Web-Based Learning Enhancements: Video Lectures Through Voice-Over PowerPoint in a Majors-Level Biology Course

By Nathan H. Lents and Oscar E. Cifuentes

The current study is an experimental introduction of web-based lecture delivery into a majors-level introductory biology course. Web-based delivery, achieved through the use of prerecorded Voice-Over PowerPoint video lectures, was introduced on a limited basis to an experimental section while a control group, with the same instructor, received standard in-class lecture delivery. In this study, select lectures were delivered to the experimental section via videos, replacing in-class attendance of live lectures. Through the course of the semester, our detailed analysis reveals that internet-delivered video lectures prepared students for exams as effectively as live in-class lectures. This indicates that students can learn complicated biology course material through prerecorded, web-delivered lectures much as they do through in-class attendance of those same lectures. Although further careful study is needed, these results warrant further experimentation in web-based teaching methods in the sciences.

The increased use of internet-based resources and digital media for teaching has been a major effort of colleges and universities throughout the world (Rosenberg 2001). With access to high-speed broadband internet connections ever increasing among student populations, some of the obstacles to advanced digital course content are beginning to erode (Garrison and Kanuka 2004; Carpi and Mikhailova 2003). The advantages of these modes of instruction are many, especially for the particular challenges that face commuter and inner-city students (Carpi 2001; Saenz et al. 1999; Songer, Lee, and Kain 2002). Specifically, web-based course content can help accommo-
date worthy, but often disadvantaged, inner-city students who must juggle other serious time commitments such as full- or part-time employment, or caring for children and other family members (Saenz et al. 1999; Songer, Lee, and Kam 2002; Hobson-Horton and Owens 2004; Summers and Hrabowski 2006). Further, these modes of instruction can help facilitate student empowerment of, and engagement in, the learning process, transforming students from passive “recipients” of instruction to active participants (Carpi and Mikhailova 2003; Linn, Davis, and Bell 2004). Indeed, web-based teaching methods place much more personal responsibility on students for their own learning (Linn, Davis, and Bell 2004; Land and Greene 2000; Shetlar 2005).

The implementation of web-based instruction has been slow in some college curricula, most especially in majors-level science courses (Linn, Davis, and Bell 2004; Kardasz and Wallace 2001). This is understandable: There is nearly uniform agreement that replacement of laboratory experiences with computer simulations or other e-resources is insufficient, even irresponsible, and markedly diminishes the concrete comprehension of scientific concepts by students (Gandolfo 1998; Sundberg, Armstrong, and Wischusen 2005). All agree that in order to gain true appreciation of the intrinsically complex nature of the natural world and the seemingly abstract and confounding material presented in science courses, students simply must investigate these phenomena for themselves with their own hands and eyes in the laboratory setting (Sung et al. 2003; Brown 2001; Kaspar 2002). Further, many institutions have recently seen major gains in student learning and academic success through the increased use of mandatory “recitation” (discussion) sections, as a companion to classroom instruction (Carpi and Mikhailova 2003; Gosser et al. 1996; Curtis 2002; Fortus et al. 2004). These discussion-based, student-centered sessions do not serve as a platform for teaching new information, but rather for expanding on the central topics covered in lecture through project challenges, critical-thinking questions, and group work. Peer-Led Team Learning (PLTL) and Process-Oriented Guided Inquiry Learning (POGIL) are excellent examples of the successful use of student-centered learning sessions in the sciences (Gosser and Roth 1998; Farrell, Moog, and Spencer 1999). The strict requirement of laboratory education and the success of recitation sessions has led some to conclude that the replacement of any classroom time with digital resources is neither desirable nor possible in the sciences.

However, a middle ground may be possible. Although all agree that the laboratory experience is irreplaceable and that recitations dramatically improve student performance, perhaps some lecture sessions lend themselves to web-based delivery methods (Garrison and Kanuka 2004; Riffell and Sibley 2005). After all, in science courses throughout the country, lectures are performed in the traditional method of instructors delivering highly prepared, extremely information-dense lectures to mostly passive student listeners. This lecture mode, if dated, is the hallmark of undergraduate science education around the country and the world, owing mostly to the immense volume of material that must be covered in each course (Sundberg, Armstrong, and Wischusen 2005). However, this begs the question: If students are mostly passive listeners to prepared lectures, might this experience be conveyed via video link just as effectively as it is in the classroom? Indeed, some campuses have long histories of delivering lectures to students through some form of recorded video, with documented success (Tobagi 1995; Dutton, Dutton, and Perry 2001; Scanlon 1997; Barrie and Presti 1996; Francis 2000).

