Technology in the Freshman Biology Classroom: Breaking the Dual Learning Curve

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Introduction

The development of the Internet in the past decade has, without doubt, revolutionized the teaching of biology. The ease of information accessibility via the web has made it possible for instructors to greatly enhance the learning environment with supplemental information. Even the smallest and most rural schools now have access to current discoveries and issues in the biological sciences, as well as expanded library facilities, virtual tours of museums, and online tutorials. However, these advances have also produced some real challenges for educators. The natural progression of science has resulted in a demand to compress more information into the freshman biology curriculum. This has occurred simultaneously with an increase in faculty workloads and class sizes (National Science Foundation 1996). Thus, while many instructors may have a desire to reform their curriculum, often the time for development of the electronic resources is not available.

The problem facing most instructors in attempts to incorporate technology into science classes is that most students remain focused not on the technology, but on the lecture presentation (Laurilland 1993). Thus, if you expect the students to have anything more than a passive role in the process, they are quickly faced with the problems of a dual learning curve. The terminology and concepts of an introductory biology class typically present a challenge to most students, when coupled with the requirements to learn to manipulate multimedia presentations and programs, the results may be devastating. In this type of system the biology instructor often assumes the simultaneous tasks of lecturer, computer science instructor, help desk technician and graphics designer. The demand on instructor time and resources often reduces teaching effectiveness (Palloff & Pratt 1999) and produces frustration for both the student and instructor.

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At Floyd College, a two-year institution of the University System of Georgia (enrollment approximately 2,400), an opportunity presented itself to convert a curriculum, which had changed little in the previous three decades, into a technology-enhanced environment. In September of 1998, the college became a pilot institution of a program called the Instructional Technology Project (ITP). The basic premise of the ITP is that all students and faculty would have universal 24-7 Internet access. This was accomplished by requiring that all students lease a laptop computer from the college. This laptop (a Windows 95™ machine with a 166 Mhz processor, 32M of RAM and a 56K modem) was built to the college's specifications and was equipped with Microsoft Office 97™ and Earthlink™ dial-in access. The identical construction of the machines guaranteed that all students would be using the same platforms. This provided the unique opportunity for instructors to develop class materials knowing the software that the students had at their disposal. As part of the project, the faculty was required to incorporate technology into existing curriculums. The basic requirements of the faculty were the use of e-mail, design of course web pages, and utilization of the college's online library resources. However, the faculty was encouraged to develop innovative, technology-enhanced teaching strategies, and many of us viewed this as an ideal opportunity to revise both curriculums and instructional methods.

As with any project of this magnitude, there were several problems associated with the implementation of the program. From the perspective of the faculty, the primary concern was in time management. Although the faculty and staff of the college received their computers a year prior to the students, this coincided with a 10-year review of the college by an accreditation committee and preparation for a conversion to a semester-based academic calendar within 24 months. While training was provided on the new computers and the programs packaged into Microsoft® Office 97™ (Word™, Excel™, PowerPoint™, etc.), there was little standardization across the campus on how the technology was to be incorporated in the classroom. For example, the construction of web pages for classes was being performed simultaneously on Netscape® Composer™, Microsoft® Word™, Microsoft® FrontPage™, Adobe® PageMill™ and other editing platforms. While this allowed for individual choice, what resulted was an increased demand on faculty time as they experienced individualized learning curves for each software system that they experimented with.

The following year, the students were issued laptop computers. From the perspective of the students in the general biology classes, the first indication of a problem with the ITP presented itself with exam I. The class average for this exam was 13% lower than previous classes over the past few years. While this phenomenon may have been the result of normal class variation, coupled with this was a higher than average drop rate for the course in the first few weeks. Similar situations were occurring in other general science classes. Input from the students and classroom discussions indicated that the students were experiencing a dual learning curve between course material and the technology requirements of the course. It was obvious towards the end of the first fall of the program that the quantity of technology in the classroom was taking a higher priority than the quality of education. Rather than enhancing the learning experience, the increased demand on time, for both the faculty and students, was actually creating a more stressful classroom environment.

