Construction and Evaluation of an Online Microbiology Course for Nonscience Majors

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The development of web-based technologies provides a new method for course delivery. As with any new technique, evaluation is a necessary tool to determine if the method is consistent with expectations. This study describes the conversion of a nonscience majors’ microbiology lecture course to online delivery and evaluates the hypothesis that the online course can be as effective as the traditional course. Course examination scores are compared between the face-to-face and online sections over a 3-year period. On all but one of the course examinations, no significant difference is found for those students in these two distinctly different course types. The success rate, as defined by those students earning grades of C or better, is high for both course types, although the traditional course success rate is slightly higher. Student evaluations of the courses are also positive, though some differences are noted. Overall, student performance in the online course is equivalent to that in the traditional course.

Web-based technologies can provide an alternative method for presenting course material that is independent of the traditional classroom. Online-delivered courses can provide for more flexible course scheduling by students and potentially increase the available audience for the course, especially at institutions serving large commuter populations and nontraditional students (14). Krawiec et al. (6) note that bacteriology is a subject well-suited to the development of online course materials due to the availability of numerous electronic resources, such as the Microbelibrary sponsored by the American Society for Microbiology (http://www.microbelibrary.org) and other electronic collections. Web-based instructional materials can also provide content in a way that a textbook or lecture cannot, including the ability to give students several ways to interact with fundamental ideas through animations and interactive exercises, as well as place questions within the content to increase student interactions with the content (8).

Yet, successfully transitioning from the traditional classroom presents challenges regarding how to properly deliver course information in a web-based format. Some students may perceive a diminished level of interaction with the instructor in an online course (6, 10) or that online course modules require too great of a work load (6). Faculty may also be concerned with the time commitment associated with an online course (7). To address some of the challenges of online teaching, Graham et al. (3) suggest seven principles of good online course design based upon the seven principles of good practice in undergraduate education (1).

This study describes the conversion of a nonscience majors’ microbiology lecture course, Applied Microbiology, from traditional delivery to almost a 100% web-based format and evaluates the hypothesis that a well-designed online course can be as effective as a traditional course in teaching microbiology to nonbiology majors. A few other studies have shown no difference in student learning between face-to-face and online learning experiences for science courses, including a nonscience majors’ environmental science course (10), a course for undergraduate physiology students (2), an introductory biology course at a community college (5), and a graduate bioinformatics program (9).

Applied Microbiology is a three semester credit hour (SCH) course for nonbiology majors that is taken primarily by students in the university’s hospitality management program. A separately-graded laboratory course (Applied Microbiology Laboratory, 1 SCH) accompanies the lecture and is offered in only a face-to-face format. Concurrent enrollment in both the lecture and laboratory is recommended, but not required. Development of the online course material began in March of 2001, with the first offering of the online version of Applied Microbiology in the spring semester of 2002.

METHODS

Development of online materials. The conversion of the course to online format began with the development of lesson outlines based on existing lecture note materials. Unlike the classroom schedule, where a particular topic must be presented in x number of 50- to 80-minute intervals, the online environment allows for flexible amounts of material to be presented in each lesson. During the conversion of this course, 27 traditional lectures that had been delivered in 80-minute class periods were redistributed among 17 online lessons (Table 1). Groups of four to five of these lessons were then placed into a total of four major topics: history and diversity; biotechnology and food microbiology; and microorganisms and disease. The information covered in each of these topics corresponded to the material for one of the four lecture examinations.
Using the lesson outlines as a guide, the verbal portions of the lecture were adapted to a written format. Of particular concern during this process was the need to augment the written text with appropriate visual and other stimuli to provide a complete learning experience in place of the traditional classroom. Graphical elements included in the course design were of two types: those for visual appeal and those to provide information. A graphic for visual appeal, such as a photograph of a bottle of wine used while discussing wine fermentation, provides no new information, but helps to break up the monotony of the text and maintain visual interest. An informational graphic might encompass some illustration that would have been drawn on the chalk- or whiteboard in a traditional lecture setting. Another type of informational graphic available in an online course is an interaction, such as a Flash animation, which might allow students to visualize a complex process or interact with the figure in a dynamic way (Fig. 1), a component that is absent from a face-to-face lecture. Other multimedia elements, such as sound files or video clips, can also enhance the online learning environment. Some graphical elements for this course were created by the author using commercially-available illustration software, while complex Flash animations and other multimedia were developed for the course with assistance from a campus-based course development center.

