Technology Instead of a Textbook

Alternatives for the Introductory Biology Classroom

Eric J. Simon

Introduction

Technology is playing an increasingly important role as a teaching and learning supplement in modern classrooms. Potential benefits of the Internet, CD-ROMs, course web sites and other computer-based resources include increased communication among students and between instructor and students (Dowden & Humphries 1997; Hedges & Mania-Farnell 1998–9), enhanced explanation of difficult concepts through multimedia (Fifield & Peifer 1994; Dori et. al. 1994–5), and exposure of students to the World Wide Web as a research tool (Baggott et. al. 1999).

Biology in particular benefits from the application of technology in the classroom since rapid advancements in the field make it nearly impossible for textbooks to remain current. This is especially true when teaching introductory biology to nonscience-major students. Instructors can often engage this potentially hard-to-reach audience by discussing the most current events in biology—cloning, DNA fingerprinting, reproductive technologies, genetically modified foods, AIDS, etc.—subjects that are most relevant to students' lives and interests. Additionally, technology such as a content-heavy course web site offers the opportunity to focus the curriculum from the full range of possibilities to the specific subset appropriate to that introductory course.

Many biology instructors are seeking to take advantage of these benefits by using technology as an increasingly integral part of the teaching experience (King & Hildreth 2001). This raises the question of how far this process can go. Can technology in fact replace more traditional modes? Or, on the other hand, can too much technology harm the learning experience?

This paper describes a series of classes wherein technology usage was taken to its ultimate degree: as a replacement for, rather than a supplement to, a traditional textbook. First, the development and implementation of the technologies will be discussed. Data will be presented on student opinions of their effectiveness: what advantages and disadvantages the technology offered compared to more traditional media. The shortcomings of this technology will be addressed along with practical suggestions for reducing these obstacles.

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Background

Fordham College at Lincoln Center is an academically competitive four-year liberal arts college in the Jesuit educational tradition located in Manhattan. In order to fulfill the science requirement of the general education core curriculum, all nonscience-major students are required to take "Perspectives: Biology" and either "Perspectives: Chemistry" or "Perspectives: Physics," each a one-semester introductory course with no prerequisites. Sections of these courses are limited to 24 students each, drawn from all class years. The student body includes a significant number of nontraditional students—those not entering a full-time college program immediately out of high school, including adult and part-time students—a growing population with increasing impact on curriculum design at Fordham College and elsewhere (Neely et al. 1998). About half of Fordham's students commute to school from throughout the greater metropolitan area, creating another population with unique needs, particularly the desire to use their commute time (typically about one hour) as productive study time.

This study encompasses five semesters and two summer sessions from fall 1997 through fall 1999. During this time, I taught a total of nine sections of "Perspectives: Biology" and five sections of "Perspectives: Chemistry" with a total of 294 students.

Creating Online Content

Fall 1997 was my first semester teaching "Perspectives: Biology," and I used a standard nonmajors textbook (Campbell et al. 1997). A minimal course web site was created that included lecture outlines, announcements, grades (posted using anonymous code words), and the occasional exam hint. In addition to the material that I created, every student contributed course-relevant content that I checked and added, expanding the usefulness of the web site throughout the semester.

During the next semester (spring 1998), I expanded and added more detail to the lecture outlines and continued to administer the student contributions. The content of the web site was augmented to include many of the useful features of a textbook: sample problems for each set of lecture notes, a glossary, links to additional Internet resources, and graphics, all created by students through the assignment of graded "web site construction projects." In this way, the creation of the course web site was a group effort on the part of all students and the instructor, a method termed collaborative web site construction (Simon 2001a).

By the end of the second semester, students informally reported that the course web site was more useful in their learning than the textbook. I asked the students about using the web site in substitution of the textbook in future sections of the course. Student response to this idea was generally positive, so I pursued the idea.

Technology Instead of a Textbook

During the summer 1998 section of "Perspectives: Biology," students were given the option of purchasing the textbook or relying solely on the class web site. Every member of the class chose the web site, probably less a reflection on the quality of the site than on the high prices of college science texts. To accommodate this, I amplified the lecture outlines into more complete notes. After a successful trial run during the summer, I decided to carry the experiment further. Beginning in fall 1998, and continuing for all semesters thereafter, web site utilization was mandatory for all of my sections and a textbook was not offered.

Over several semesters, the technology was applied in various new ways. Beginning in spring 1999, the web site materials were printed on CD-ROMs that were distributed to all interested students, giving the means to access the materials without having access to the Internet, which is particularly useful to commuting students with laptops. In fall 1999, the materials were adapted for use in a distance learning format, one that depended solely on the web site for content and had no other supplementary texts. During this semester another new option was also introduced: 10 students were provided with electronic books (or e-books) onto which the course materials could be downloaded on a weekly basis and then read anywhere, without requiring access to a computer (Simon 2000, 2001b).