If the possibilities for success through web-based teaching are many, the potential pitfalls are more. If any attempt at remote access to video lectures is attempted, one must be cognizant that this mode of instruction (1) may not work well for every student or even most students; (2) may not necessarily provide any record of attendance/compliance (i.e., students are on their own); (3) does not provide instant feedback from students regarding areas of confusion or misunderstanding; and (4) is inherently less engaging, and any personal dynamic of the instructor (or rapport with students) could be lost. The list could go on. Therefore, the introduction of lecture via video into a science course must be carefully planned, cautiously executed, and continually scrutinized to ensure that benefits outweigh drawbacks and that student learning is not harmed in the process (Songer, Lee, and Kam 2002; Gandolfo 1998; Brown 2001).

**Project design**

The current project, an experimental introduction of video lectures, was conducted at John Jay College of Criminal Justice, of The City University of New York, an all-commuter campus in the heart of New York. As of fall 2008, John Jay College enrolls 12,615 undergraduate students, more than half of whom come from households earning less than $30,000. Among the 839 forensic science majors, 58% are minorities and 70% are women. The use of video lectures was introduced into one section of Biology 104: Principles of Modern Biology II in the spring of 2008.

Bio 104 is the second course in the two-semester sequence of biology courses required of all forensic science majors at John Jay College. Five sections of Bio 104 ran in spring 2008. Sections 1 and 2 were a so-called “double section” in which the students were split in half for laboratory and recitation (and had different instructors therein) but met jointly for the lecture. Section 5, on the other
TABLE 1  
Description of the control (sections 1 and 2) and treatment (section 5) groups for this study.

<table>
<thead>
<tr>
<th>Section</th>
<th>Format</th>
<th>Instructor</th>
<th>n attempted</th>
<th>n withdrawn</th>
<th>n passed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and 2</td>
<td>Standard lecture</td>
<td>Lents</td>
<td>63</td>
<td>4</td>
<td>57</td>
</tr>
<tr>
<td>5</td>
<td>Mix: standard + video</td>
<td>Lents</td>
<td>25</td>
<td>1</td>
<td>24</td>
</tr>
</tbody>
</table>

hand, was a “single section,” and the lecture sessions for section 5 and sections 1 and 2 were both taught by the same professor (Lents). (Taught by a different instructor, sections 3 and 4 were not part of this study.) Thus, section 5 could serve as an “experimental group,” within which video lectures could be introduced to a relatively small cadre of students, with an immediately comparable “control group” (sections 1 and 2) against which performance could be measured (see Table 1).

The control group, sections 1 and 2, began the semester with 63 students, with four withdrawing from the course before semester’s end (n = 59), while the experimental section 5 began the semester with 25 students and had 1 student withdraw (n = 24). Although students who officially withdrew from either section will not be included in the study, those who finished the course but did not receive a passing mark will be considered (n = 2 for sections 1 and 2, n = 0 for section 5).

The format of the video lectures began as follows. On the first day of class, the use of video lectures was explained to section 5. (They had previously been advised that this section would “involve some distance learning,” and that regular access to a computer with broadband internet access would be essential.) Students and the instructor agreed on two upcoming dates on which class would not meet and the lecture would be provided via video. For the video lecture, the instructor used the Camtasia software (Smith and Smith 2007) suite to make a Voice-Over PowerPoint (VOPP) (Latchman et al. 1999) recording of the lecture given to sections 1 and 2. Thus, the video lecture seen by section 5 was identical in content to that delivered live to sections 1 and 2. The first two video lectures covered material that would be tested on the first in-class exam, thus providing for quick feedback on the success of the program and allowing for adjustment to the distance-learning scheme, if needed.

The analysis of performance by the experimental group was initially performed in two ways: comparing overall exam performance by the two groups, and comparing question-by-question performance on those questions covering material that was delivered via video. Additional modes of project analysis will be discussed as the data are presented.