Another design decision in the development of an online course relates to the schedule of instruction. The scheduling flexibility of online courses allows for several options on the timing of release of course material, including either self-paced or timed release. For this course, timed release was chosen, with each lesson open to students for approximately 8 days.

One of the biggest challenges in converting a course to fully-online delivery may be in determining the method for evaluating student learning. Some methods, such as homework assignments, are easily adapted to the online learning environment and can be turned in electronically. Class discussions can be included in the course in either a synchronous (live chat) or an asynchronous (discussion board) manner. For examinations, a major issue is the ability to maintain academic integrity in a distance learning environment. For this reason, the course in this study required that students come to a proctored on-campus site for examinations.

**Evaluation of student performance.** Data were collected for a retrospective study of student performance in the traditional and online sections of Applied Microbiology for the period between July 2001 and May 2003. During this timeframe, three traditional sections and three online sections were taught by the investigator. Performance data included student exam scores and course letter grades. Laboratory
averages were also compared to serve as a control, since the laboratory experience was the same for all students regardless of lecture format. A comparison of the weekly topic schedule for lectures for both traditional and online sections and laboratory is given in Table 1.

Exam scores and laboratory averages were analyzed by independent-samples t test and analysis of variance using the SPSS statistical program. Letter grade distribution was analyzed using a two-tailed Mann-Whitney U test. The test was performed using the utilities available on the VassarStats website (http://faculty.vassar.edu/lowry/VassarStats.html).

Comparison of student evaluations. Student course evaluations from the same 3-year time period were also compared. Evaluations from both versions of the course utilized the standard departmental course evaluation instrument. This instrument consisted of 18 Likert-type questions (three of these questions related to the laboratory only and were excluded from this study) and two free response sections, one for favorable comments and another for unfavorable comments. For online sections, two additional questions relating to online instruction were added, as well as an additional comment section relating to web course improvement. All student responses were anonymous (Table 2). The evaluation results were analyzed using a two-tailed Mann-Whitney U test performed on the VassarStats website.

RESULTS

Student performance. The analysis of student performance utilized information from only those students who had completed all portions of the course, including the associated laboratory component. During the study period, 73 students in the traditional sections and 61 students in the online sections met these criteria.

The demographics of the students in each class were similar (Table 3). Males comprised 47.9% \((n = 35)\) of students in the traditional sections and 45.9% \((n = 28)\) of those taking the course online. Females comprised 52.1% \((n = 38)\) and 54.1% \((n = 33)\) of the students respectively. The ethnic distribution for the traditional sections was 68.5% \((n = 50)\) Caucasian, 11.0% \((n = 8)\) African-American, 11.0% \((n = 8)\) Hispanic, and 9.6% \((n = 7)\) Asian. For the online sections, the distribution was 68.9% \((n = 42)\) Caucasian, 8.2% \((n = 5)\) African-American, 9.8% \((n = 6)\) Hispanic, and 13.1% \((n = 8)\) Asian. For the online sections, the distribution was 68.9% \((n = 42)\) Caucasian, 8.2% \((n = 5)\) African-American, 9.8% \((n = 6)\) Hispanic, and 13.1% \((n = 8)\) Asian. In the traditional sections, 79.5% \((n = 58)\) of the students were in the 18- to 23-year old age range and 20.5% \((n = 15)\) were 24 years of age or older. Students in the 18 to
The results of the t test analyses of final laboratory averages showed no significant differences between traditional and online section students (Table 4). This is an indication that the students in the two groups are similar. No comparisons are available for students who took the course without the laboratory component due to the small sample size available for the study period (only three students in the traditional sections and 13 in the online sections did not take the laboratory).

Although the mean scores on the four regular exams of the students in the traditional sections were higher than those of the online students, only one of the four, Exam #3, showed a significant difference (Table 4). Additionally, student performance on the comprehensive final examination showed no significant difference between the two groups.

