An Activity-Based Format Increased Student Retention in a Community College Microbiology Course

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Microbiology is offered each semester at the Allied Health Campus of Pearl River Community College. The evening course meets weekly for 16 sessions from 5 p.m. to 10 p.m. Most students enrolled in the course are in one of the seven associate degree allied health programs on the allied health campus. Among the challenges of teaching a course in this situation is retention of enrolled students. Although the course is required for most of the allied health programs on the campus, many students enrolled, attended class for a few weeks, and withdrew from the course. During the 1998-1999 school year the retention rates for students enrolled in the night microbiology classes for Fall and Spring semesters were 52% and 47%, respectively. The format for the 1998-1999 academic year was a conventional course with 2½ hours of lecture material followed by 2 hours of laboratory. Little or no effort was made to correlate laboratory and lecture topics. The course format for Fall 1999 was modified to (i) provide the laboratory component at the beginning of the time slot, (ii) tailor the lecture topics to relate to the laboratory component each night, and (iii) add an outside reading component. The laboratory served as an introduction to the lecture topic, and the lecture became more significant since it related directly to the laboratory experience. Following this format change the retention rate for the Fall 1999 semester increased to 80%.

Laboratory exercises coordinated with and preceding lecture topics in an introductory microbiology course taught to allied health students in associate degree programs had a positive effect on retention of enrolled students. Learning scientific concepts should be an active, not a passive, process (6). A learning activity is most effective when it both precedes and relates to the introduction of a concept (1, 10). Using laboratory activities to introduce concepts has been recommended by both the American Association for the Advancement of Science and the National Research Council (6, 10). The practice of coordinating laboratory activities with lecture topics has been shown to develop the understanding of concepts in both physics and chemistry (3, 4, 7, 11).

For practical reasons (class size, teaching load, laboratory space), the lecture and laboratory components may be taught as totally separate courses with the laboratory taught by a variety of instructors. Often, there may be no effort to correlate the laboratory and lecture aspects of the course. While some college students are abstract learners with the ability to develop relationships between the hands-on activities in the laboratory and the concepts in lecture, other students, concrete learners, are not as successful in building these connections. A study of community college students in Mississippi demonstrated that this is a population of concrete learners rather than abstract learners (5). The failure to build the bridge between a laboratory exercise and the lecture concept diminishes the value of both the lecture and the laboratory experience for many students. A schedule of laboratory activities and lectures that assisted students in making the connection between a hands-on laboratory experiment and a concept from lecture by the coordination of laboratory activities with lecture information is beneficial to many stu-

dents.

Laboratory exercises are expensive in: the need for supplies, time expended in laboratory prep (media, samples, culture), actual clock hours spent in laboratory sessions, and disposal of biohazardous material. In addition, only 1 credit hour is generated from 2 hours of official class time. The ability of the students to learn new concepts through their laboratory experiences, however, justifies the expenditure of time and resources.

Microbiology is a required course for students in many allied health disciplines. At Pearl River Community College (PRCC), microbiology is required for associate degrees (AD) in nursing, respiratory therapy, dental hygiene, medical laboratory technician, and surgery technician. Table 1 indicates the typical class distribution by program or major of students enrolled in microbiology courses taught on the Allied Health Campus of PRCC. The lecture was offered for 3 credit hours and the lab was offered for 1 credit hour. Although the course is required for several associate degree programs, many students at PRCC enrolled, attended class for a few weeks, and withdrew from the course. During Fall 1998 and Spring 1999 semesters, the retention rates for students enrolled in the Microbiology course were low (Table 2). The high attrition

TABLE 1. Typical areas of study for students enrolled in microbiology at PRCC in the night course on the Hattiesburg campus

Area of study	% Students
Associate degree (AD) nursing	37
AD medical laboratory technician	16
AD respiratory therapy	18
AD dental hygiene	11
AD surgical technician	5
AD radiological technician	2
Baccalaureate degree	11

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rate motivated the adjunct instructor to design a course that would encourage students to complete the course.

