Beyond the printed page: physiology education without a textbook?
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Beyond the printed page: physiology education without a textbook?

Stavrianeas S, Stewart M, Harmer P. Beyond the printed page: physiology education without a textbook? Adv Physiol Educ 32: 76–80, 2008; doi:10.1152/advan.00031.2007.—Pedagogical innovations, ideas, and outcomes designed to enhance student learning in physiology courses are encouraged by our professional organizations and are actively discussed at conferences and in *Advance in Physiological Education*. Here, we report our experiment with freely available internet-based material as a substitute for the textbook for a single chapter on muscle physiology in a sophomore-level Human Physiology course. Student reactions to the textbookless curriculum were registered with the use of a questionnaire. Their responses indicated that they enjoyed the online material (animations, images, reviews, etc.), the emphasis on important concepts, and the variety of resources. Furthermore, students were almost unanimous in their praise for such pedagogical approaches to science education. Yet, students were reluctant to part with their textbooks. We believe that with subsequent iterations of this course we will be more successful at further separating the learning experience from the textbook. Reliance on freely available material may eventually relieve students from the burden of purchasing a costly textbook.

Physiology education; web-based teaching; textbook-less curriculum

In a recent article, Joel Michael (16) discussed reasons why students find physiology difficult to learn. Michael emphasized the potential disconnect between how we teach course content and how students learn the material. His conclusions echoed the recommendations of the influential BIO 2010 report (8), and he placed the onus upon educators to improve physiology education. On the other hand, Silverthorn et al. (18) clearly illustrated that, for a variety of reasons, faculty members are often reluctant to change their approaches to the teaching of physiology, at least with regard to the specific modules used in their study. During his acceptance speech as the Arthur C. Guyton Teacher of the Year, John West (23) concluded that “there is probably no best way of teaching physiology to medical students in the year 2002.” As educators, we should all take notice of Arthur Guyton’s approach to physiology teaching (9):

What actually happened was that the students, instead of looking at me as the teacher, sat in their desks with heads bowed and hands moving as rapidly as they could taking notes, trying to get all the ‘facts’ of physiology written in longhand or shorthand or in cryptic phrases. This was their method of learning.

Guyton revolutionized the way physiology was taught mainly by observing his students and addressing their needs. In other words, he found a way to connect with them, educate them, and make them appreciate the beauty of physiology as a discipline. Accordingly, we feel that it is our obligation to find ways to connect with our own students using what means we have available to us.

Current science education standards have established both the need for better-prepared scientists (e.g., Refs. 1 and 8) and, perhaps more importantly, for improved science education for all students [see also comments by Koppal and Caldwell (13)]. The American Physiological Society Frontiers in Physiology initiative is designed to contribute to the transformation of science education at the K–12 level called for by Project 2061 (2). One of the main goals of the program is to “increase teachers’ skills in developing, assessing, and utilizing web-based curricular materials and resources, especially in integrating online resources into inquiry-based teaching.” Clearly, the importance of the internet in this effort cannot be overemphasized, and considerable literature exists to support the central role of internet-based information for student learning. In a recent editorial in the *Chronicle of Higher Education*, Alan Lesher (15) reiterated our responsibilities as scientists, and he challenged us to “find ways to move science forward while adapting to [the public’s] legitimate concerns.” Such efforts are not new. In a recent National Academy of Sciences workshop titled “Reconsidering the textbook,” participants spoke of the transformation of our role as educators from information holders to information brokers and interpreters (17). The abundance of online information will continue to transform the role of the textbook and its significance in the educational process. The ongoing debate about the ever-rising costs of textbooks (4) and the proliferation of course add-ons that increase the price (3) have been extensively discussed (e.g., Ref. 10). In response, some have done away with textbooks altogether (22), whereas others have examined the potential for online textbooks with mixed results (6). Significantly, such discussions about textbooks come at a time when others question the need for a textbook in science courses (7). Alternative methods of content delivery make extensive use of the internet, taking advantage of the availability of information, often in real time, and of the habits of a generation of students fully accustomed to the use of this technology for a multitude of activities (19). In the essential *Handbook of College Science Teaching*, Brooks and Crippen (5) provide examples of how web-based activities can enhance student learning through practice and feedback. The use of powerful assessment techniques allows instructors to not only monitor student progress but also to complement classroom instruction and create a comprehensive learning environment for their students (5). In the same volume, Weintraub (21) discusses the benefits and perils of web-based information and presents a working strategy to enhance students’ critical thinking skills through the internet.

