of this report.

Aside from a few minor editorial changes in other chapters, the amendments inspired by Survey 1 were the only alterations made to the textbook between the spring 2017 semester and the fall 2017 semester. Chapter 6: Life Molecules - Proteins and Nucleic Acids was chosen for the suggested changes because it was of an average length, challenge level, and format compared to other chapters in the unit and offered similar content and structure to Chapter 5: Life Molecules - Carbohydrates and Lipids. The changes made to Chapter 6 included the addition of a short chapter summary, a “mini-glossary” defining core terms, and a small sample of practice questions with answers printed upside down. No other changes were made to Chapter 6 and these supplements were not added to any other chapters. Students were not informed in any manner of which chapter was altered.

Table 1. Questions and Likert-type prompting statements used in Survey 1, including abbreviated labels for Likert-type statements.

Dichotomous Questions Yes/No responses	1) Did you purchase a printed version of the class textbook?	
	2) Did you use the online version of the class textbook through Moodle?	
Likert type questions Five options: strongly disagree somewhat disagree neutral somewhat agree strongly agree	1) I read my textbook regularly.	read regularly
	2) There is no need to read the textbook to succeed in Biology class.	no need to read
	3) The textbook helps me learn what I hoped to learn in my Biology class.	helps learning
	4) I would have preferred a more typical college textbook.	prefer typical textbook
	5) I often get bored reading my Biology textbook.	get bored
	6) The cost of my Biology textbook influenced my decision to purchase it.	cost affected purchase
	7) The Biology textbook reading was difficult to understand.	difficult to understand
	8) I like knowing that former students contributed to the Biology textbook and that I might add to it.	like student-written
	9) The Biology textbook is well written.	well written
	10) The Biology textbook has too many complex words that make it challenging to follow.	too complex
Multiple-answer checkbox: Which of the following features would most improve the textbook? (choose up to 3)	more images	
	a glossary	
	connections to current scientific literature	
	chapter summaries	
	review questions	
	in-text worksheets	
	more connections to daily life	
	examples of scientists and their work	
	links to supplemental resources (web pages and videos)	
	improved clarity of writing	
other; please identify:		
Open-ended questions	What feature(s) of the textbook did you most appreciate?	
	Please share one or two specific suggestions for improving the class textbook.	

Survey 2 was offered after the first unit exam and provided additional qualitative and quantitative data about student use of and satisfaction with the textbook. Survey 2 further contributed to addressing the question of which textbook characteristics support student

satisfaction by enabling testing for the possibility that student satisfaction differed between the altered Chapter 6 and other, unchanged chapters in the same unit. . Survey results coupled with the literature review suggested the importance of exploring student reflection on two additional features of the textbook: connection to daily lives and quality and utility of imagery. The two most redundant Likert-type statements from Survey 1 were replaced with prompts in Survey 2 concerning textbook imagery and connection to students' lives. The reason for replacing statements instead of adding to them was to maintain a similar length of surveys. Survey 2 also differed from Survey 1 in asking students to select the most beneficial chapters to their learning from unit 1 and share reflections on any differences between the chapters. The questions and prompts used in Survey 2 are listed in Table 2, again including abbreviated statements for the Likert-type prompts.

Readability was calculated using five common tools to measure readability on a grade-level scale: the Flesch-Kincaid, Coleman-Liau, SMOG, Automated Readability, and the Linsear Write indices. Each calculation was based upon a collection of five 100-200 word paragraphs selected randomly (excluding introductory or concluding paragraphs) from within randomly selected chapters. This method was repeated three times.

Data analysis

The student surveys generated four types of data. The dichotomous questions and the two surveys are treated as categorical data to enable comparison of responses based upon different groups of students. The Likert-type data are response variables used to explore student use and satisfaction with the textbook. The multiple-answer checkbox responses are response variables used to explore suggested textbook changes in Survey 1 and chapter preferences in Survey 2. Lastly, the open-ended questions represent student responses in their

Table 2. Questions and Likert-type prompting statements used in Survey 2, including abbreviated labels for Likert-type statements.

Dichotomous Questions Yes/No responses	1) Did you purchase a printed version of the class textbook?	
	2) Did you use the online version of the class textbook through Moodle?	
	3) Are you taking the online class or the face-to-face class?	
Likert type questions Five options: strongly disagree somewhat disagree neutral somewhat agree strongly agree	1) I read my textbook regularly.	read regularly
	2) The textbook helps me learn what I hoped to learn in my Biology class.	helps learning
	3) I would have preferred a more typical college textbook.	prefer typical textbook
	4) The cost of my Biology textbook influenced my decision to purchase it.	cost affected purchase
	5) I often get bored reading my Biology textbook.	get bored
	6) The Biology textbook is well written.	well written
	7) The figures and images are confusing and fail to help clarify the written text.	images confusing
	8) I like knowing that former students contributed to the Biology textbook and that I might add to it.	like student-written
	9) The textbook helps to connect biology to my life and things that matter to me.	connects to my life
	10) The Biology textbook has too many complex words that make it challenging to follow.	too complex
Multiple-answer checkbox: Which are the highest quality chapters in the textbook from unit 1? In other words, which chapters did you most appreciate or benefit from reading? (choose up to 3)	Chapter 1: Intro to Biology	
	Chapter 2: An overview of science	
	Chapter 3: Intro to Chemistry	
	Chapter 4: The properties of water	
	Chapter 5: Life molecules – carbohydrates and lipids	
	Chapter 6: Life molecules – proteins and nucleic acids	
	Chapter 7: An overview of cells	
	Chapter 8: Eukaryotic cells	
	Chapter 9: Cell functioning	
	Chapter 10: Membrane function	
Likert-type questions specific to the changes implemented to the textbook (same options)	1) I would use the text more if all chapters were like the one(s) I selected above.	
	2) There were no differences for me between any of the chapters in unit one of the textbook.	
	3) Having completed exam one, I am more likely to read the textbook during unit two.	
Open-ended questions	1) What do you like about the Biology textbook in general?	
	2) What did you like about the chapter(s) you selected as the best one(s)?	
	3) Please share one or two specific suggestions for improving the Biology class textbook:	

own words; these were used to inform both the changes to the textbook after Survey 1 and explore for patterns in satisfaction with the textbook using responses from both surveys.

The checkbox question, “Which of the following features would most improve the textbook? (choose up to 3)” was analyzed by comparing frequencies of choices. The open-ended request, “Please share one or two specific suggestions for improving the class textbook” was examined for themes of repeated suggestions. These two items were interpreted collectively to inform the changes to the textbook in Chapter 6. The Survey 2 checkbox question, “Which are the highest quality chapters in the textbook from unit 1...?” was also analyzed by comparing choice frequencies to determine which chapters were reported as most beneficial and of highest quality by students.

