Student Responses to Active Learning Strategies in a Large Lecture Introductory Microbiology Course

Erica Suchman¹, William Timpson², Kathleen Linch³
Sylvia Ahermae⁴, & Ralph Smith¹

Department of Microbiology¹, Center for Teaching and Learning²,
Department of Mathematics³ & Rocky Mountain Teachers Education Collaborative⁴
Colorado State University
Fort Collins, CO 80523
Email: esuchman@cvmbs.colostate.edu

ABSTRACT: In an attempt to create a better learning environment for our large (100-300 student) junior level introductory microbiology course we introduced several methods to foster a more interactive classroom. These included student participatory demonstrations, student discussions of microbiology in the news, a variety of extra credit assignments, and the use of small groups. Small group activities include forming six-person groups early in the semester, completing four in-class group examinations, and submitting a poster describing a disease of their choice at the end of the semester. The results of our analysis show that the vast majority of students felt that they had benefited from the various active learning strategies and appreciated these innovations as active and creative extensions of their learning even though it required initiative and creative teamwork. This requires increased workload for the instructors, but the benefits seem worth the additional time and effort. This paper describes the methods used and provides a summary of students’ responses to the activities.

KEYWORDS: active learning, microbiology course, learning strategies

INTRODUCTION

Colorado State University, like many universities all over the nation, is coping with increased enrollment in the life sciences by enlarging lecture sections and decreasing the number of sections provided for lecture-only courses. Accordingly, our microbiology course (MB300) has seen a dramatic increase in the number of students enrolled. Prior to Fall 1997, MB 300 was delivered in a traditional large lecture format where students typically took down everything said in class to enable them to perform well on multiple choice exams. In these large lecture courses students often reported that they felt isolated, anonymous, and passive. Furthermore, although some students may thrive in a traditional lecture course, others possess learning styles, which benefit from other course structures [Timpson, Bendel-Simso 1996]. Tobias [1990], for example, has described the loss of talented students from science because of their unhappiness with traditional lecture instruction and courses graded on a curve, preferring more cooperative and supportive structures. A series of reports from the Carnegie Commission on Higher Education [Boyer 1990; Glassic et. al, 1997; Kenny 1998] have called for innovations to address longstanding problems with undergraduate education generally.

In restructuring we wanted to cover essential material and add opportunities for students to participate in the learning process during the class period. We believe the poster, group examinations, and extra credit assignments we use in MB 300 are viable ways to involve undergraduates in a large lecture course in inquiry-based course assignments, activities which require some measure of individual initiative, critical thinking and creativity. These assignments also attempt to address the two primary factors in effective postsecondary instruction as identified by Lowman (1995), intellectual excitement and rapport. Creating a poster or science based work of art for public display added a level of performance that tended to heighten student motivation and participation (Timpson et. al., 1997). Our requirement for group exams and the poster project in which students work in teams expanded on Lowman’s (1995) notion of
Finally, redesign of MB300 was guided by Tobias’s (1990) groundbreaking work in reporting the discouragement which talented students experienced in large science classes when the instructor focus was on information transmission within an individualized and competitive course design. Noting the large proportion of women and minority students who went onto successful careers in other fields, Tobias labeled the problem as one of “cloning,” where teachers (primarily white and male) replicated themselves and their own preferences for learning.

After creating these interactive activities we wanted to know if the students realized the benefits of these types of activities, particularly because they were being carried out in a large lecture course, and required more time and commitment from the students and instructors. Although the research shows these activities benefit student learning, that does not necessarily translate to student feelings of benefit.

MATERIALS AND METHODS

**Class characteristics:** Our course is an introductory Microbiology course in which 10% of the students are microbiology majors. Students are from approximately 30 different science majors across the campus. Eighty percent of the class are juniors or seniors, and the course is taught at a junior level. Prerequisites include general biology and organic chemistry. The course consists of three one-hour lectures per week, and 46 hours are available for instruction, including a two-hour final examination. Grades are determined based on the percentage earned from a 600 point total, as described in Table 1.