During every semester, students contributed materials to the course web site that expanded its usefulness in subsequent semesters. Additionally, in order to gauge student reaction to the replacement of traditional classroom media with technology alternatives, anonymous evaluation forms were distributed to all students near the end of each semester in which the technology was used, from summer 1998 through summer 1999. The purpose of these questionnaires was to learn if students preferred a traditional textbook or the technology alternatives and why.

Evaluation

In total, 154 students from five sections of "Perspectives: Biology" and two sections of "Perspectives: Chemistry" responded to the technology questionnaires. The questions and summarized responses are listed in Tables 1–5.

The first question asked "How useful were the online materials?" Answers were rated using a Likert scale format, from 1 being "least" to 5 being "most." The questions defined "online materials" as encompassing all of the alternative technologies available to the class: the course web site, CD-ROMs, and e-books, depending on the semester. The responses are summarized in Table 1. The average response of 4.3 indicated a high degree of satisfaction with the technologies. It should be noted, however, that a small number of students were highly unsatisfied with the materials. It is probably inevitable that a small percentage, including both traditional and adult students, will always prefer books: in this case, 6 out of 154, or 4%.

The reported degree of satisfaction does not distinguish whether the students would have preferred a traditional textbook. To address this key issue, three yes or no questions were posed: "Do you feel your learning experience was hindered by using the online materials instead of a textbook?" "Would you recommend taking a course with only online materials to a friend?" and "Do you think the objectives of the course would have been better fulfilled if a textbook had been used instead of the online materials?" As summarized in Table 2, student response to these three questions was consistently in favor of technology usage: 87% (128/147) felt that their learning experience

Table 1. Summary of student responses to the question: "How useful were the online materials? (1 = least useful . . . 5 = most useful)" (N = 154).

Rating	*# of Respondents*
1	3
2	3
3	10
4	61
5	73
(no answer)	4
Average	**4.3**

Table 2. Summary of student responses to three questions designed to compare the experience of using technology to the more traditional textbook experience (N = 154).

Question	*Yes*	*No*	*(no answer)*
"Do you feel your learning experience was hindered by using the online materials rather than a textbook?"	19 (13%)	128 (87)%	7
"Do you think the objectives of the course would have been better fulfilled if a textbook had been used instead of the online materials?"	9 (6%)	137 (94%)	8
"Would you recommend taking a course with only online materials to a friend?"	134 (89%)	17 (11%)	3

was not hindered by the absence of a textbook, 89% (134/151) would recommend such a course, and 94% (137/146) did not feel that a textbook would have helped them better fulfill the course objectives.

The next, and perhaps most useful, set of questions was designed to compare student experience with technology to that with traditional textbooks. Responses to three such questions are summarized in Tables 3–5. First, students were asked "What was the major advantage of using online materials over a textbook?" The most popular response (see Table 3) was the cost savings (the web site was free and the CD-ROM cost a few dollars, while the standard course textbook has a retail price of $87). The cost savings, while clearly an advantage to all students, is particularly appreciated by nonmajors, an audience that, in general, has no desire to keep the textbook and resents the high prices and low resale values of college science texts.

A second advantage mentioned nearly as often was the concise and succinct nature of the instructor-written lecture notes. One lecture's worth of my notes typically ran 10 to 12 pages, compared to the textbook, which often used 20 to 30 pages to cover the same material, albeit within a broader, more generalized context. Many students printed out the lecture notes and annotated them during class, a task simplified since the notes closely followed the lecture. Another frequently mentioned advantage was the savings in weight, a feature that never occurred to me but was a popular answer among all sections polled. Students also appreciated that the materials were easily accessible from home, work, relatives' houses, etc. Other responses included the up-to-date nature of the lessons, the increased interactivity offered by the media, easy access to grades on the course web site, and paper conservation.

The next question asked "What was the major disadvantage of using online materials instead of a textbook?" The most often cited disadvantage (see Table 4) was a lack of computer or Internet access. Even though Fordham College, like most educational

Table 3. Summary of student responses to the question: "What was the major advantage of using online materials over a traditional textbook?" (N = 154).

Response	*# of Respondents*
cost	60
concise/lean/focussed/specific material	52
easier to carry/less weight/compact	28
accessibility/easy to access/ availability	26
up to date	9
well organized/straightforward	9
more interesting	7
increased interactivity	7
inclusion of sample problems	6
access to grades	4
applicability to lecture	3
promotes computer usage	3
less reading	2
more substantial	2
saves paper	1
searchable	1
improved layout	1
student contributions	1
convenience	1
easy to use	1
animations	1

Table 4. Summary of student responses to the question: "What was the major disadvantage of using online materials over a traditional textbook?" (N = 154).

Response	*# of Respondents*
lack of computer access/lack of web access/inconvenience of access	35
not enough visuals/poor quality visuals	16
not enough information	7
need to print out	5
comfort with books	4
cannot annotate	4
not portable	4
too much information	2
typographical/proofreading errors	2
incomplete glossary	2
disorganized	2
computer screen difficult to read	2
not enough examples	1
not updated often enough	1
lack of index	1
lack of references	1
lack of alternative point of view	1
lack of remedial information	1
more work for students	1

institutions, had multiple facilities at which the students could access the Internet (e.g. computer lab, library, dorm room connections, etc.), the students complained of failing hardware and occasional Internet traffic delays—a problem highlighted this most recent semester when the university's service provider experienced an outage for the entire day of the first exam. These occasional problems seem to be inevitable until the day when the Internet is as reliable as the telephone.