Because quantitative representation of Likert-type responses does not carry a truly numeric meaning and as several variables failed test for normality, quantitative data were analyzed using non-parametric tests. Likert-type data were coded numerically from 1 = “strongly disagree” to 5 = “strongly agree.” Response values for each statement were compared for differences based upon the survey taken, the use of print or electronic versions of the textbook, and the class format (online or face-to-face) using the Mann-Whitney U test. An additional variable was calculated as an index of overall student satisfaction with the textbook by compiling the six Likert-type questions used in both surveys that most clearly reflected positive or negative reactions to the textbook into one mean score to determine a general level of satisfaction with the textbook. Negatively-phrased questions were recoded inversely; for example, responses to “I get bored reading the textbook” were adjusted so that “strongly agree” was coded with a 1 and “strongly disagree” with a 5. The six questions included were: “reading helps,” “prefer typical textbook,” “get bored,” “like student-written,”

“well written,” and “too complex.” To explore for relative differences in the intensity of responses, Likert-type data were analyzed using the Kendall coefficient of concordance.

Quantitative data analyses were completed using Qualtrics to report counts and frequencies of responses and using SPSS to test for differences. Analyses in SPSS applied two-tailed tests with $\alpha = .05$. Open-ended survey responses were analyzed by first examining for patterns of their positive or negative nature, then more specifically by tallying repeated statements. Calculated indices of readability were rounded to the nearest whole number grade level and are reported with the range of results and the mean value from the three tests using all five indices.

CHAPTER 4. RESULTS

Survey 1: informing changes to the textbook

There were three main objectives of the first survey: 1) to provide information about which kinds of changes students determined would most benefit the textbook, 2) to contribute to overall understanding of student satisfaction with their textbook, and 3) to serve as a baseline for comparison with student feedback in Survey 2 after the suggested changes were made. Of the 49 students emailed to participate in Survey 1, 17 accessed and completed the survey for a response rate of 35%. Nine of the respondents reported purchasing the print version of the textbook, and nine reported using the digital version of the textbook. The first goal, to inform changes to the textbook, was the foundation for subsequent alteration of the textbook before the Survey 2. The three selections for changes to the textbook chosen with the highest frequency by respondents were textbook additions instead of alterations: a glossary, chapter summaries, and review questions (Table 3). The two written responses for the “other” category were “I didn't find anything to add or take away” and “A couple grammatical errors.”

Of the 17 respondents to Survey 1, 12 chose to respond to the open-ended question, “Please share one or two specific suggestions for improving the Biology class textbook.” The responses were diverse, generally falling into one of two categories. Firstly, several responses included positive reactions to the textbook, represented by comments such as, “I [did not] find anything that [would] have a positive impact if changed” or simply, “none noted.” Secondly, several comments mentioned one or two specific suggested improvements without any frequency to indicate a clear pattern. The only repeated suggestion was two comments referring to a need for improved writing quality. Other suggestions reiterated

Table 3. Frequencies of Survey 1 selections for the multiple-answer checkbox question “Which of the following features would most improve the textbook (choose up to 3).”

Choice	Count	%
more images	4	11.4%
a glossary	6	17.1%
connections to current scientific literature	2	5.7%
chapter summaries	5	14.3%
review questions	7	20.0%
in-text worksheets	2	5.7%
more connections to daily life	2	5.7%
examples of scientists and their work	2	5.7%
links to supplemental resources (web pages and videos)	2	5.7%
improved clarity of writing	1	2.9%
Other (please identify)	2	5.7%
Total	35	100%

several of the research-supported options that were selected for in the survey’s checkbox question. For example, students proposed worksheets and summaries by stating, “Maybe including some practice worksheets at the end of each chapters along with a summary for additional practice,” vocabulary assistance with, “A glossary would be extremely handy!” and connections to student lives with, “Trying to connect something to every day life...”

Survey 2: responses to textbook changes

All other results from Survey 1 were analyzed alongside Survey 2 to allow for collective and comparative examination. Survey 2 was distributed to 62 students of which 31

responded for a response rate of 50%. Two of the 31 respondents chose not to complete the survey, resulting in 29 surveys completed. Eighteen of these respondents reported purchasing the print book, 22 reported using the digital version of the book, and the class format was evenly distributed with 14 respondents enrolled in the face-to-face section and 15 in the online section. Unsurprisingly, there was a strong correlation between students enrolled in the online section and students using the digital version of the textbook (data not shown). The response of greatest interest was the students' selection of chapters in response to the multiple-answer question, "Which are the highest quality chapters in the textbook from unit 1? In other words, which chapters did you most appreciate or benefit from reading in our Biology textbook (choose up to 3)?" The research objective was to explore if the additions to Chapter 6, informed by Survey 1, resulted in a greater selection rate of Chapter 6 as being of the highest quality and benefit. The results did not support this conclusion, instead indicating a diverse set of selections generally favoring other, unchanged chapters. Chapter 6 focused on two groups of biological molecules, and was chosen at a lower rate than the similar Chapter 5 that also focused on two groups of biological molecules (Table 4).

From the 24 responses to the open-ended question, "What did you like about the chapter(s) you selected as the best one(s)?" only one referenced the additions to the updated chapter, stating, "I liked chapter 6 because of the vocab list and questions." Three themes are apparent in the written responses. Ten of the 24 respondents shared appreciation for features related to readability such as clarity of text and ease of reading. For example, students wrote, "They described everything simply enough for students to understand, but also taught us new vocabulary and applications," "Simple explanations of complex ideas," "The chapters I selected were the easiest, for me, to progress through," and "Descriptions, definitions

Table 4. Frequencies of Survey 2 selections for the multiple-answer checkbox question “Which are the highest quality chapters in the textbook from unit 1? In other words, which chapters did you most appreciate or benefit from reading in our Biology textbook (choose up to 3)? They are listed here with brief summaries; flip through your textbook if that helps refresh your memory.”

Answer	Count	%
Chapter 1: Intro to Biology	6	7.6%
Chapter 2: An overview of science	5	6.3%
Chapter 3: Intro to Chemistry	6	7.6%
Chapter 4: The properties of water	6	7.6%
Chapter 5: Life molecules - carbohydrates and lipids	11	13.9%
Chapter 6: Life molecules - proteins and nucleic acids	7	8.9%
Chapter 7: An overview of cells	9	11.4%
Chapter 8: Eukaryotic cells	11	13.9%
Chapter 9: Cell functioning	13	16.5%
Chapter 10: Membrane function	5	6.3%
Total	79	100%

were well explained.” Six comments included some mention of the content as a strength of the chapter(s) chosen, with one student writing, “I liked the content in them it had nothing to do with how they were written.” Other content-related comments mentioned students’ personal interest in the chapter, with responses such as, “I would say most interesting.” The third theme was comments related to utility and benefits to student learning, with responses such as, “I learned a lot and it helped clarify subjects I didn't understand,” “I felt that they

provided information that best helped me understand the unit as a whole,” and “Covered material I was unfamiliar with.”

Beyond these three themes of readability, content, and benefit to learning, the most common strength mentioned concerned images, both in their utility, “Effective pictures,” and in their integration into the text, “I liked the image-text connection in that chapter the most.” There were no additional specific comments related to textbook features such as glossaries, summaries, worksheets, review questions, or writing quality. The three chapters most frequently chosen as preferred were 5, 8, & 9. In isolation, the students who chose these three chapters show the same themes as the whole survey in valuing readability, content, and benefit to learning in the chapters they chose.