### Table 1. Point distribution for General Microbiology

<table>
<thead>
<tr>
<th>Examinations:</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midterm 1</td>
<td>100</td>
</tr>
<tr>
<td>Midterm 2</td>
<td>100</td>
</tr>
<tr>
<td>Midterm 3</td>
<td>100</td>
</tr>
<tr>
<td>Comprehensive final exam</td>
<td>200</td>
</tr>
<tr>
<td><strong>Group exams</strong></td>
<td></td>
</tr>
<tr>
<td>3 Graded group exams, 20 points each, lowest score dropped</td>
<td>40</td>
</tr>
<tr>
<td><strong>Poster project</strong></td>
<td></td>
</tr>
<tr>
<td>Mandatory Preparation meeting</td>
<td>5</td>
</tr>
<tr>
<td>Group grade</td>
<td>10</td>
</tr>
<tr>
<td>Individual grade</td>
<td>35</td>
</tr>
<tr>
<td>Student’s evaluations</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>600</td>
</tr>
</tbody>
</table>

**Possible extra credit** | Points
--- | ---
1 extra credit assignment | 10
Microbucks | 10

Graduate teaching assistants are generally not assigned to this course, but up to three undergraduate teaching assistants are available.

**Extra Credit Assignments:** One time during the semester, students are given the opportunity to raise their score in the course by participating in an extra credit assignment designed to encourage them to "think outside of the box" about microbiology. Students can earn up to 10 points by completing one of three to four alternative projects, such as reading a given research article, performing a library search of a specific topic, searching for specific information on the web, or creating a 3-D model, or poster of a complex biological process such as DNA replication, translation, or conjugation. Each semester the options change.

**Microbiology in the News Extra Credit/Microbucks:** We believe that showing students the relevance of microbiology to their everyday lives will motivate them to learn microbiology. We decided to give students “microbucks” (worth one point of extra credit) for finding interesting and relevant articles in the paper, and sharing them with the class. Studies on information processing indicate that student ability to sustain their attention and recall new material is at its lowest at the midpoint of a lecture. In general, students need to periodically work with new material to prevent a rapid learning loss (Craik & Hockhart, 1972, Woolfolk, 1995). Therefore, 20 minutes into class we stop and choose students to discuss articles they found in a recent newspaper. This process takes about 5
minutes of class time. Only 3 stories are discussed each lecture, and students are not required to have earned microbucks for any specific grade.

**Student Participatory Demonstrations:** Students can earn extra credit by participating in demonstrations that illustrate difficult microbiological concepts. Each demonstration takes no more than 10 minutes, involves up to 6 students and illustrates flagella movement, Hfr interrupted mating genome mapping, transduction, cloning, the Ames test, replica plating for mutant isolation, transcription, or translation.

**Small group in-class examinations:** In the third week of class students are given a practice examination where they are asked to form six-member groups and complete a non-graded in-class exercise. This exercise requires them to synthesize information from lectures and text to complete a simple task relevant to the subject matter in lecture. The practice exercise in the 3rd week is not graded, and a general discussion (20 minutes) is conducted to summarize the class activity. Three graded in-class examinations are given later in the semester and cover metabolism; transcription, translation and mutations; and viral life cycles and antiviral drugs. During the second group examination (after the drop deadline), students form permanent six-member groups. We found it important to form permanent groups after the drop deadline, to eliminate fragmented groups that result from students dropping the course. The students are each given the in-class examinations 1 week before they are to meet. On the day of the in-class examination, groups meet to compile a common answer. During the class period, the instructor circulates to answer questions, observe progress, and attendance. Groups compile a common answer to the in-class examination, and turn it in for credit. Each graded in-class examination is worth 20 points for each student, and the lowest score for the three examinations is dropped. This eliminates make-up examinations for students who miss one examination. Due to the difficulty we experience in writing really good critical thinking questions, we do not allow students to keep graded exams. However, correct answers are posted, and students can look at their exams during office hours.

**Small group poster projects:** Student groups are given a handout that describes the poster project. Each group selects a unique infectious disease. Each poster must describe the disease, the microbe, epidemiology of the disease, treatment, prevention, and diagnosis. Each student selects one section that is his/her responsibility, and the group is responsible for a format, editing, references and accuracy. Students are given expectations, a suggested layout, recommended reference styles and a grading rubric. One week before posters are due one class session is devoted to an exchange of draft materials, and group members evaluate and guide each other's materials. Posters are hung in the microbiology building using inexpensive runners and large paper clasps. Posters are graded on the quality of the input from each student and the appearance of the poster. Posters remain on view for the rest of the semester. The instructors generate a set of questions from the posters, and two class periods are dedicated to poster viewing and answering the questions posed. Students are told that 10 of these questions will appear on the final. Each student peer evaluates his or her fellow group-members on the quality of their contribution to the groups efforts. Peer evaluation helps motivate students who might otherwise be tempted to allow other members to do all the work.