Clearly, educators have engaged with this issue for a long time and at a national level. In our case, as physiology educators, it is incumbent upon us to find ways to connect with our students both in terms of breadth and depth of material and with regard to their ability to be critical...
consumers of scientific information as well as careful researchers.

The internet has unquestionably transformed the way by which information is exchanged, analyzed, and incorporated into our existing knowledge base. Naturally, the ubiquitous nature of internet-based communication has been explored as a means to augment the educational experience of students in science, technology, engineering, and mathematics. There exists an abundance of internet resources to enhance students’ understanding of material. The teaching and learning of physiology received attention when the Harvey Project was established in 1998. This collaborative effort was funded by the National Science Foundation for the purpose of creating a virtual library of digital resources relevant to physiology education (12). Since then, numerous websites have been generated, and there exists an abundance of digital resources relevant to the teaching of physiology. And although such efforts are certainly forward thinking, most are complementary to the “traditional” textbook-based teaching, and they reflect the uncertainties of a new pedagogical practice, with preliminary results that are far from conclusive.

In the spirit of Guyton, and mindful of our charge as educators, we sought to transform the teaching of physiology at our institution through use of the internet as a means for delivering course content. In part, our decision was motivated by an earlier approach in which it was revealed that the use of internet technology as a supplement to course materials enhanced the understanding of course content in first-year medical students (9). In the present study, we examined whether students would be receptive to an alternative to traditional textbook-based models for learning, an approach already implemented by several others (e.g., Refs. 19 and 20). Specifically, we were interested in quantifying students’ impressions and opinions on learning without the use of their textbook for a single chapter on muscle physiology.

EXPERIMENTAL PROCEDURES

All the students (n = 18) in a sophomore-level Human Physiology course volunteered to participate in the project at the beginning of the semester and signed the appropriate informed consent forms. For the first 6 wk of the course, students were free to use their textbooks to study material for every chapter covered. The textbook used is a mainstream text, in its latest edition, and the students have access to supplementary online resources available from the publisher. The same textbook (always in its most current edition) has been used for 8 consecutive years because student evaluations reveal a high degree of satisfaction with it. During that initial 6-wk period, students also had access to the instructor’s PowerPoint slide presentations via the course webpage. Most students also took advantage of the availability of these slides in Adobe Acrobat format for the purpose of taking notes. By making this material available, we have, over the years, successfully transformed this course from an instructor-centered class to a student-centered learning environment, where the emphasis is on understanding rather than on memorization. While lecture and instructor-led discussions are the main educational tools used, discussion and collaboration among peers are common and encouraged, both inside and outside the classroom. This approach also allows us to focus the students’ attention to the selective material covered in class and avoid cumbersome details that may detract from the educational objectives mentioned earlier. We followed the same pedagogical philosophy for this semester.

On the seventh week, students were asked to refrain from using their textbooks for the study of the chapter on muscle physiology, relying solely upon the material available over the internet and their notes. They all agreed to do so, and adherence to this stipulation was based on an honor system. Similar to all other chapters, the material was organized in PowerPoint slides with particular emphasis placed on mechanisms rather than on details. The slides contained links to various websites covering the material under study, often making reference to primary literature. In addition, they contained a variety of digital animations, images, and interactive tools freely available on the internet. As with all other chapters, students were asked to focus on and understand the material covered in class and avoid overly technical details of mechanisms. All other class activities (laboratory reports, written assignments on specific topics, student research projects, etc.) were identical to previous classes.

As soon as the chapter was finished, and before the section exam, students were asked to complete a survey designed to assess their opinion of this approach to a textbookless curriculum (see Table 1). Students indicated their responses anonymously on a 4-point Likert scale and were also encouraged to provide qualitative responses to each question.

At the end of the survey, students were asked to respond to four open-ended questions designed to provide insights for future iterations of this activity (Table 2). Finally, student performance was evaluated by comparing their exam scores with results from previous years. We did not assess whether students were clear regarding specific learning objectives for this chapter because these educational objectives were not different from the rest of the course, despite the use of a different mode of delivery (lecture and internet as opposed to lecture and textbook).

RESULTS

The student responses to the survey are numerically shown in Table 1.