Interactions between course delivery type and either the students’ age, sex, or ethnicity were examined by two-factor analysis of variance (Table 3). Interaction effects were not found between course type and age range for most of the exams, with the exception of Exam #2. For Exam #2, an interaction effect was noted where students in the 18 to 23-year old age range did better on this exam if they were in the traditional format sections, while the students age 24 and older who were in the online sections had a higher average than similar students in the traditional sections. No significant interactions were found for any of the exams for course type and sex. However, an interaction effect was seen in the laboratory average; males in the online sections had a much lower average than any of the other groups. Likewise, no interaction between course type and ethnicity was seen for the exams but was found for the laboratory. Caucasian students in the traditional sections had a higher laboratory average than those in the online section, while non-Caucasian students had a higher laboratory average if they were in the online sections.

The distribution of final grades was also examined. For the traditional sections, 97% of the students who began the course completed it, with only 3% withdrawing or earning an incomplete. The completion rate for the online students was 95%. The success rate, defined as students who earned a grade of A, B, or C, was 96% for the traditional students and 82% for the online students. The distribution of letter grades for each delivery method is shown in Fig. 2. The differences in grade distribution for students in the two course formats was found to be significant ($U_A = 3656.5, Z = -3.52, P = 0.0004$).

**Student evaluations.** A total of 76 students were enrolled in traditional sections of the course during the study period, and 73 were enrolled in online sections. Course evaluations were obtained from 53 students in traditional sections (69.7%) and 66 students in online sections (90.4%). The difference in response rates may be attributed to the timeframe of evaluation delivery. Evaluations in traditional sections were administered during a single class period, while online sections had access to the evaluation instrument over a 3- to 5-day period.

Overall, students in both versions of the course gave positive evaluations. All areas evaluated by the instrument were ranked near or higher than the “above average” level in each version of the course. There were, however, six questions on which there was a significant difference in the rankings by students in the different versions of the course. In each of these six cases, the students in the online sections gave a lower mean rank than those in the traditional section (Table 2).
In overcoming those limitations, while not increasing the tools available in an online learning environment can assist lecture notes. Good instructional design and use of the many courses must go beyond the simple posting of a professor’s between the instructor and student in the classroom. Online delivery relative to the personal interactions that exist be-care must be taken to recognize the limitations of distance provides a positive learning experience for students. Particular in this process is worthwhile if it results in a course that pro-

A tremendous amount of planning and effort is necessary when creating an online course. However, the effort expended in this process is worthwhile if it results in a course that provides a positive learning experience for students. Particular care must be taken to recognize the limitations of distance delivery relative to the personal interactions that exist between the instructor and student in the classroom. Online courses must go beyond the simple posting of a professor’s lecture notes. Good instructional design and use of the many tools available in an online learning environment can assist in overcoming those limitations, while not increasing the instructional workload for the faculty (7, 15). The effective use of course tools such as e-mail and discussion may actually provide increased interaction among course participants (16).

While one may wonder whether all this work is worth the effort, it is important to remember that there are also advantages to online course delivery. An online course can provide an opportunity to reach students who might not have been able to access the course due to geographic distance or because of other constraints on their schedule, such as work or family obligations. In addition, while online courses