Preproject analysis: Baseline values
Before any meaningful analysis of experimental data (student performance) can be conducted, we must first ensure that the two groups of students, experimental and control, are reasonably “normalized” for fair comparison (i.e., that the experimental section is not enriched, for whatever reason, with stronger or weaker students). Fortunately, two good parameters for normalization exist in this instance: (1) Bio 104 is a direct continuation of Bio 103, making Bio 103 performance an appropriate and reliable measure of prior performance in biology, and (2) in addition to the lecture sections, Bio 104 involves recitation and laboratory
sections, both with entirely distinct grade measures and instructors. Thus, performance in these other course sections by the two groups of students also serves as an independent indicator of academic performance in areas of the course not directly impacted by the experiment at hand. Figure 1 shows the normalization performance measures for the two groups of students. One can immediately see that the groups are essentially indistinguishable in terms of their prior performance in Bio 103, and that their performances in the other facets of Bio 104 in the spring of 2008 were very similar. (Values for all charts throughout are average scores, and error bars represent the $p = .05$ confidence interval.)

Project results and analysis

Early returns

The first exam provided the first opportunity for feedback regarding the success of video lectures in student learning. As mentioned previously, this exam encompassed two lectures of material covered by video lectures for the experimental group, representing approximately 28% of the exam questions. To assess performance by the experimental group and thus the effectiveness of VOPP, we analyzed overall exam performance and the performance on the specific questions that directly tested material covered only by video lectures. Figure 2 shows the results of the first test.

As shown, the overall performance of the experimental group on exam 1 was slightly reduced compared with that of the control group, and closer inspection reveals that the disparity was even greater for the specific questions covered by the two video lectures. However, the average scores on exam 1 (left) and the specific questions covered by video lecture (right), by the control and experimental groups. Although the average for students in the hybrid section was lower, especially for questions that covered content delivered by video, this difference was not statistically significant due to the large ($p = .05$) confidence interval (error bars) of the hybrid section. This large standard deviation indicates a wide range of grades in this section.

Average scores on exams 2, 3, and 4, including where appropriate the questions covered by video lectures, by the control (sections 1 and 2) and the experimental group (section 5). Results indicate that students who received some instruction via video lecture fared as well as those who were taught exclusively in the live classroom setting.
large $p = .05$ confidence interval (error bars), indicative of a broad distribution of grades, renders these differences statistically insignificant. Yet these data argue that reduced student learning of the material covered by video lectures could have resulted for the reduced student performance on exam 1.

A fruitful discussion

The disappointing performance of section 5 on the first exam gave pause to the study, and the instructor chose to devote 10 minutes of class time to discuss the topic of learning by video lectures with the section 5 students. This discussion, entirely led by students, turned into a very productive session. Some students confessed to not being particularly thrilled with the concept of video lectures and reported that they often had trouble staying focused or stimulated while watching the lectures on the computer. The instructor asked the class if they would like to terminate the use of video lectures. At this point, a few students offered to explain to the class why they preferred the video lectures and the advantages they offered. Paraphrased points specifically mentioned by students (in no way prodded by the instructor) were as follows:

1. While watching the video, one can pause frequently to take notes, and then fully pay attention when the instructor is expanding on a topic or giving examples.
2. One can have the textbook close at hand, such that
   a. one can open to the relevant figures as they are covered, jotting notes on them as the instructor explains and expands, and
   b. upon any point of confusion, the video can be paused, material in the text can be consulted for clarity, and then the lecture can be continued.
3. The video can be rewound and difficult concepts repeated several times.
4. One can watch the entire lecture two or even three times.

Following this discussion, all students agreed to give the video lectures another try, keeping in mind some of the helpful advice that some students offered.

Continued project analysis

For the period covering exam 2 material, three lectures were selected by popular vote for delivery via video lecture (an increase from the two lectures for exam 1). Again, the mode consisted of recording the exact lecture given to sections 1 and 2 in VOPP format, using Camtasia, and delivering this lecture to section 5 via the web. Student performance on exam 2, however, was markedly dif-
different from that on exam 1 (Figure 3). Although the wide \( p = .05 \) confidence interval precludes statistically relevant differences between the group, we can conclude with confidence that the group of students subjected to video lectures performed, as a group, as well as those who attended the traditional in-class lecture.