Students who were using the web site, particularly commuting students, frequently expressed a desire for a more portable "carry it on the train" format that would preclude the need for an active Internet connection. This issue was addressed in two ways. Beginning two semesters into the study, in response to this complaint, CD-ROMs were made that could be used in portable laptop computers. Most recently, electronic books distributed to some students allowed for convenient reading of the course materials in any location [more information on the use of e-books in the classroom will be presented elsewhere (Simon 2000, 2001b)].

Another disadvantage often cited by students was a lack of high quality illustrations. This is hard to overcome, since I lack the talent required to generate diagrams on par with those in a textbook. Improvement was made to the visual component through several means: assigning the creation of visuals to students as a graded project, accepting them as extra credit, hiring talented students to assist, accessing Internet databases of noncopyrighted graphical images created for educators (such as the Access Excellence Graphics Gallery at http://www.accessexcellence.org/AB/GG), and using shareware to create animations that often illustrate biological concepts better than any still image can.

Also mentioned as a disadvantage by students was the shortage of content, particularly remedial information, on the web site compared to a textbook. This issue was addressed by constantly expanding and updating the lecture notes each semester. Consequently, this complaint is rarely heard anymore. Other cited disadvantages of the online content included the hassle of printing out the lecture notes, a general comfort with books over computers, the inability to annotate the CD-ROM material, the difficulty of reading off a computer screen, and a lack of references.

The final question asked: "Please suggest improvements for future versions of the online materials." Most of the responses (see Table 5) can be summarized as "more of the same." Adding more visuals was the most cited suggestion, followed by more practice questions, glossary entries, and Internet links. These shortcomings were addressed by having students in every semester add on to the work of their previous peers, thereby continuously improving the quantity of content and emphasizing the continuous nature of scholarly work. Future sections were encouraged to create more visuals, for example, to relieve the deficiencies cited. As a consequence, these suggestions are seen less frequently. Other suggestions made by the students included references to further reading, a guide to using the technologies, time lines, and an improved layout. Each of these useful suggestions is under development.

Applicability

The methods used in the present study are broadly applicable to many college and high school courses. It is important to note, however, that in order for such ideas to be successfully implemented, the student body must have extensive access to computer hardware and the Internet. This is true of nearly all colleges, but, at the present time, not all high schools are equally advantaged. While most schools and libraries today provide access to computers for their students, not all students—particularly those from lower income families—have access at home, and these students would need to rely on a printed text.

Table 5. Summary of student responses to the question: "Please make suggestions for additional materials that can be included in future versions of the online course materials." (N = 154).

Student Suggestion	*# of Respondents*
more/better illustrations	42
more sample questions/answers	20
more glossary definitions	6
more Internet links	4
articles	3
a guide book	2
time lines	1
more interesting layout	1
references	1
printable lecture notes	1
summaries	1
faster posting of grades	1
puzzles	1
old tests	1
more detail	1
chat room	1
animations	1
pointers to additional information	1

As computer technology becomes more ubiquitous throughout our society, the number of students precluded from using technology instead of a textbook should be reduced.

While the results presented here for introductory science curricula are encouraging, upper level courses that depend heavily on specialized texts and journal articles, such as molecular biology or immunology, would fare poorly under such a system. The introductory biology curriculum, however, seems very well suited to such efforts (King & Hildreth 2001).

The instructor needed no special training, most of the software was included with the operating system or was shareware, the hardware used was within reasonable budgetary constraints, and the entire set of materials was built from scratch in just two semesters using collaborative web site construction techniques (Simon 2001a).

Conclusions

In an increasingly technological world, alternative media will continue to gain prominence in the classroom. Instructors presently find themselves in a transitory moment, when long-held methods of teaching and learning are being challenged by newly developed technologies. It is possible that within a few decades the printed textbook will go the way of the slide rule, mimeograph and film strip—each a longtime classroom staple supplanted by better technology. Therefore, now is the time to ask whether electronic media are appropriate for the classroom and how they can best be adapted to student learning.

The results presented here suggest that technology can be a promising alternative to traditional textbooks in the introductory biology classroom. Student response to such an effort was consistently positive, with savings in cost, weight and length of reading assignments the most often cited advantages. The disadvantages, such as difficulty in accessing the material and shortage of visuals, can be addressed in creative ways.

Once in place, the multiple benefits of electronic media, such as the ability to dynamically customize the curriculum, animations, interactive bulletin boards (Collins 1996–7), distance learning formats (Gibson & Herrera 1999; Boettcher 1998), and hyperlinking to further resources, can be utilized. Such benefits have the potential to aid both students and instructor by improving the teaching and learning process.

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