<table>
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<tr>
<th>Item</th>
<th>Variable</th>
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<th>DoF</th>
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<td>79.3% (11.5), n = 44</td>
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<td>82.0% (9.9), n = 16</td>
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<td>Comprehensive final exam</td>
<td>18-23</td>
<td>79.7% (10.5), n = 58</td>
<td>76.1% (12.3), n = 44</td>
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<td>73.7% (9.6), n = 15</td>
<td>78.2% (12.3), n = 17</td>
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<td>Laboratory avg.</td>
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<td>84.5% (7.5), n = 35</td>
<td>78.7% (12.2), n = 28</td>
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<td>83.6% (12.2), n = 38</td>
<td>87.3% (7.0), n = 33</td>
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<td>Lecture exam 1</td>
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<td>75.5% (11.6), n = 32</td>
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<td></td>
<td>Female</td>
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<td>70.6% (18.0), n = 33</td>
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<tr>
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<td>71.2% (12.4), n = 27</td>
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<td>0.002</td>
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<td></td>
<td>Female</td>
<td>73.5% (14.9), n = 37</td>
<td>72.5% (14.0), n = 33</td>
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<tr>
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<td>80.7% (10.6), n = 28</td>
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<td>1.32</td>
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<td>77.9% (10.7), n = 33</td>
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<td>Lecture exam 4</td>
<td>Male</td>
<td>86.2% (10.3), n = 35</td>
<td>78.9% (8.7), n = 24</td>
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<td>82.3% (8.9), n = 33</td>
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<tr>
<td>Comprehensive final exam</td>
<td>Male</td>
<td>78.0% (10.6), n = 35</td>
<td>73.3% (11.3), n = 28</td>
<td>1</td>
<td>1.99</td>
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<tr>
<td></td>
<td>Female</td>
<td>78.8% (10.6), n = 38</td>
<td>79.6% (12.5), n = 33</td>
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<td>Laboratory avg.</td>
<td>Caucasian</td>
<td>85.0% (9.4), n = 50</td>
<td>81.4% (11.3), n = 42</td>
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<td>Lecture exam 1</td>
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<td>70.6% (20.5), n = 19</td>
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<td>Lecture exam 4</td>
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<td>Comprehensive final exam</td>
<td>Caucasian</td>
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<td>Non-Caucasian</td>
<td>79.4% (9.2), n = 23</td>
<td>77.1% (13.8), n = 19</td>
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* A value of ≤ 0.05 was considered significant.

**DISCUSSION**

A tremendous amount of planning and effort is necessary when creating an online course. However, the effort expended in this process is worthwhile if it results in a course that provides a positive learning experience for students. Particular care must be taken to recognize the limitations of distance delivery relative to the personal interactions that exist between the instructor and student in the classroom. Online courses must go beyond the simple posting of a professor’s lecture notes. Good instructional design and use of the many tools available in an online learning environment can assist in overcoming those limitations, while not increasing the instructional workload for the faculty (7, 15). The effective use of course tools such as e-mail and discussion may actually provide increased interaction among course participants (16).

While one may wonder whether all this work is worth the effort, it is important to remember that there are also advantages to online course delivery. An online course can provide an opportunity to reach students who might not have been able to access the course due to geographic distance or because of other constraints on their schedule, such as work or family obligations. In addition, while online courses
require a much higher input during the development phase, the instructor can also reap some long-term benefits, including a more flexible teaching schedule and an opportunity to examine new teaching approaches that may strengthen traditional classroom instruction (4). With proper planning, the conversion between a traditional lecture course and online delivery can be a successful endeavor for all involved.

When introducing any new method of delivery in teaching one’s classes, it is important to evaluate the method with at least a standard of “do no harm” (13). In this study, the students in the traditional and online sections have very similar outcomes on the items examined. With the exception of one lecture examination out of four, there is no significant difference between the mean scores of students in the two course types (Table 4). Likewise, no significant difference was found for the comprehensive final examination means. Both versions of the course have very strong success rates, but there was a significant difference in the distribution of letter grades (Fig. 2). Students in the traditional sections earned a preponderance of B grades, while the grades for the online sections were more evenly distributed between B and C to approximate a more normal curve. Since there was little difference in examination scores between the two groups, other grade factors are the likely cause of this grade distribution difference. A significant portion of the participation grade for the traditional sections was a class attendance grade, while the participation grade for online students consisted of graded assignments. These methods for determining the participation grade are not equivalent and are weighted in favor of the traditional student for whom a higher grade could be earned simply by attending class. The assessment of the participation grade in the course should be reevaluated to identify a method that will work equally well with both course formats.