**Evaluating Student Responses:** Two formal evaluations are conducted each semester. During the eighth week, a faculty member of the Center for Teaching and Learning (William Timpson) is invited in as an expert in postsecondary instruction and learning to facilitate a class meeting. Drawing on the work of Glasser (1969 a & b, 1992) and others (Timpson & Bendel-Semso, 1996), Timpson uses the standard University student course evaluation form and a structured process to solicit student appreciation, concerns and recommendations for improvement. This evaluation takes 20 minutes of class time, and generates a written student evaluation of the class to the midpoint of the course. At the end of the semester students are then provided the same university-wide form to complete. Instructor-asked questions are permitted, and are used to evaluate many of the innovations that we have introduced. During the fall, 1998 semester, additional evaluation was provided by one of the authors (Sylvia Ahermae), a teacher-in-residence who attended class daily. She observed student participation, the pattern and frequency of student questions, and circulated around the room to observe and listen to student concerns and comments. In addition another of the authors (Kathleen Linch), an undergraduate student majoring in math education was hired to conduct student consultation groups during the semester. Three groups were targeted: one involved students currently enrolled in the course; a second involved students who had identified their interest in K-12 or higher education; and a third group involved students who had taken the course within the past two years. Between seven and ten students participated in each consultation group. Student consultation groups met outside of class, filled out a questionnaire designed by the instructors, and engaged in free-flowing conversation facilitated by Ms. Linch. Their discussions were recorded on tape or teaching assistants were present to transcribe student comments.

**RESULTS**

We wanted to make the large lecture setting seem smaller, to create a more diverse learning environment that would foster learning and retention in students with different learning styles, and to have students take...
a more active role in their own education and develop teamwork skills. In general, we expected these strategies to improve student morale and deepen student learning.

To determine if students felt these activities were achieving these goals, during the end of semester evaluations students were asked about the benefit of specific active learning strategies. We analyzed the responses of all responding students in the last four semesters, for both Dr. Smith's and Dr. Suchman's sections. The questions we asked included:

1. Did Microbiology in the News added to your understanding and appreciation of Microbiology?
2. Did lecture demonstrations help you visualize microbial concepts?
3. Did extra credit exercises expand your knowledge?
4. Did the group projects benefit you?
5. Did the poster project help you learn about diseases?
6. Did the group exams help improve your learning?

For each of the questions the majority of students (greater than 70%) responded that they agreed or strongly agreed that it did (Table 2). The microbiology in the news and extra credit options were particularly popular. Many students commented on their end-of-the semester evaluations how much they appreciated both the break in lecture and hearing about real world applications of microbiology. The extra credit exercise is the most popular active learning strategy we use, primarily because students feel they can prove their abilities outside of examinations and recoup points lost on examinations.

**Table 2: Student Course Evaluations of Active Learning Strategies**

<table>
<thead>
<tr>
<th>Question</th>
<th>% Marking Agree or Strongly Agree</th>
<th>% Marking Neutral</th>
<th>% Marking Disagree or Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microbiology in the News added to my understanding &amp; appreciation of Microbiology</td>
<td>Dr. Suchman a 87.7 Dr. Smith b 89.5</td>
<td>Dr. Suchman 7.7 Dr. Smith 7.6</td>
<td>Dr. Suchman 4.6 Dr. Smith 2.9</td>
</tr>
<tr>
<td>Lecture Demonstrations helped me visualize microbial concepts</td>
<td>Dr. Suchman c 85.7 Dr. Smith d 91.5</td>
<td>Dr. Suchman 12.6 Dr. Smith 6.6</td>
<td>Dr. Suchman 1.7 Dr. Smith 1.9</td>
</tr>
<tr>
<td>Extra Credit Exercises Expanded my Knowledge</td>
<td>Dr. Suchman e 94.0 Dr. Smith f 95.6</td>
<td>Dr. Suchman 4.5 Dr. Smith 2.7</td>
<td>Dr. Suchman 1.5 Dr. Smith 1.7</td>
</tr>
<tr>
<td>The poster project helped me learn about diseases</td>
<td>Dr. Suchman g 70.6 Dr. Smith h 79.0</td>
<td>Dr. Suchman 17.6 Dr. Smith 14.0</td>
<td>Dr. Suchman 11.8 Dr. Smith 7.0</td>
</tr>
<tr>
<td>The group exams helped me improve my learning</td>
<td>Dr. Suchman g 76.4 Dr. Smith h 71.0</td>
<td>Dr. Suchman 11.8 Dr. Smith 14.0</td>
<td>Dr. Suchman 11.8 Dr. Smith 15.0</td>
</tr>
</tbody>
</table>

a: 284 students surveyed, b: 659 students surveyed, c: 175 students surveyed, d: 590 students surveyed, e: 67 students surveyed, f: 293 students surveyed, g: 51 students surveyed, h: 114 students surveyed.