These numerical responses and their written comments to each question provided important feedback to the course instructor. Students indicated that the format and layout of the

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean Student Response</th>
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<tbody>
<tr>
<td>1. The format and layout of the pages made sense to me (I = never made sense; 4 = always made sense).</td>
<td>3.16</td>
</tr>
<tr>
<td>2. Content beyond the slides (e.g., web-based links and animations) worked smoothly (I = never worked smoothly; 4 = always worked smoothly).</td>
<td>3.00</td>
</tr>
<tr>
<td>3. I found the material to be clearly worded and appropriately detailed (I = never clear; 4 = always clear).</td>
<td>3.33</td>
</tr>
<tr>
<td>4. I found the level and depth of content to be as effective as that of a printed textbook (I = amount unacceptable; 4 = amount excellent).</td>
<td>3.00</td>
</tr>
<tr>
<td>5. I thought delivery of the material in an online fashion was creative (I = strongly disagree; 4 = agree).</td>
<td>3.56</td>
</tr>
<tr>
<td>6. The content of this particular course works well as an online textbook (I = does not lend well; 4 = lends considerably well).</td>
<td>3.19</td>
</tr>
<tr>
<td>7. The interactive resources (e.g., animations, quizzes, etc.) helped enrich my understanding of the material (I = not helpful at all; 4 = very helpful).</td>
<td>3.72</td>
</tr>
<tr>
<td>8. Overall, I think the idea of a virtual textbook is a good one (I = strongly disagree; 4 = strongly agree).</td>
<td>3.00</td>
</tr>
</tbody>
</table>

The survey was administered to students upon completion of the sample chapter. Students provided responses to these questions using a 4-point Likert scale as shown in parentheses. All questions yielded a normal distribution except for questions 5 and 7, which yielded a strong negative distribution.
Teaching With Technology

online slides made at least some sense to them. Their specific comments revealed that students “appreciated the generous use of diagrams” and felt that “[there were] good details with each slide,” “it was very nice,” and “the introduction of the material was very logical.” One minor criticism referred to the size of the slides in the Adobe Acrobat handouts, suggesting that we create handouts with 2 slides/page rather than 6 slides/page.

One of the most difficult aspects of this project was to make all digital material available to students working on a variety of different computer platforms and operating systems. Unfortunately, the technology is not ubiquitous; thus, it was anticipated that some students would experience difficulties in viewing the various animations. Their responses (question 2) indicated that while the slides and links worked smoothly, not all animations worked all the time. Students provided some insight as to the reasons with comments such as “Sometimes my computer would not open the link,” “the videos on the slides wouldn’t work on my computer,” and “I can’t access the links or animations at home. Actually I can’t access any of the slideshow from home but it worked fine in the library—the links worked but the animations did not.”

It was our intent to provide a chapter with emphasis on the mechanisms involved in the function of skeletal muscles, such as excitation-contraction coupling, proprioception, motor unit activation, etc. We elected to do so by delivering the material in graphic form (images, diagrams, etc.), requiring students to fill in the blanks during lecture. Student responses to questions 3 and 4 indicated mixed reactions. The comments emphasized the lack of significant detail in the material covered: “Sometimes I could have used a little more detail.” Two students indicated that the level and depth of content were “poor,” by writing “I felt that some areas the book could have provided background info necessary for understanding” and “I feel like you will need a lot more content to match a text.” Without dismissing the student’s criticism, we choose to interpret this as a failure on our part to effectively communicate to the students that in this chapter we elected to “zoom out” in favor of the big picture of structure and function rather than emphasize every minute detail of the molecular processes at work as in previous chapters (i.e., action potential or metabolism).

Some students reflected positively: “Able to present text in a fashion that was easy to see. To the point” and “Maybe even better, exact info I will need to know” when they answered question 4.

The fact that students considered the online delivery of material “creative” (question 5) provides evidence for our assumption that today’s students are familiar with several ways of accessing information. Specific comments emphasized the fact that students were comfortable with using the internet. Positive responses included the following: “Made material clear because of direct visual and info on certain slide[s],” “The links were very helpful, especially ones that tested my knowledge,” “I really like it, I don’t ‘zone out’ near[ly] as much as when I’m reading a text book,” and “It’s good that you’re moving toward this. The web will only get better as a resource.” On the other hand, other students who otherwise were positive also wrote the following: “Yes, but I still like having the book” and “I feel that I have a bias towards having a text book and feel that it is easier for me to access info using the book and not online.”