Following exam 2 and beyond, student discussion of the video lectures was more uniformly positive, and a short conversation following exam 2 confirmed that the previous student discussion changed many students' approach to the video lectures. Bolstered by this success, we used the same procedures with exam 3 lectures, again selecting three lectures for video. As Figure 3 shows, section 5 students continued to fare as well as their counterparts in sections 1 and 2 on lecture exams.

Responding to individual student needs

Cognizant that all students learn differently and that group pressures may prevent students from speaking in contrast to their peers, just prior to exam 3, the instructor invited students to take an informal (anonymous) survey and asked if, for the remaining portion of the course, they would prefer only video lectures, only in-class lectures, or the current mix of both modes of delivery. He also provided a fourth option: all lectures delivered in class as normal, but also recorded and posted online, available to all, with attendance at the in-class lecture entirely optional. Students overwhelmingly preferred this last option, and the modality of delivery was adjusted.

The new mode was that the normal lecture would be delivered live to section 5, but also recorded for web posting, and students had the option to attend the live lecture, view the lecture on their own, or both. (Previously, the recorded lecture was taken from the delivery to sections 1 and 2 and the live lecture to section 5 was cancelled altogether.) A total of five lectures was covered in this manner, one

Scores for exam averages (left) and final course grades (right) by the control and experimental groups (section 5). Although the average grades were indistinguishable, the larger \( p = .05 \) confidence interval (error bars) of the hybrid section indicates a wider range of grades.
pertaining to exam 3, and four to exam 4. The four attendance-optimal lectures pertaining to exam 4 made up all but one of the lectures dedicated to exam 4 (one lecture was kept mandatory). Thus the section 5 average on exam 4 (see Figure 3) consists of a mixture of the scores of students who attended all the live lectures, and those of students who often chose not to attend the live lecture. Thus, we endeavored to probe deeper into the exam 4 grades of students as a function of how many of the four attendance-optimal lectures they chose to attend. As shown in Figure 4, we could not detect any strong correlation between attendance at live lectures and exam performance.

Last, we attempted to gain insight into which students chose to attend the five optional in-class lectures and which opted only to view the video lecture, so as to reveal any trends regarding strong or poor academic performance in the decision to attend live lectures versus recorded video lectures. To that end, we calculated student performance on the four lecture exams and the course overall, and made comparisons based on how many of the five optional in-class lectures they chose to attend. These data are shown in Figure 5 and reveal no strong correlation between student decisions to attend live lectures versus watching video lectures at home and their overall academic performance in Bio 104.

Final project analysis

The result of all of this exhaustive data analysis seems to point in the direction that video lectures are as effective as live lectures in the delivery of content in the Bio 104 course. Surprisingly, no strong differences in academic performance were found on the basis of whether students attended an in-class lecture or only viewed the video of it, nor were strong trends found regarding the choice to attend optional classes among strong or weak students. In keeping with this analysis, we compared the exam average and overall course grade (which includes the recitation and laboratory sections) of the students in both sections and found no significant difference in student performance whether students sat in class to hear all lectures (sections 1 and 2) or received between 32% and 48% of the lecture material via video lecture (Figure 6).

Student perceptions

Although our analysis of student performance indicates that video lectures can be an effective means through which students learn essential course material in Bio 104, not to be lost in this analysis are student perceptions of this approach. To that end, we conducted a Student Assessment of Learning Gains survey and asked students to provide their honest, anonymous feedback on the entire process. Not surprisingly, the results varied from student to student, but the majority of students reported learning gains through the use of video lectures (Figures 7a and b).

At first glance, it is somewhat difficult to imagine how students could learn more effectively from a video lecture than an in-class lecture, in which question/answer sessions are absent and all instructor charisma and enthusiasm is muted. However, the advantages that students reported with video lectures (previously listed) must serve to overcome some of the drawbacks of a prerecorded medium. Indeed, students reported that they would often view lectures more than once, and that they would frequently pause or rewind the videos (Figures 7c and d). The opportunity to view and hear lecture material more than once and to pause the video in order to take notes or seek clarity on a confusing point may indeed represent the major advantage of video lectures.