The two Likert-type questions related to chapter preferences provided no evidence of strong preferences or that the chapters were thought to be largely different from one another. When responding to the statement, “There were no differences for me between any of the chapters in the Biology textbook so far,” the most frequent responses were “neither agree nor disagree” and “somewhat agree.” When responding to the statement, “I would use the Biology textbook more if all the chapters were more like the one(s) I selected above as the best one(s),” the most common response was “neither agree nor disagree,” with only five of 29 students selecting either “somewhat agree” or “strongly agree” (Table 5).

Survey 2 also asked the open-ended question, “Please share one or two specific suggestions for improving the Biology class textbook,” allowing for comparison to the first survey and guidance for future changes. The responses displayed a similar pattern to those of Survey 1 in that several students responded with positive feedback instead of suggestions for improvement, such as “Honestly, I think it is just right,” and “I don’t really have any

Table 5. Frequencies of Survey 2 selections for Likert-type statements related to chapter differences.

Question	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I would use the Biology textbook more if all the chapters were more like the one(s) I selected	2 6.9%	2 6.9%	20 69.0%	2 6.9%	3 10.3%
There were no differences for me between any of the chapters in the Biology textbook so far	3 10.3%	5 17.2%	12 41.4%	8 27.6%	1 3.5%

suggestions. I find it quite useful!” The responses that did include suggestions were similarly diverse to those in Survey 1, with no clear pattern of disproportionately repeated suggestions. The most common suggestions were related to images, with four comments related to a need for improved image quantity or quality, as seen in comments such as, “The only thing I would suggest is possibly better pictures. Some were hard to work with.” Three comments were related to a desire for improved assistance with vocabulary, such as, “Possibly add a glossary at the back where all [bolded] terms are listed, and an index at the end with important topics and their page numbers for ease of looking up [specifics].” There was one request for links to animation, one request for larger print, one for color diagrams in the print offering, and one specific suggestion for a content addition with, “Include a section with a more thorough explanation of Interphase.”

Open-ended responses concerning student satisfaction with the textbook

The remaining open-ended question was asked in both surveys, regarding what the students appreciated about the textbook. Responses were again diverse and included some dominant themes. Fourteen responses made mention of clarity or ease of use, with responses

such as, “I felt that the book was easy to read, I felt like I was able to take in a lot of information but it wasn't over done” and, “Easy to follow for how much information is really there.” Thirteen comments reflected in some way on the organization of textbook, appreciating its short length and writing style, reflected in comments like, “It is concise, and well written. All aids are great and the style was as fun as a textbook gets,” and “I like that the chapters are short and concise, so we still learn from them and get the meat of the units but aren't sitting forever reading and forgetting.” Seven students highlighted the textbook's student authorship, with comments such as, “I like that other students have contributed” and, “That it carries many voices, not just one author.” Four respondents appreciated the images, sharing, “I love all of the illustrations because I am a visual learner” and, “the illustrations are well thought out, and placed where they are most helpful. Not the words in one area, and the illustrations 3 pages later.” Four responses mentioned that the textbook was closely connected to class content, with comments such as, “Chapters corresponding with lectures.” Four students mentioned the low cost as a strength, as illustrated by the statement, “Thank you for saving me \$MONEY!” One comment mentioned appreciation for links to external sources. The pattern of students reporting appreciation for the textbook's clarity and simplicity is likely related to its readability. Calculated grade-level indices of readability ranged from 11 to 13 with an overall mode and mean level of grade 12, reflecting a readability level expected for high school seniors.

Likert-type responses concerning student satisfaction with the textbook

The generally positive statements shared in the open-ended questions were reinforced by the responses to Likert-type questions. The composite index of student satisfaction with

the textbook based on the six clearly positive or negative Likert-type questions had an average value of 4.35 on a scale in which 1 represents extreme dissatisfaction and 5 represents the highest possible satisfaction. A final indicator of student satisfaction with the textbook is reflected in the Survey 2 responses to the Likert-type question, “I will use the text more now...” in which 24 of 29 student responded with either “agree” or strongly agree.”

These patterns of student satisfaction with the textbook are shown in the frequencies of selections in each individual Likert-type question, displayed in Table 6. For example, the four items “read regularly,” “helps learning,” “like student-written,” and “well written” all resulted in greater than 50% of students responding with “strongly agree” in both surveys. Similarly, the three clearly negative statements asked in both surveys, “prefer typical textbook,” “get bored,” and “too complex” showed greater than 50% of responses as “strongly disagree” in both surveys with one exception. The Survey 2 response to “get bored” showed 41.4% reporting “strongly disagree” and 27.6% reporting “somewhat disagree.” Only two students across both surveys chose “strongly disagree” in response to any of the positively phrased statements, and no student chose “strongly agree” for any of the negative statements. These findings collectively reinforce the general pattern of high student satisfaction with their textbook. The item “cost affected purchase” resulted in the least skewed responses of any question asked, with large portions of students responding across all choices from “strongly disagree” to “strongly agree.” The four Likert-type statements concerning the textbook that were included in only one of the two surveys also showed a pattern of disagreement with negatively-phrased items such as “images confusing” and agreement with positive ones such as “connects to my life” (Table 6). The similarities in

responses between the two surveys and the degree of student agreement with each statement are displayed in Figure 1.

Table 6. Student survey responses to Likert-type statements (total count and percentage) related to textbook use and satisfaction in both surveys.

Survey #	Strongly disagree		Somewhat disagree		Neither agree nor disagree		Somewhat agree		Strongly agree	
	1	2	1	2	1	2	1	2	1	2
read regularly	0 0.0%	1 3.5%	1 5.9%	5 17.2%	2 11.8%	2 6.9%	4 23.5%	6 20.7%	10 58.8%	15 51.7%
prefer typical textbook	11 64.7%	15 51.7%	2 11.8%	8 27.6%	4 23.5%	6 20.7%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
helps learning	0 0.0%	1 3.5%	0 0.0%	0 0.0%	3 17.7%	3 10.3%	4 23.5%	6 20.7%	10 58.8%	19 65.5%
get bored	9 52.9%	12 41.4%	3 17.7%	8 27.6%	5 29.4%	5 17.2%	0 0.0%	4 13.8%	0 0.0%	0 0.0%
cost affected purchase	9 52.9%	9 31.0%	0 0.0%	2 6.9%	5 29.4%	7 24.1%	1 5.9%	1 3.5%	2 11.8%	10 34.5%
like student-written	0 0.0%	0 0.0%	1 5.9%	0 0.0%	2 11.8%	8 27.6%	1 5.9%	3 10.3%	13 76.5%	18 62.1%
too complex	10 58.8%	15 51.7%	4 23.5%	12 41.4%	3 17.7%	2 6.9%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
well written	0 0.0%	0 0.0%	1 5.9%	1 3.5%	1 5.9%	3 10.3%	5 29.4%	9 31.0%	10 58.8%	16 55.2%
no need to read	9 52.9%		3 17.7%		3 17.7%		2 11.8%		0 0.0%	
difficult to understand	14 82.4%		2 11.8%		1 5.9%		0 0.0%		0 0.0%	
connects to my life		1 3.5%		0 0.0%		6 20.7%		10 34.5%		12 41.4%
images confusing		18 62.1%		9 31.0%		1 3.5%		1 3.5%		0 0.0%