Interaction between course type and students’ age, sex, or ethnicity was not widely noted for the examinations in the course (Table 3). Only one exam, Exam #2, showed an interaction for age in which the 18- to 23-year old students who were in traditional sections had a higher average than those in the online sections, and the students age 24 and older who took the course online averaged higher than those in the traditional sections. Interestingly, interactions between course type and both sex and ethnicity were found for the laboratory averages. The laboratory average for males in the online course was much lower than any of the other groups, which all appeared to be similar. For ethnicity, non-Caucasians in online sections did better in the laboratory than those in the traditional sections, with the opposite seen for Caucasian students. While the group sizes were too small to allow meaningful statistical analysis of the individual non-Caucasian ethnic groups, a review of the laboratory averages for each ethnic group showed that the trend of higher laboratory averages for online students was true for each of the non-Caucasian groups represented in this study (data not shown). While the reason for this outcome is not clear, similar results have been shown by Riffell and Merrill (11) for laboratory performance of ethnic minorities who are enrolled in hybrid-format (partially-online) lecture courses in introductory biology.

While students in both versions of the course are generally positive on their evaluations, it is interesting to note that there were significant differences in the rankings by the two groups for six questions (Table 2). Online students rank the course slightly, but significantly lower on each of those questions, including four which related directly to student-instructor interactions and communication. Another question on which the online students’ ranking is significantly lower is “The course organization aids in studying and understanding the materials covered.” The narrative comments which most directly address course organization are those that discuss course assignments. Several students suggest either more assignments or better clarification of assignments. Another suggested improvement to course organization is to add more frequent quizzes to the course.

The final question for which there is a significant difference between online and traditional students’ responses is the question, “The instructor meets class regularly and punctually.” Given that the course materials in the online sections are released regularly and according to a set schedule, it is likely that the difference seen in the responses to this question may be due to the question not being worded appropriately for the online sections. One student mentions

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**TABLE 4. Comparison of performance between students in traditional and online sections**

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<tr>
<th>Item</th>
<th>Mean (SD) Traditional</th>
<th>Mean (SD) Online</th>
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<th>t*</th>
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<td>Laboratory avg.</td>
<td>84.0% (10.2), n = 73</td>
<td>83.3% (10.6), n = 61</td>
<td>132</td>
<td>0.395</td>
<td>0.694</td>
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<td>Lecture exam 1</td>
<td>73.3% (13.8), n = 69</td>
<td>71.8% (16.8), n = 59</td>
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<td>0.548</td>
<td>0.585</td>
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<td>72.8% (14.9), n = 72</td>
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<td>83.0% (9.6), n = 73</td>
<td>79.2% (10.7), n = 61</td>
<td>132</td>
<td>2.18</td>
<td>0.031*</td>
</tr>
<tr>
<td>Lecture exam 4</td>
<td>84.5% (12.7), n = 72</td>
<td>80.9% (8.9), n = 57</td>
<td>127</td>
<td>1.84</td>
<td>0.068</td>
</tr>
<tr>
<td>Comprehensive final exam</td>
<td>78.4% (10.5), n = 73</td>
<td>76.7% (12.3), n = 61</td>
<td>132</td>
<td>0.872</td>
<td>0.385</td>
</tr>
</tbody>
</table>

*Independent-samples t test comparing performance between students in traditional and online course sections.

A value of ≤ 0.05 was considered significant.
in the narrative comments that it is difficult to answer some evaluation questions because they are targeted more toward a traditional class. This indicates that the instrument used to evaluate traditional courses needs to be modified to account for instructional differences in online delivery, as noted by Roberts et al. (12).

Students in the online sections are very positive on the questions specific to the online version of the course. The students rank both questions, “The course modules in WebCT were an effective means for presenting the subject material” and “In general, communication with the instructor was effective through e-mail and discussion forums,” as “above average.”

Overall, the students in the online version of Applied Microbiology are performing at a level nearly equivalent to those in the traditional section. While exam averages and letter grades were slightly lower for online students, students in the online microbiology course for nonscience majors were positive on student evaluations and were generally successful in the course. From these observations, the online version of the course provided a reasonable alternative to the traditional delivery method of the same course material. Future research should explore the reasons why some exam scores were lower for online students and whether additional course elements could counteract this trend. As well, further examination of student evaluations of the course format and a comparison of how students’ attitudes toward microbiology might be affected by course delivery method would be useful.

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REFERENCES