In order to make an assessment on the impact of the laptops on the students, a computer competency survey was adapted from an existing survey in use by a geology faculty member. The survey was initially designed to assess basic computer skills for the purpose of forming project teams in a high-tech geological science class. The 33 questions of the survey ranged from general questions, such as previous use of a computer, upward to more advanced topics on word processing, HTML language, etc. When adapted for assessment, rather than a team-building tool, it provided a means of determining the general computer knowledge of the students entering these freshman level classes. Since the purpose was not to assess the individual student, but to generate a snapshot of the computer literacy of the class, the survey results were kept anonymous. This also encouraged participation and honesty in the survey. The responses to the survey were simple yes and no answers rather than the more subjective graded survey response (for example: 1 being low, 10 high).

The survey was first administered to 151 students in four science classes (three biology, one geology) during the fall of 1997. Table 1 summarizes the key questions analyzed from this survey. What was most striking from this data was that while the majority of students indicated that they had previous experience with a computer (97.4%), when asked about e-mail and Windows 95™ applications, fewer than 50% of the students responded that they had previously used these programs. This indicated that computer experience does not necessarily indicate the ability to manipulate a computer in an educational environment. This information presented a serious challenge to the ITP project, since an underlying premise was that most students would possess basic computer skills prior to entering the classroom, thus making advance training of the students unnecessary. Before proceeding further into the development of a high-tech classroom, a system needed to be developed by which an instructor could be certain of the average technological competence of the class before assigning projects.

Table 1. Survey data of student entry-level computer skills. Survey results of 151 students in first-semester science classes in the fall of 1997.

Technology	*Percent of Students Indicating Experience With This Technology*
Office 97™	16.6
E-mail	41.1
Windows 95™ Applications	54.4
Windows 95™ Operating System	57.6
Library Computer Systems	78.1
General Computer Use	97.4

Implementation of a Modular Course

Despite the widespread use of computers in educational settings, it is unlikely that most institutions have the resources to train all incoming freshmen in computer literacy topics prior to the start of classes. While our institution does have a computer literacy class in the curriculum, it was not practical to add it as a prerequisite for the general biology courses since this would most likely disrupt the two-year timetable of the degree program. Thus, a method was needed to enhance computer competency in the classroom without sacrificing valuable time dedicated to the curriculum. In other words, the course needed to be designed so that the technology training ran in the background of the course to reduce the dual learning curves that formed the basis of many student complaints.

The concept that arose from this philosophy was a course designed so that it consisted of discrete modules of information supplemented by technology-based projects, which trained the students in the use of their laptop computer over time. At Floyd College, this was practical due to the fact that all students are required to take a two-course sequence in a science discipline. Thus after completion of the introductory course, most students would be comfortable with the technology aspects of the course, which in turn would enable the instructor to expand on the technology level of the second course of the sequence.

The first course reworked in this manner was a freshman biology course for science majors in the winter of 1998. The course was designed around five modules (see Table 2), each involving a technology-based project. These projects were designed to build on one another, so that the skills obtained in the previous module were necessary for completion of the next module. For each project, students were given handouts and linked to already existing computer science or college reference materials. An overview of each of these projects is listed below.

E-mail

Since the initial survey indicated that less than 50% of the class had experience with e-mail systems, and since the use of e-mail is an important component of any electronic classroom (Hedges & Mania-Fernell 1998), the logical first project involved e-mail systems. At the time, the e-mail system of the students was Pegasus Mail (since updated to Microsoft Outlook). The e-mail project simply required the student to send an introductory statement to the instructor that included his/her major, previous science classes, a brief bio, and expectations of the course. The students were also encouraged to send attachments if they were not familiar with the process. This project served multiple purposes. First, it provided background information on each student that previously had been done using handouts. Second, it made the students feel more comfortable using the e-mail system as a means of communication with the instructor. Finally, it allowed the instructor to construct an accurate e-mail distribution list for the course. This list was used throughout the class for announcements and tutorial assistance.

Electronic Discussion Boards

As noted by Collins (1997, 1998) and others, the increase in the average class size of many biology courses has resulted in a decrease in instructor contact time with each student. Furthermore, in an introductory class, many students do not feel comfortable communicating directly with an instructor. While electronic discussion boards had been available for some time to students in the sciences, there were typically few postings and almost no interaction between the students at the site. Having established a basis for student-instructor communication in the previous module, the next step was to encourage student interactions using an electronic media. This was crucial for projects in subsequent courses where the students would evaluate the projects of their classmates. For this project, the instructor posted critical thinking topics for the student to comment on. The student was required to respond to the instructor directly, and then comment on a classmate's posting. Grades were assigned based on interaction, rather than content. This approach was highly successful, and resulted not only in a significant increase in student use of this media, but in an increased student comfort level with electronic communication.