The mean scores and distribution of student responses to question 6 indicated that students did not agree in their assessment of how well our chosen method of delivery (PowerPoint, Acrobat, and lectures) worked compared with an online textbook (question 6). Their comments indicated that perhaps they misinterpreted the question comparing this course with their regular textbook. We offer some indicative comments by students: “Most of the time the content worked well online but it also required access to computer,” “If more detail and attention to step by step process is provided like what we see in the book,” “For the most part but I feel as if the book helps a lot to tie everything together.” On the other hand, perhaps they have never had to use an online textbook for any other class. Our survey did not address students’ previous experiences with any online delivery method (distance education, online textbook, discussion lists, etc.). Others were pleased with the results: “Aids not only in providing another format of learning besides text, but also allow for more in depth discussion in class.” One student also recognized that “This works very well. It will take much more time though to set it up properly.”

Unquestionably, the use of animations, interactive quizzes, images, etc. enhanced the students’ understanding of the material (question 7). Their responses were very favorable: “Yes! It let me know what info I absorbed and what I needed to spend time with,” “The animations helped me concretely see all the smaller details in the larger scheme of things,” “Seeing moving animations of certain physical processes helps me to get a better visual understanding. I like these A LOT!” and “Interactive resources enabled harder concepts to be broken down and more understandable than just reading the text.” In addition, the collective class scores on the section exam were not different from the scores from other classes taught in previous years and selected randomly. A statistical analysis comparing the section exam scores for this class with six other classes from previous years revealed no differences between the classes that used a textbook and this class (α = 0.05 by ANOVA). We concluded that the textbookless mode of delivery did not negatively impact student performance on the exam.

Perhaps the single most important question for the authors was whether students would endorse the textbookless curriculum (question 8). Most responses were positive (strongly disagree, n = 1; mostly disagree, n = 2; mostly agree, n = 9; and strongly agree, n = 5), and responses included the following: “Yes. If it means not having to buy the very expensive textbook,” “Provides alternative way of learning that appeals to all learning styles,” “Less cost to students and material you can update,” and “I liked having the info determined by the prof. No need to sift through dense, unnecessary material of textbook.” Others had a more mixed reaction: “Sometimes it’s nice to have the book for backup, but I like the idea of less cost” and “It was a good idea but not so good as using the textbook.”

Table 2. Open-ended questions in the survey administered to students upon completion of the sample chapter

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
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<tr>
<td>Two things I liked about the virtual textbook chapter were:</td>
<td>Two things I dislike about the virtual textbook chapter were:</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Finally, two students were clearly disagreeable in their opinion: “I think it is helpful as a supplement but should not replace the textbook” and “I feel that using only this way leaves a gap.”

The open-ended questions (Table 2) were designed to solicit feedback about the students’ experience with the textbookless curriculum. Students were very clear on what they enjoyed and what they did not. Aspects of this experiment that they liked included the following: animations, links to other websites that gave further explanation, quizzes, interactive visuals/graphs/links, and that the online material kept them involved. In addition, they indicated that they felt “relief of not feeling overwhelmed with both book and slide material.” Students also stated that the textbookless teaching curriculum “allowed [them] to know the specific parts of the chapter [that] the professor wanted to emphasize” and that they valued “the extra details and attention during lecture” and that this approach “makes preparing for the chapters easier” without “being weighted down by the book.”

On the other hand, students also indicated that not being able to go back and read the textbook caused them to feel “lost with some of the material and not having a book to reference easily.” They were uneasy with the “lack of specific detail” even though this was a stated objective of this experiment. Students also pointed out that “sometimes the book is a good resource if you do not have access to internet, but have time to study” and that this approach was problematic in that it “allows no room if you miss something in lecture.” Students complained that it was “hard to not look at the book” and that they had to have access to a computer and go to “online resources and links to fully understand material.”

Students thought that this approach to teaching could work well in other courses, such as anatomy, nutrition, microeconomics, biochemistry, and other science-based classes. While students did not elaborate on their reasoning, one indicated that “it is very dependent on how the class is run/expectations.” The success of future iterations of this course will facilitate the incorporation of these elements into other courses at our campus through teaching workshops and demonstrations.