During the student consultation meetings students were also asked about the benefit of specific active learning strategies. The questions we asked included:

1. Did the group exams help you understand the concepts?
2. Did the group exams help you learn how to work with people?
3. Did the people in your group contributed equally?
4. Did you enjoy the group projects?
5. Do you prefer to work alone rather than in groups?
6. Would you rather learn about diseases from lecture than from posters?

On questions 1-4 the majority of students (greater than 51%) responded agree or strongly agree (Table 3). On the last two questions more students disagreed than agreed, although a large percentage were neutral. This indicates that a large percentage of students would prefer to have active learning strategies utilized in their courses. Interestingly, only 53.9% of the consultation group members indicated they enjoyed the group projects but 80.4% or Dr. Suchman's and 69.8% of Dr. Smith's students indicated they benefited on end of semester evaluations, showing they realized the benefit even if they did not enjoy the process.
Table 3: Student Consultation Group Results Evaluating Group Activities

<table>
<thead>
<tr>
<th>Question</th>
<th>% Marking Agree or Strongly Agree</th>
<th>% Marking Neutral</th>
<th>% Marking Disagree or Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The group exams helped me understand the concepts</td>
<td>63.5</td>
<td>11.5</td>
<td>25.0</td>
</tr>
<tr>
<td>The group exams helped me learn how to work with people</td>
<td>51.9</td>
<td>21.2</td>
<td>26.9</td>
</tr>
<tr>
<td>The people in my group contributed equitably</td>
<td>51.9</td>
<td>15.4</td>
<td>32.7</td>
</tr>
<tr>
<td>I enjoyed the group projects</td>
<td>53.9</td>
<td>19.2</td>
<td>26.9</td>
</tr>
<tr>
<td>I prefer to work alone, not in groups</td>
<td>32.7</td>
<td>21.2</td>
<td>46.1</td>
</tr>
<tr>
<td>I would rather learn diseases from lecture than posters</td>
<td>28.6</td>
<td>23.8</td>
<td>47.6</td>
</tr>
</tbody>
</table>

Table 3. a: 52 students surveyed, b 21 students surveyed

Furthermore, one of the authors (William Timpson) facilitated 20-minute interactive whole class debriefing sessions and found clear evidence of growing student support for these group projects despite the challenges associated with this kind of graded teamwork. Impressively, students were nearly unanimous and clear about the benefits to them of using microbiology content in creative ways on the posters. Furthermore, the teacher in residence (Sylvia Ahermae) noted in her final analysis of our courses that most students she spoke with felt that group projects were a positive experience. Many noted the pride they felt when viewing their creative works displayed in the hallways of the Microbiology building and when they saw how professional the posters appeared. Admittedly, some students felt that the posters were not college-level work. Therefore, we now spend more time discussing the use of posters as a method of communication at professional meetings, and how this project will help prepare them for these types of activities.

DISCUSSION

From our analysis, the majority of students found these innovations to be beneficial. One concern we had about demonstrations and some of the more artistic projects in this course, was that students would find them childish or beneath them. However, the students’ overwhelming agreement with the benefit of extra credit assignments, demonstrations, and "Microbiology in the news", reassures us that this is not a problem. In fact, students seem to appreciate the extra effort to help them visualize these concepts. Moreover, we feel that we now ask questions on examinations that demand a greater level of critical analysis than we could before we added these active learning strategies. However, we have not conducted any formal research into this area. Furthermore, it would be of interest in future studies to determine how student self-assessment and course assessment correlates with measures of student learning such as examination scores, poster grades, group exam scores, and final course grades. In summary, we believe that while adding active learning strategies to our course resulted in a dramatically increased workload for the faculty involved, it was worth the effort since student enthusiasm and learning in our course has increased. Furthermore, students recognize the benefits of these activities and feel they are helping them to learn, even though they are being conducted in a large lecture course. Therefore, we plan to continue the use of the active learning strategies in our large lecture course.

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LITERATURE CITED


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Bob Wallace, Ripon College

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