Table 2. Modular basis of the course. This course was first conducted to a single class in the fall of 1998.

Module Number	*Subject Matter*	*Technology Project*
1	Organization of Matter	E-mail
2	Cell Biology	Discussion Board
3	Bioenergetics	Use of CD-ROM and Multimedia
4	Cell Division and Genetics	Use of Internet Browsers, Evaluation of Web Sites
5	Evolution	Overview of Microsoft® Office™ (PowerPoint™, Word™)

CD-ROM & Multimedia

Most textbooks now come with, or make available to the students, a supplemental CD-ROM. These multimedia platforms often have a wealth of useful information, including tutorials, quizzes and a glossary of key terms. However, in discussions with students during office hours, it was noted that few of the students used these tutorial resources to assist them with difficult topics. When questioned, many of these same students stated that they simply did not know how to use the CD-ROM. Thus, the third project of the course introduced the students to using multimedia technology. After a lab in enzyme kinetics, the students were directed to a lab on the CD-ROM that graphed the effects of temperature, pH and substrate concentration on the activity of several enzymes. The students were required to analyze their data in comparison to the theoretical results from the presentation and discuss their findings. Feedback from this exercise indicated that the exercise not only helped them understand the experiment more fully, but also allowed them to visualize what happens to the results when variations are made in the experiment. After this, the students were much more likely to use the technology independently to verify their results and discussions before submitting the reports.

Internet Browsers

The major Internet browsers (Internet Explorer, Netscape, etc.) are designed for ease of navigation. The survey had indicated that a significant percent of the students had previous experience with computers, and most of this experience involved the Internet. The problem with most students was in the evaluation of quality web sites for research and some of the advanced aspects of using a browser (bookmarks, URLs, search engines, etc.). Using material prepared for faculty training by our instructional technologist, a quick exercise was prepared for the students in which they searched for a web site related to an assigned topic (for example, cloning). The student then was responsible for evaluating the site and posting an evaluation , and the site address, to the discussion board. The final aspect of the project required them to critique a classmate's posting. Many students commented on the quantity, not quality, of information on the web and many offered suggestions for future searches to their classmates. By this module of the course, electronic communication was commonplace and the majority of the students were experiencing a high comfort level with their laptops.

Microsoft® PowerPoint™

The final module of the course serves as a transition to the second course in the sequence. The topic of evolution leads to material on speciation at the start of the next semester. The technology project for this module was also designed to be a bridge between the two courses. The survey indicated that fewer than 20% of the students had experience with Microsoft® Office 97 (which was installed on their laptops). Using e-mail, it was determined that most students felt comfortable with the basic operation of Microsoft® Word, but few had experience with PowerPoint™ presentations. PowerPoint™ presentations are an integral component of the ITP project, so the students at this point had considerable exposure to this type of presentation. Using training materials available from a computer literacy class, a project was designed in which the student prepared a mini-presentation (between three and five slides) on a topic associated with his/her major. The project needed to include some clip art (CD-ROM project) and references to Internet materials (Internet Browser project). The project could be either e-mailed as an attachment (E-mail project) or submitted on disk.

While each of the projects listed above had individual goals that were designed to enhance the learning environment, they were all components of a system designed to prepare the students for more high-tech projects in the second semester of the course. In the second semester, the students were required to prepare more detailed PowerPoint™ presentations, and/or web pages, using multimedia (clipart, audio, sometimes video) on a topic of interest. This was done in place of the historical research paper. While some training was still required, specifically in web-page construction, the major technological problems were almost non-existent. While specific breakdowns on time demands and help-related questions are not available, the observation was made that there was a significant decrease in technology-related problems in comparison to previous classes. This is supported by informal discussions with students both in class and during regular office hours. Efforts are underway to develop an evaluation system to quantify these changes. More importantly, the students had a higher level of interest in the research that resulted in some exceptional projects. A few of these projects were integrated into the Floyd College Cyber-Swamp, a resource web site for K–12 educators on wetlands-related issues. Links to this site are provided at the end of the manuscript.