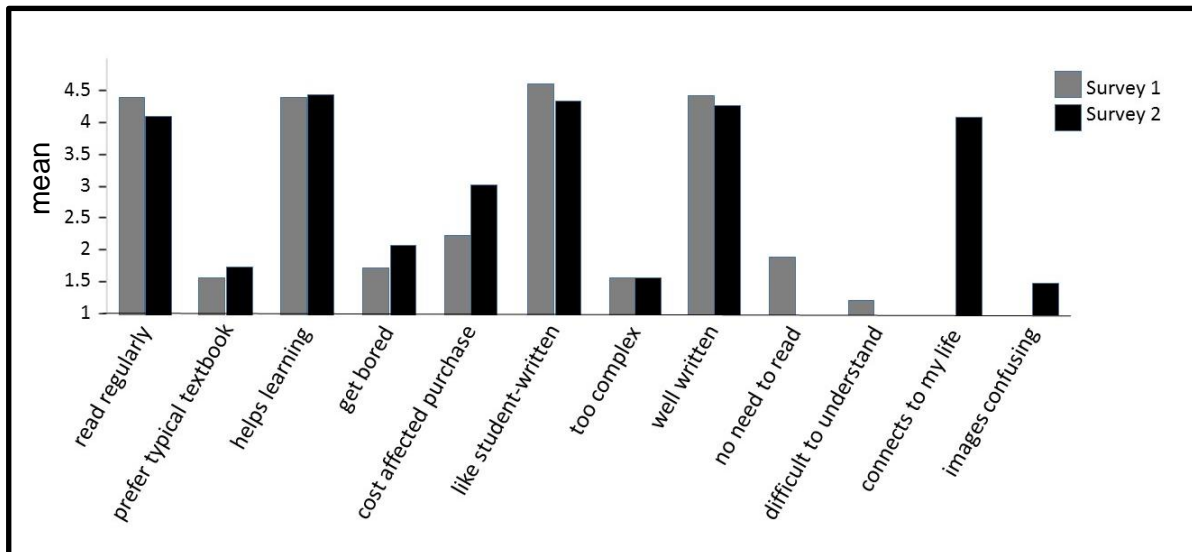


Figure 1. Mean coded values ranging from 1 = “strongly disagree” to 5 = “strongly agree” for responses to Likert-type questions related to textbook use and satisfaction in both surveys.

There were no significant differences in student responses between the two surveys for any of the Likert-type questions. When comparing responses based upon whether or not the student purchased a print version of the textbook, only “read regularly” was significantly different ($p < 0.05$) with students who reported purchasing the print textbook reporting lower agreement with regularly reading their textbook. When comparing responses based on use of the electronic version of the textbook the only significant difference ($p < 0.05$) was students who use the electronic textbook reported stronger disagreement with the statement “no need to read.” In exploring for differences based upon class format, the only difference was that face-to-face students were significantly ($p < 0.01$) more likely to disagree with the item “prefer typical textbook” than were online students, although no student in either class format selected “agree” or “strongly agree.” The Kendall coefficient of concordance revealed no significant differences in the strength of agreement with the six Likert-type items indicating positive or negative satisfaction with the textbook.

CHAPTER 5. DISCUSSION

Interpretation of results

Science coursework is included as an essential component of general education in most colleges to support understanding of natural phenomena, foster the development of inquisitive minds, and maintain an informed citizenry in an increasingly technological culture. In spite of this commonly required coursework, scientific literacy is often inadequate among college graduates (Gonzalez-Espada, 2009; Impey et al., 2011). Furthermore, just as professors often find underdeveloped scientific literacy in their students, students frequently express frustration with science courses that are poorly taught, based upon memorization and passivity, or lacking applicability to their lives (Zhao, Witzig, Weaver, Adams, & Schmidt, 2012). Increasing student satisfaction with college science education is an important part of enhancing scientific literacy.

Textbooks are one of the most common resources required by professors (Burton, 2014) and accessed by their students (French et al., 2015) in general education science courses. Although regular reading of textbooks can improve learning in science courses, they are frequently underused due to student disinterest, challenging concepts and vocabulary, and high costs (Skinner & Howes, 2013; Swanson, 2014). Many colleges and professors are attempting to address these challenges through increasing use of open textbooks, e-textbooks, wikis, and other textbook alternatives. Less common, but increasingly recognized is the use of student-written textbooks. A student-written textbook helps to provide relatively affordable, up-to-date, and accessible resources to complement classroom instruction in place of a traditional publisher textbook.

The purpose of this research was to explore student satisfaction with a student-written textbook in a college-level biology class. The main objectives were to inform the instructor of the student experience with the textbook and highlight specific changes to improve the textbook. Two separate, similar surveys illustrated the students' experiences with their student-written textbooks in multiple sections of the same course. The findings include two key themes: student reactions to the implementation of recommended changes to the student-written textbook and student satisfaction with the textbook.

The most surprising finding in this study was that in spite of the stated preference for specific textbook features (consistent with published research) such as a glossary, chapter summary, and practice questions, students demonstrated no preference for the chapter in which these features were added. The updated Chapter 6 was similar in content (biological molecules), language, and length to its preceding chapter, which was selected at a higher frequency than Chapter 6 as a student preference. The additions were written with some student input, in language of similar readability, and with similar organization. The additions did not add excessively to the length of the chapter, with the result still shorter than some other chapters in the unit. The open-ended question, "What did you like about the chapter(s) you selected as the best one(s)?" provides insight into why students did not preferentially choose the augmented and supposedly superior Chapter 6. Comments such as, "I liked the image-text connection in that chapter the most" support the value of textbook features that were not included in the Chapter 6 improvements. Such preferences highlight a diversity of student experiences and values in interacting with their textbooks. The three dominant themes from these responses were related to readability, interesting content, and helpfulness with learning. The value to students from connecting textbook content to class learning goals

is consistent with the general agreement with the Likert-type question asking if students would be more likely to read their textbook after completing their first unit exam.

The patterns in student explanations for their chapter preferences support a speculative explanation for the diverse selection of preferred chapters. Student satisfaction with a particular chapter might be more strongly influenced by personal preferences for specific content, perceived benefit to achievement, or comfort level reading. These preferences might override other structural and pedagogical features of a chapter such as those added to Chapter 6. Student-reported interest in a glossary, chapter summaries, and practice questions are likely genuine but secondary to other textbook features experienced in diverse ways by different students. This diversity was present in Survey 1, wherein the improvements to Chapter 6 were inspired by the most frequent, but by no means exclusive, suggestions for textbook improvements.

The diverse selections of chapter preferences is consistent with the lack of agreement or disagreement with the Likert-type statements, “There were no differences for me between any of the chapters in the Biology textbook so far,” and “I would use the Biology textbook more if all the chapters were more like the one(s) I selected above as the best one(s).” The most frequently reported response to both statements was “neither agree nor disagree.” Furthermore, there was no evidence for any difference in the degree of agreement between any of the Likert-type indicators of student satisfaction. These results support the possibility that student satisfaction with the textbook is based more upon their experience with the whole textbook and less upon characteristics of specific chapters. Although there were reported chapter preferences based upon differences in content, readability, and connection to students’ lives, the overall satisfaction appears to be unrelated to specific chapters or to the

changes implemented in this research. This does not mean that responding to student feedback and suggestions was not valuable, but that it may generate undetectable improvements in student satisfaction when the textbook as a whole is generally satisfying. The possibility for increasing student satisfaction may depend on implementing whole-textbook changes.