Finally, students shared some important perspective as to how they liked being taught. One student stated the following: “I really enjoy having the slides to printout because I can make detailed notes on hard copies of confusing graphs. I also find it very helpful when we step back to look at the BIG picture of a system or process. Constant review is very helpful.” Another student pointed to a different issue, stating that “Reading a computer screen for long periods of time hurts the eyes. I much prefer a book. However, anything that is interactive helps me learn.” Students also offered helpful suggestions for improvements: “If this is something you want to do it might be a good idea to provide a slide of vocabulary or important terms instead of just presenting them in the lecture. This would be very helpful and then everyone would have those valuable words in their notes.” Another student added the following:

I really did like the virtual textbook overall. However, having said that I do not think the textbook should be taken out of class. Many times it is far easier to see the material laid out in front of you and it is also good for the receptive nature when used in conjunction with the lectures. I know how expensive books are for students, but why not do it like we did in high school and have a class set that students check out for the semester? I think that would be a far cheaper solution overall and we wouldn’t have to spend extra time learning the chapters through only using the virtual textbook.

DISCUSSION

We were interested in exploring the feasibility of using internet-based technology and resources as a substitute for the classic textbook in a sophomore-level human physiology course without altering any other aspect of the course. Students were allowed to use their textbook for 6 wk prior to a voluntary switch to the online material for a chapter on muscle physiology. At the completion of the chapter, students were surveyed with regard to their experiences. Overall, students enjoyed the process and found some room for improvement with our approach.

An additional component of this educational experiment was our attempt to educate students how to become critical consumers of scientific information. Given the abundance of internet resources on any given topic, students must be educated as to what constitutes accurate and trustworthy information and how such information can be distinguished from less accurate or arbitrary material. By providing examples of accurate and useful information, we help our students improve their critical thinking skills.

In an effort to further cultivate students’ critical thinking skills, lectures were focused on the physiological mechanisms under study, and only the necessary details were presented and discussed in class. However, previous discussions with students revealed that, invariably, an undesirable consequence was that some students lose focus when exposed to a broad and detailed topic. It is for this reason that lectures were designed to emphasize mechanisms rather than details. The fact that students had access to their textbook for the first 6 wk of the semester meant that they were familiar with the general tone and level of detail of the textbook, and they were able to appreciate the depth of the material. Even though all the lectures were always focused on mechanisms, students were expanding their understanding of mechanisms (from lecture) to the level of detail (in the textbook). Interestingly, given the lack of access to the textbook in this teaching experiment, students noticed the lack of detail in the lectures, and some registered their disapproval. However, given the emphasis placed in the course, the lack of detail was not interpreted as a significant criticism of the textbookless curriculum. If details were desirable, it would have been easy for the course instructors to create a narrative to accompany the online material.

An a priori assumption was that students would be familiar with web-based material and would not be distracted by the nonlinear nature of the information. Researchers are investigating the cognitive effects of web-based applications and have demonstrated differences in performance compared with linear textbook reading (i.e., Ref. 14). Although such considerations are beyond the scope of this report, instructors must consider such matters when contemplating the implementation of a web-based textbookless curriculum. It is possible that the nature and abundance of available information on muscle physiology are easy for students to comprehend, and this may explain why there was no decline in performance in the section exam.

One aspect that proved problematic for the authors was the students’ reference to this textbookless curriculum as an “online textbook.” In fact, our aim was to bypass the “textbook”
altogether, by providing a visual map of concepts, allowing students to fill in the gaps through a variety of online material selected for them by the instructor. To that end, it appears that students may have expected textbook-quality material to be available on the internet for them to access. In subsequent iterations of this experiment we will make this distinction more clear.

Without diminishing the importance and value of a good physiology textbook as a resource, our goal was to examine the necessity of the textbook and to attempt to dissociate the learning process from the textbook itself. In the process, we were interested in investigating the possibility that we may be able to teach physiology without burdening students with the cost of expensive textbooks. As evidenced by the students’ exam scores and survey responses, we were successful. Following student comments, we will make minor changes in our strategy for the next iteration of the course. This approach may also benefit educators at a variety of settings where access to textbooks and/or other material is lacking, such as community colleges and high schools. Finally, we believe that the reliance on internet technology as a means of communicating material to our students will further change the way we teach physiology in the future, much in the way that our communications with students (e.g., e-mail) or student assessment techniques (e.g., classroom performance systems) have changed our approach to teaching in recent years.

ACKNOWLEDGMENTS

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GRANTS

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