As a final point of analysis, it occurs to us that, when lecture attendance was optional and videos of the lecture were posted to the web, nothing stopped students from attending the lectures and watching or reviewing the videos while preparing for exams. Indeed, a significant number of students reported doing exactly that, indicating an unexpected but advantageous component of our project (Figure 7e).

Conclusions and caveats

Although additional study is needed, this experimental foray in video lectures has been encouraging. Students have proven that they are capable of learning the complicated course material of Bio 104 that is normally conveyed through in-class lectures via video recordings. However, a number of very important caveats warrant mention before any further promotion of web-hybrid enhancement in the sciences should be considered.

1. First, neither the laboratory nor the recitation sessions of Bio 104 were altered in any way during this study. It remains a strong possibility that a large portion of student learning occurs during these sessions and tampering with the delicate and tightly woven interactions of the three sessions must be done with great care.

2. John Jay College enrolls an entirely commuter and primarily low-income student population. Thus, the advantages of modes of distance- and web-based learning may be particularly strong for this demographic. Residential campuses and those enrolling students who do not typically work outside school or care for family members might not find the same advantages with web-based learning.

3. Although students self-selected into the experimental hybrid learning group for this study, future offerings of hybrid sections could attract students who do not yet exhibit the personal responsibility necessary for success in an attendance-optimal setting. Rather, these sections may attract students looking only for reduced time commitment, the opposite of which is likely required for successful hy-
Questions, possible answers, and student responses to an anonymous Student Assessment of Learning Gains survey conducted at the end of the semester within section 5.

a. Overall, I feel that the use of video lectures improved my learning in this course.

- 10 strongly agree
- 6 agree
- 6 indifferent
- 2 disagree
- 0 strongly disagree

b. Compared to traditional in-class session, I feel that video lectures prepared me for exams.

- 9 much better
- 4 somewhat better
- 7 as well
- 4 not as well
- 0 worse

c. The average number of times I would view a video lecture is.

- 15 strongly agree
- 4 agree
- 2 indifferent
- 2 disagree
- 0 strongly disagree

d. While I viewed the video files, I would frequently pause the video in order to write things down.

- 6 strongly agree
- 4 agree
- 3 indifferent
- 3 disagree
- 2 strongly disagree

e. Even when I attended the optional in-class lectures, I _______ watched the videos as well.

- 6 every time
- 4 usually
- 3 sometimes
- 3 rarely
- 5 never
- 3 N/A

4. Although Bio 104 is composed largely of freshmen, it is the continuation of Bio 103. Thus, these students had already survived some amount of “screening” by passing Bio 103. The use of video lectures in Bio 103 or other courses consisting mostly of first-semester freshmen may not fare as well.

5. Biology courses, and especially Bio 104, are inherently less quantitative and skills based than other science courses in the curricula of most science major programs of study. Rather, Bio 104 is extremely information dense. Therefore, it is possible that in choosing Bio 104 for this experiment, we have selected the course that most lends itself to this medium. It may be that similar success in other courses is simply not possible, given their emphasis on the progressive building of complex quantitative skills.

6. In-class exams were maintained for this study. We cannot envision any web-based substitute for in-class exams that would meet the intensity, rigor, and security required of effective examinations in this and other science courses.

In sum, we feel that this project has been a success and that the carefully monitored introduction of web-based instruction can succeed under the right circumstances. Our future directions of research into this area involve enhanced student-student and student-teacher contact through Instant Messaging (IM), online study groups and chat rooms, online professor office hours, and online review sessions, and the increased use of digital media in biology instruction, both in the classroom and for private student study. With a wealth of quality open-source information now at students’ fingertips through the internet, we need only give students proper direction toward a lifetime of science learning.

Acknowledgments
This work was made possible by a grant from the Alfred P. Sloan Foundation to the The City University of New York to
foster the development of online teaching resources. The authors would like to thank the TechSmith Corporation for technical help with the Cantasta Studio Software and Anthony Carpi, Diana Friedland, and George Otte for critical reading of the manuscript and many helpful and constructive discussions.

References

Nathan H. Lents (njlents@jjay.cuny.edu) is an assistant professor in the department of sciences at John Jay College of Criminal Justice, of The City University of New York, in New York. Oscar E. Cifuentes is a research assistant in the laboratory of Professor Lents at John Jay College.