Several outcomes of this research suggest high student satisfaction with the student-written textbook. The open-ended questions demonstrated several specific features that the students appreciated in their textbook. These responses helped address one of the secondary research questions, “In what ways do published research and student feedback share implications for improving student-written textbooks, and in what ways do they differ?” There were more consistencies than differences in recommendations for quality textbooks between student responses in this project and published literature. Many of the specific features that students appreciated about their textbook and suggested for the future are echoed in published research. For example, statements such as, “I felt that the book was easy to read, I felt like I was able to take in a lot of information but it wasn't over done” and appreciation for the “simple, clear, easy to understand writing” can readily be interpreted as valuing readability. Readability is a commonly cited strength of a quality textbook (Crow, 2004; Durwin & Sherman, 2008; Griggs & Marek, 2001). The calculated textbook readability of grade level 12 suggests room for inclusion of more challenging language in future editions, but may also be fitting and welcoming to the students of diverse educational backgrounds common in a two-year college.

Other similar indicators of a quality textbook between the literature and survey responses include references to the value of brevity (Kortz et al., 2017), connections to daily

lives (Gonzalez-Espada, 2009), integration with course content (Baker-Eveleth et al., 2011), quality images (Gurung & Martin, 2011), and affordability (Senack & Donoghue, 2016). Students showed a higher rate of preference for vocabulary assistance, chapter summaries, and practice questions. These are all characteristics of textbooks cited as beneficial in published research (for example, Bliss, 2013) consistent with the findings that students tend to be accurate judges of what they will benefit from in a textbook (Durwin & Sherman, 2008).

The quantitative data reinforced the conclusion that students experienced high satisfaction with their student-written textbook. All Likert-type questions with a clearly negative or positive statement showed a consistent tendency toward agreement with positive statements and disagreement with negative statements. In most cases, students agreed with statements stating that the textbook was well written, connected to their lives, helped their learning, was valuable for being written in part by former students, and that they read it regularly. Most respondents disagreed with statements that the textbook was boring, difficult or unnecessary to read, overly complex, had confusing images, or left them preferring a traditional publisher textbook. This pattern of positive responses was consistent with the largely positive results revealed by synthesizing multiple items into one indicator of satisfaction. Open-ended questions further support students' generally positive self-reported experiences with the textbook, with several affirmative statements reported even in response to a question requesting suggestions for improvement. The open-ended question exploring what students appreciated about the textbook highlighted a clear pattern of valuing features such as the affordability, readability, images, brevity, and connection to class learning objectives. These responses highlight an encouraging degree of value from diverse strengths

of the textbook. While less common, the most frequently shared reflections of a negative nature were in response to the quality of writing and images along with some specific suggestions for improvements or additions.

The two surveys provided insight into student interactions with their textbooks unrelated to the core objectives of exploring chapter preferences and student satisfaction. There were few significant differences in Likert-type responses based upon the variables related to the use of the digital versus printed textbook or enrollment in the online versus face-to-face sections of the biology class. The question about use of the digital book was included in addition to asking about the purchase of the print book because some students, as expected, reported using both. Students who reported purchasing the print book reported being less likely to regularly read, whereas digital textbook users were more likely to disagree that there is no need to read the textbook. Students in the face-to-face class were less likely to prefer a traditional textbook than online students. Given the small sample size and low number of significantly different responses, these results should be interpreted cautiously, but the differences collectively suggest that students enrolled in an online section are more likely to depend on their textbooks relative to students in a face-to-face class.

Benefits of a student-written textbook

There was no evidence found in this study that the use of a student-written textbook was detrimental to students. When considering possible benefits to students, this research did not examine learning outcomes or achievement, but rather focused on student satisfaction. Although student satisfaction can be a valid indicator of resource quality and is related to learning success (Bliss, 2013; Durwin & Sherman, 2008), it should not be interpreted as a

surrogate for academic achievement. There are two distinct realms of potential benefits for students from using a student-written textbook: the use of the textbook as a resource and the process of contributing to it. This latter component is not explored in this project, but the ownership, engagement, motivation, metacognitive awareness, and achievement when students are actively involved in the development of course resources are valuable assets from developing a student-written textbook (Bovill & Cook-Sather, 2011; Zhao et al., 2014). Furthermore, the opportunity to incorporate student choice, collaboration, and creativity can enhance motivation and engagement (Killingbeck, 2006; Siefert, 2010). Other strengths from student-written textbooks that were not readily apparent in survey responses include constructivist learning (Straits & Wilke, 2007), critical thinking (Ravid et al., 2008), student empowerment (Nahornick, 2014), and contribution to writing skills (Galbraith, 1999). Some outcomes from using student-written textbooks contribute particularly to science education. Encouraging students to ask questions, propose explanations, and evaluate evidence for conclusions supports inquiry-based learning and the pursuit of scientific literacy (Wilcox, Kruse, & Clough, 2015).

Some of the research-supported benefits from using student-written textbooks were also shared in the survey responses. Numerous survey responses indicated an appreciation for the readability and the connection to students' lives, which are unsurprising consequences of incorporating student voices into the writing of a textbook (Knecht & Najvarová, 2010). In addition to general appreciation that the textbook was student-written, the open-ended response, "That it carries many voices, not just one author" highlights the value of a textbook with diverse perspectives. Professor editing can help support a cohesive structure and flow that still honors the distinct voices of the student authors. The incorporation of student

experiences with class content can enhance the connection of the textbook to the class learning goals, another feature to improve satisfaction shared in student responses as valuable.

The most obvious benefit from use of a student-written textbook is reduced costs. The textbook used in this research cost roughly \$20 in print and is free online to all students. Students in past semesters have printed and bound the book in color at the campus copy center for about \$50. The question, “The cost of the book affected my decision to purchase it” was likely too ambiguous to help discern the importance of the textbook price to students. The responses to this question were the least tilted toward agreement or disagreement of the 12 questions related to textbook satisfaction. The intention was to avoid using a statement such as, “I appreciate that the text is inexpensive” to which the answer would likely be so predictable as to be meaningless. The phrasing chosen, however, could be interpreted in enough different ways as to make the results uninformative. Because textbook prices are a significant challenge for college students, particularly at two-year institutions, it is worth considering that the appreciation for low cost skewed student responses toward the positive. While this may be a factor, results indicated many other specific values cited by students such as readability, length, class integration, and content interest. Furthermore, in spite of the clear benefit to students from low cost textbooks, students expect and value quality textbooks for reasons other than cost (Gerhart et al., 2015).