Conclusions

There are many excellent examples of the use of technology resources to enhance learning in an electronic environment. For example, e-mail (Hedges & Mania-Fernell 1998) and discussion boards (Collins 1997, 1998) have been shown to increase instructor-student interactions. However, most endeavors with technology in the classroom typically focus on the use of a single technology to address a specific problem. While there is no question that from a pedagogical perspective this is an ideal situation, the transition to the electronic classrooms of the future will require that multiple technologies be used simultaneously. As noted previously, this can place a significant drain on an instructor's time. In such a scenario, course content is usually the first casualty.

The question may then be asked as to whether the modular outline proposed above has been successful in reducing the dual learning curve and restoring both student and faculty faith in the use of technology. From an instructor's viewpoint, the system presented above greatly reduced the quantity of time devoted to technology-oriented issues in the classroom. While it is true that this course did demand more instructor time than a typical lecture-based course, the majority of this time was spent in researching Internet sites for content, and then assessing the effectiveness of the projects in enhancing student learning. Since the modular course was designed around materials available from other courses and faculty training manuals, there was little time spent on development of classroom training materials. In fact, the materials generated by the students within the projects often were incorporated into lesson plans and future projects for other classes. Thus instead of devoting time to reinventing the wheel every semester, time could be spent on course enhancement. Ideally, this is the fundamental goal of the Internet and emerging technologies on education.

Table 3. Comparison of student satisfaction with the technology components of modular and non-modular courses. Data were collected from a random survey of 100 students from fall 1997 to fall 1998.

	% of Students in Agreement with Statement	
Statement	Without Modular Format	With Modular Format
1. I have used e-mail regularly in the course.	73.8	100
2. I have used the CD-ROM provided with the textbook.	60.0	74.0
3. I have used the Internet based resources provided with the course.	63.8	89.0
4. I feel that the technology resources have helped my performance in the course.	38.8	89.0
5. I feel that my computer abilities have improved as a result of taking this course.	57.5	100.0

But more importantly it comes down to the student. If a student feels comfortable with the technology, then the classroom environment becomes less stressful and usually learning is enhanced. In the modular-based course the downward trend in exam grades was reversed, and student performance displayed the same distribution as pre-technology enhanced classes. From an observational viewpoint, the students appeared to have a lower stress factor with the modular course, which manifested itself in a higher performance on the projects. A supplemental survey at the end of the course addressed the use of technology in the classroom. The survey was given to one course that used the modular format outlined above, and a control class in which the students had access to the same resources, but not the modular training format. The results of this survey (Table 3) clearly illustrate that the use of the modular format has not only encouraged the students to use the technology-related components of the course, but that the use of the technology components has enhanced their performance and improved their computer skills. Prior to the modular course, fewer than 39% of survey students believed that the technology used in the course helped their performance in the class. In comparison, 89% of the students in the modular format believed that the technology had enhanced the learning process. In addition, 100% of these students indicated that their computer skills had also benefited from the course, in comparison to fewer than 58% of the pre-modular classes. Thus, the modular design had not only enhanced the learning process, but also had succeeded in providing training in computer skills. These skills will carry over into later courses in the sciences and other disciplines.

There is no doubt that rapid increase in technological resources is going to have a revolutionary effect on the teaching of the sciences. However, students who enter the classrooms typically are not on a level playing field with regards to computer skills. This severely inhibits the ability of the instructor to develop a high-tech course and often results in the instructor assuming the role of a computer science instructor. What is desired in a classroom is not biology-enhanced technology, but rather an emphasis on technology-enhanced instruction of biology. The results presented here give one option to instructors who want to incorporate multiple electronic technologies into their curriculum. What this study indicates is that the modular infusion of technology into a classroom has the ability to balance the technology and biology of the course, and lessen the dual learning curve that many students experience in a high-tech classroom. In this type of environment, both the instructor and student benefit.

Internet Information

Information on the technology-enhanced and online courses developed at Floyd College as part of the Instructional Technology Project may be obtained by visiting the Floyd College Cyber-Science web site at *gaia.fc.peachnet.edu*. Contact information for the online instructors and examples of online and technology-enhanced courses are available at this site.

The Floyd College Cyber-Swamp may be visited online at *gaia.fc.peachnet.edu/swamp*. To view the student projects referenced in this manuscript, follow the Resources link, then Student Projects.

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