Student-written textbooks are only one possible method to reduce textbook costs. Open textbooks, etextbooks, and wikis all provide textbook alternatives at reduced cost relative to printed publisher textbooks. Each alternative presents unique and overlapping opportunities. If implemented carefully, student-written textbooks have the potential to

incorporate many of these strengths. Like open textbooks and etextbooks, they can be offered online, updated regularly, and linked to online resources. Like wikis, they can be used to support student choice, collaboration, and student engagement with course materials. A student-written textbook can readily be offered both online and in print; students generally prefer printed textbooks (Woody, Daniel, & Baker, 2010) and appreciate being able to choose a printed or digital textbook instead of being forced to use one or the other (Bliss, 2013). Student-written textbooks have advantages over other textbook alternatives by not necessarily requiring as many technological resources or skills and by supporting a strong sense of ownership over individual contributions.

Concerns and project limitations

There are important concerns associated with the use of a student-written textbook. The process of incorporating student contributions and editing the product is more time-consuming than simply ordering a textbook. The process can be professionally challenging and is not certain to produce a reliable, accurate textbook (Allin, 2014; Seifert, 2010). Professor guidance and monitoring are essential to maintain acceptable accuracy (Simon, 2001). The grade 12 level readability of the textbook in this project suggests that the writing may limit opportunities to appropriately challenge students. While these concerns are critical, there was no clear decline in performance, engagement, or achievement in the biology class following the implementation of the student-written textbook, but this is not supported by any data. Concerns about assignment challenge and selfishness in contributions (Bonk, Lee, Kim, & Lin, 2008; Ravid et al., 2008) can be addressed to some degree with careful standardization of expectations. A student-written textbook could potentially limit professor

expertise; professors often use textbooks that exceed student learning goals to guide course content (Kortz, Grenga, & Smay, 2017) and inform a deeper understanding of concepts that is important for effective instruction (Weinberg, & Wiesner, 2011). Textbooks are resources for professors as well as students, and in the absence of a comprehensive publisher textbook professors must commit to regular external reading in their course's field of study. The issue with writing quality may not be as problematic as assumed; practice with writing is an essential student exercise and the information shared with others is valuable even when it has errors (Duke, Purcell-Gates, Hall, & Tower, 2006; Siefert, 2010).

There are also important limitations in this research. The low sample size suggests that results should be interpreted conservatively; genuine differences between, for example, the two surveys or the experiences of online and face-to-face students may be undetected. A low response rate not only contributes to the low sample size, but also presents the possibility of biased results. The response rate in Survey 1 was likely lower because students were not attending class during the summer. The moderate response rate in Survey 2 supports greater confidence in the results, but was still not ideal. The main concern with a low response rate is a non-response bias, in which the responses differ between responders and non-responders. Non-response bias is possible, but not certain, with low response rates. Despite legitimate concern for validity due to low response rates, the implications are difficult to discern and may not be as problematic as assumed. Simulations of low response rates and respondent counts show evidence of being reliable estimates for high response rates and respondent counts in college student surveys (Fosnacht, Sarraf, Howe, & Peck, 2017).

Findings should also be tempered by the fact that the research was conducted by the professor in four sections of one college biology course. Possible threats to the validity of the

results, therefore, include the limited scope from using one course at one institution and the influence of the professor-student relationship on student responses. The lack of student preference for the supplemented Chapter 6 was a surprising finding. It is possible that the survey question “Which are the highest quality chapters in the textbook from unit 1? In other words, which chapters did you most appreciate or benefit from reading?” was too vague to adequately capture student appreciation for the specific additions of a summary, glossary, and practice questions. A more direct question referencing these changes might have better elicited responses reflecting their value to students. The similar levels of agreement in Likert-type responses related to satisfaction with the textbook could indicate that several distinct items were similarly satisfying for students or it could indicate a pattern of students consistently selecting positive responses regardless of the specific question. To some degree, this risk is minimized by the phrasing of several questions in a negative manner (for example, “I often get bored reading my textbook”). This risk should not be understood to question the conclusion that students experienced high satisfaction with their student-written textbook, but does encourage restraint in drawing conclusions from individual items.

Conclusions

This project was motivated by a desire to explore and improve student satisfaction with a student-written textbook in one college-level, general education biology course. To that end, the project has been successful and informative. There are three predominant answers to the research question: “How can a textbook created largely through student contributions best be written and structured in an introductory science course to enhance student satisfaction?” The answers to this question are: 1) Continue using the student-written

textbook. In the words of one student, “keep doing what [you’re] doing.” 2) Include a glossary, more high-quality images, and short supplements such as chapter summaries and local connections to everyday life, all using student contributions. 3) Continue exploring how to improve the text by concurrently exploring published research and student feedback. These answers underscore a compelling “yes” in response to the secondary question “Is it in the students’ best interest to be using these student-written textbooks?” Collectively, the high reported rates of purchasing and reading the textbook alongside the positive student survey reflections suggest that, in the context of this study, the student-written textbook helped to address the underlying problem of underuse of textbooks.

The high levels of student-reported agreement with positive statements and disagreement with negative statements in this study suggest high satisfaction with the student-written textbook, but also prevent meaningful interpretation of any differences in satisfaction between individual textbook features. The objective of contributing to educational research is equally unclear, because the examination of student chapter preferences produced no convincing results. The findings of satisfaction with student-written textbooks and the reasons for this student approval are valuable additions to our understanding of how students interact with educational resources. The most persuasive findings are the responses to the open-ended questions concerning what students appreciate about their textbooks. There is clear value placed on readability, clarity, connections to students’ lives, and integration of the textbook into the course learning goals.

The review of literature, its agreement with survey responses, and the minimal apparent negative reactions to the student-written textbook inspire a clear course of action for the future. Beyond the core changes needed, such as adding a glossary, the student-written

textbook could be improved with additions such as updated links to activities and videos, short models of scientific writing, and connections to history and local culture. These changes can be implemented without dramatically affecting the length and readability of the textbook. Professor trust in the students' contributions can create space for more storytelling, diversity of perspectives, and meaningful questions. The textbook would benefit from intentional connection to diverse cultural voices such as those in Montana's Native American communities. The textbook can be better connected to the class by discussing its purpose, creation, and maintenance more openly and by providing ample time and guidance for new student-created contributions. The digital version of the textbook should be updated to be fully accessible for students with disabilities. New student feedback and opportunities for future research will refine these goals over time. Meaningful results might be more likely if changes are explored at a whole-textbook level and textbook experiences are connected to measures of achievement. The student-written textbook was initiated with the hopes of offering a quality, affordable, satisfying textbook for Missoula College biology students. The textbook and its creation have been guided by the goals of engaging students in their own learning and connecting them to science as a process of exploration. As with scientific investigation, the development of the student-written textbook is an ongoing journey.

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APPENDICES

Chapter 6: Life Molecules - Proteins and Nucleic Acids

Introduction

This chapter continues the examination of the four major categories of life molecules, focusing on proteins and nucleic acids.

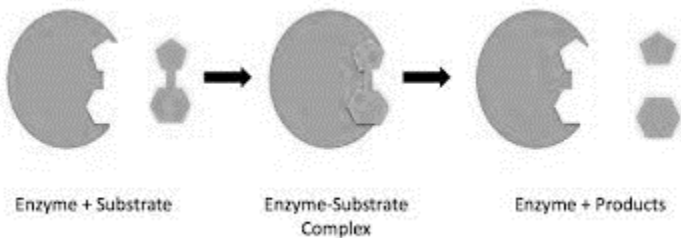
Proteins

Proteins are made up of chains of amino acids monomers and play many critical roles in the body. Amino acids are composed of carbon, hydrogen, oxygen, and nitrogen atoms, and occasionally other atoms such as sulfur, depending on the particular amino acid. Proteins are complex molecules created by dehydration reactions between amino acids. A protein molecule is held together by connections called peptide bonds that link together amino acids to make polypeptide chains. These chains can fold on themselves kind of like multifold paper towels. There are thousands of different types of proteins that are made by having different sequences of amino acids. The human body alone has over 100,000 different types of proteins. Proteins carry out many essential processes in living cells. Enzymes build and break down molecules. Motor proteins help cells continue movement. Defense proteins help fight disease and infection. Storage proteins hold energy molecules in reserve for later. Structural proteins build up cells like tissues and organs. There are many more proteins that carry out equally important duties.



Enzymes

Enzymes are proteins produced by cells that catalyze (speed up) chemical reactions during the metabolic processes of an organism. Enzymes often react with only a single substrate, the substance acted upon by the enzyme. The substrate binds to the enzyme at a location called the active site just before the reaction takes place. Enzymes can speed up chemical reactions by up to a million fold!



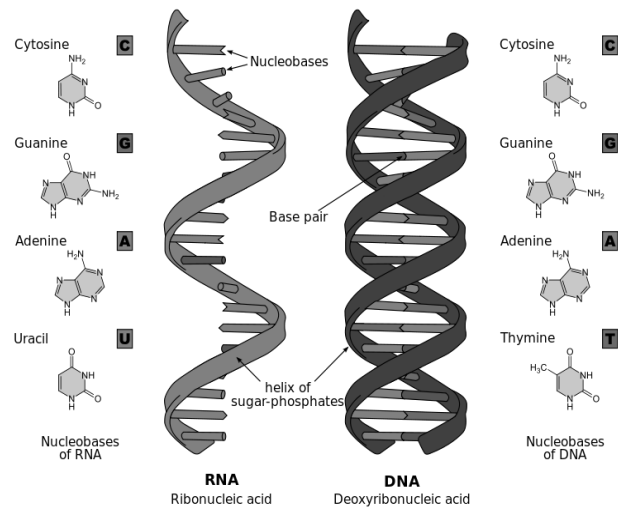
Enzymes function within narrow temperature and pH ranges, outside of which they can lose their structure and fail to function properly. Enzymes are involved in such processes as the breaking down of the large protein, starch, and fat molecules in food into smaller molecules during digestion, the joining

together of nucleotides into strands of DNA, and the addition of a phosphate group to ADP to form ATP (usable energy for life - explained in future chapters), and much more.

Nucleic Acids

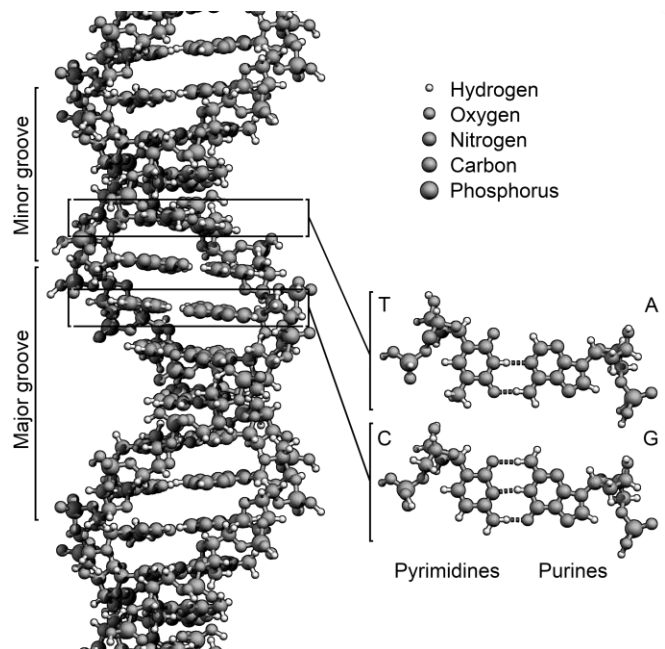
Like proteins, nucleic acids are polymers of long chains of monomers. Also like proteins, nucleic acids are made of carbon, hydrogen, oxygen, and nitrogen atoms. Nucleic acids also include phosphorous atoms, essential to the bonding of monomers into long chains.

Nucleic acids make up our DNA (DeoxyriboNucleicAcid), and RNA (RiboNucleicAcid). Some nucleic acids, like a DNA molecule in our cells, are made of thousands upon thousands of atoms in huge molecules. The monomers of nucleic acids are **nucleotides**, which consist of 3 main parts, a phosphate group, a nitrogen-containing base and a sugar group. The information of our heredity is stored in the nucleotide sequence of our DNA, found naturally as a double helix shape. RNA, among other tasks, helps to carry the instructions stored in the DNA for the building of proteins. Unlike DNA, RNA is only a single strand of nucleic acids. DNA and RNA structure and function are examined in more detail in future chapters.



Biologists at Work

Biologists explore DNA to try and dig deeper into the secrets of life. In some ongoing studies Professor James M. Berger of the California Institute for Quantitative Biology and UC Berkeley is trying to find out just how the flow of genetic information is controlled and how it might be manipulated in the future. He also shares with us some of the ongoing project areas such as DNA replication and Nucleic acid-dependent motors.



<http://berger.berkeley.edu/Research.html>. To wrap up the chapter, here's another look at the structure of DNA →

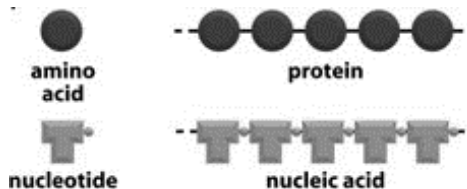
Chapter Summary

All living things are made up of organic molecules. The primary molecular building blocks of life are categorized into in four distinct groups discussed in this

chapter and the previous chapter. This chapter highlights the proteins and nucleic acids. Unlike the carbohydrates and lipids, the proteins and nucleic acids always include nitrogen in their monomer building blocks.

Proteins are large molecules constructed from chains of amino acid monomers. Among the many types of proteins in life, the enzymes are the most diverse. Enzymes regulate the activity of chemical reactions in living things.

Nucleic acids are the molecules of our genes, including the hereditary information stored in the form of DNA. The monomer building blocks of a nucleic acid are different types of nucleotides, whose sequence encodes life's genetic information.



Core terms mini-glossary

amino acid - a monomer building block in a protein, found in 20 varieties in life

catalyst - a substance that accelerates a chemical reaction

DNA - deoxyribonucleic acid, the double-stranded molecule storing hereditary information in a sequence of nucleotides

enzyme - a protein catalyst

monomer - a molecular subunit or building block used to make larger molecules

nitrogenous base - the portion of a nucleotide that distinguishes the nucleotide

nucleic acid - molecules of genetic information, such as DNA, made of nucleotides

nucleotide - a monomer building block of a nucleic acid; four varieties are found in DNA: adenine, guanine, cytosine, and thymine (uracil in RNA)

peptide bond - the covalent bond that forms between amino acids to form proteins

phosphate - one of three portions of a nucleotide, with phosphorous and oxygen

polymer - a bonded sequence of monomer building blocks in a larger molecule

protein - a diverse group of organic life molecules made of linked amino acids

RNA - ribonucleic acid, typically single-stranded molecules made of nucleotides that assist the expression of genes

substrate - the molecule being acted upon by an enzyme

Practice Questions (answers below)

- 1) Amylase is a molecule produced in our saliva that helps break down starch into sugars. What kind of life molecule is amylase?
- 2) What is the shape of a DNA molecule?
- 3) What are the five elements used to build a molecule of DNA?
- 4) Which kind of life molecule is most often found as a globular polymer with many folds, bends, and diverse shapes?

Explore online

Videos: <http://www.bozemanscience.com/molecules-of-life/>

<https://www.youtube.com/watch?v=QWf2jcznLsY>

Answers:

- 1) Protein (specifically, an enzyme)
- 2) Double helix
- 3) Carbon, hydrogen, oxygen, nitrogen & phosphorous
- 4) Proteins

APPENDIX B: OPEN ENDED SURVEY RESPONSES

Survey 1: Please share one or two specific suggestions for improving the biology class textbook

At this time I don't remember of any suggestions for improvement I might have had.
Some chapters were too short, very few were too long, otherwise it was a great book
I didnt find anything that wouod have a positive impact if changed.
None noted.
Highlight the most important facts
Maybe including some practice worksheets at the end of each chapters along with a summary for additional practice.
There were minor typos but I wouldn't be able to find them unless I read the book all the way through again. I very much enjoyed the text book!
Trying to connect something to every day life although I know it is not always possible with some of biology.
A glossary would be extremely handy!
More handling MT and it's biology and there really wasn't much else. It's all very good.
I would just say grammer. Also, I noticed that if you missed the lecture yhen the information was a lot harder to understand.
More class interaction that requires reading the book

Survey 1: What features of the Biology textbook did you most appreciate?

I appreciated the links to sources and other sites for a more clear understanding
I felt that the book was easy to read, I felt like I was able to take in a lot of information but it wasn't over done
It is concise, and well written. All aids are great and the style was as fun as a textbook gets.
Easy to follow.
Diagrams
Chapters corresponding with lectures
The simple, clear, easy to understand writing. Typical textbooks have way too much information to absorb at a time and it makes it very hard to grasp the overall point (in my opinion, and I strongly believe that I can speak for most students as well). This text book however simply explains the point very clearly and follows with additional information after the reader is able to understand what it all means.
That it was affordable! And easy to read and understand.
How well they worked with lectures
The comparisons it had.
I really liked how the chapters were organized. It helped me organize my self in the class
That it followed along with the lecture perfectly and didn't give too much unnecessary information.
The short but informative chapters
It waz easy ti understand and short and to the point. It waz not intimidating like most other textbooks.
That part of it came from past students of the class.

Survey 2. What did you like about the chapter(s) you selected as the best one(s)?

there were vary strait froward
descriptive and concise
Concepts were easy to understand
they gave a better undersatandin
I liked chapter 6 because of the vocab list and questions. 8 was well laid out and I liked the image-text connection in that chapter the most.
It lays out the basics. By cobering what we need to know amd what were learning.
They were short but also very detailed
good clarification from information learned in lab
I felt that they provided information that best helped me understand the unit as a whole.
The chapters I chose were ones that I didn't know alot about but the chapters really helped me to understand the material. I also like that the key words are in Bold with the definition or explanation for them.
Effective pictures
Simple explanations of complex ideas, these were new topics for me and I learned a lot.
The chapters I selected were the easiest, for me, to progress through.
Chapter one gave me a rundown of biology and kind of an intro to what I'd be learning about.
I feel like they were just very comprehensive
I liked the content in them it had nothing to do with how they were written
very interesting
They described everything simply enough for students to understand, but also taught us new vocabulary and applications.
Descriptions, definitions were well explained.
Covered material I was unfamiliar with.
I learned a lot and it helped clarify subjects I didn't understand
I would say most interesting.
The information in them stuck with me the most.
The pictures

Survey 2. What do you like about the Biology textbook in general?

that students contributed to it.
Utilitarian and not overly difficult to comprehend
It uses phrases that are more applicable to my life and more understanding than some company who produces just the definition of what I'm studying
the short chapters
Easy to follow for how much information is really there.
My proffessor wrote it
Its easy reading and it covwrs what were learning. No eccessive reading involved
It isnt heavy and thick
only important information mot alot of words to fill in space
It provides information in a concise form that is well-explained and easy to understand.
The price of the textbook is really generous all because of Greg. Thank you for saving me \$MONEY! The textbook is well written and is really informative.
Soooo cheap, and has exactly what you need in a simple and easy to follow format and language.
I love all of the illustrations because I am a visual learner. Very seldom do I come across confusing wording, everything is pretty well explained.
It is the only textbook I've had that doesn't blow my mind with over the top hard words. Sticks to what you need to know.
It contains a lot of very well written information that even I can understand.
its accessible and easily understood
I enjoy knowing that students had a part in it and that it was free or at least not additional to the class price
easy to read
I like that the chapters are short and concise, so we still learn from them and get the meat of the units but aren't sitting forever reading and forgetting.
the illustrations are well thought out, and placed where they are most helpful. Not the words in one area, and the illustrations 3 pages later.
That the chapters are short and to the point.
I like that other students have contributed
That it carries many voices, not just one author.
I appreciate that our textbook is informative, concise and free!
Very condensed information, not typical textbook reading. Easy to find important info.
Its easy to use

Survey 2. Please share one or two specific suggestions for improving the biology textbook

make the print a little bit bigger.
More student input can never hurt
I think vocabulary sections in term heavy chapters and quick reflection questions would help the most.
Theres nothing wrong with the book
Nothing yet. I like what you have persinally made / created for us. Biology can sometimes be a little fritening class but you have made it more enjoyable
More diagrams
keep doing what you doing
Possibly add a glossary at the back where all boldes terms are listed, and an index at the end with important topics and their page numbers for ease of looking up specefics.
The first unit was pretty straight forward so I don't know how you could make them anymore helpful than they already are.
More illustrations where it is possible, other than that I really like this book and I have never been a fan of science because it was challenging for me. I also LOVE how our online textbook shows up two pages at a time when it is maximized, that would have to be my favorite thing.
Honestly, I think it is just right.
Keeping it accessible online is stellar for people who do not have the money to purchase a hard copy.
a couple of the definitions and explanations feel repetitive and redundant
Go into a little more detail and make the units a little longer so we can have deeper understanding of the concepts
make it in color
I don't really have any suggestions. I find it quite useful!
I may be slightly wrong, but I noticed some terms were not present in the text, but were brought up in the Quizzes. Especially in the cellular respiration unit.
Include a section with a more thorough explanation of Interphase in Chapter 15.
More pictures
The only thing I would suggest is possibly better pictures. Some were hard to work with.
More links to animations for complicated subjects.
Tabs