The strategies for retention found in this report were developed for a microbiology course taught at night. The course was scheduled for 5 hours once each week during a 16-week semester. The class met from 5 p.m. to 10 p.m. Most students attended school part time and had full-time responsibilities during the day. The adjunct instructor for the night course had responsibility for all aspects of the course except choosing the texts for the lecture and laboratory components. The same adjunct instructor taught all sections of lecture and laboratory included in this study. The strategies for retention included the coordination of laboratory activities with lecture topics, implementation of the lab activities as an introduction to the lecture topic for the evening, and introduction of an assignment to read a book from the popular press.

METHODOLOGY

The students enrolled during the Fall 1998 and Spring 1999 semesters served as the control group. During these semesters, each evening session began at 5 p.m. with a short quiz as part of the lecture session of 150 minutes. Breaks were taken at 6:30 p.m. and between lecture and laboratory at 7:45 p.m. The 120-minute laboratory followed. Students were permitted to leave after the laboratory activities were completed. Many students hurried through the assigned activity and left before 10 p.m.

No effort was made to coordinate lecture topics with laboratory experiments during these semesters. A schedule of topics for the course offered to the control group is included in Table 3. The topics were presented in the sequence of the textbook *Microorganisms in Our World* (2). Students in all groups were provided with an instructor-developed two-page summary of each lecture. An instructor-developed lab manual was used for all laboratory exercises. Materials for laboratory and lecture were distributed after the quiz each week.

The students enrolled during Fall 1999 were the test group. The schedule of topics for the test group in the modified course is included in Table 3. A concerted effort was made to coordinate the lab activity with the general topic for each evening's lecture and the format was changed to begin the evening with the laboratory activities. The evening began with a short quiz at 5 p.m. followed by the laboratory activities for 120 minutes. A 15-minute break preceded the 150-minute lecture which began at 7:15 p.m. There was a second 15-minute break at the midpoint of the lecture.

Some choices for coordinated topics were obvious. During session two, the relationship between the microscopic examination of pond water and a Gram stain of yeast cells was used to introduce eukaryotic cells as well as fungal and parasitic organisms. Interpretation of antimicrobial susceptibility testing was the logical experiment to precede the lecture on antimicrobial agents. For the session that focused on the immune system, an experiment to evaluate the phagocytic activity of polymorphonuclear white blood cells was modified to provide students an opportunity to observe fixed blood smears that contained phagocytized bacilli. Gram stain theory was explained and various morphological differences as well as gram-positive and gram-negative reactions were observed prior to the discussion of bacterial cell components.

Other topics were more difficult to coordinate. The first laboratory session focused on various safety considerations based on Occupational Safety and Health Administration guidelines. These included the use of personal protective and safety equipment; prohibitions against food, drink, and tobacco in the laboratory; and the use of and rationale for choosing the appropriate disinfectants for laboratory use. Although the only use of blood for this laboratory was a set of fixed, stained blood smears, the discussion of appropriate disinfectants and sterilization techniques for bloodborne pathogens introduced viral bloodborne pathogens, which progressed into a general presentation on virology in lecture. Students had the opportunity to inoculate and interpret differential media based on the fermentation of various sugars, such as mannitol salt agar and MacConkey agar, before the lecture presentation on the principles of fermentation.

Four laboratory sessions in the second half of the course included student presentations based on the class reading project (Table 3). Each student read at least a portion of one of four assigned books. Students who read the same book gave a group presentation to the class on some aspect of their chosen book during time allotted for the laboratory. All presentations included visual aids and class handouts. Presentation formats included book summaries, a skit, and a slide show. The presentation for *Man and Microbes* by Arno Karlen preceded the immunology lecture. The student discussion of the novel *Cobra Event* by Richard Preston prefaced the topic of respiratory disease. *E. coli O157: A Mother's Story* by Mary Heersink introduced food- and waterborne infections. The student presentation on *Bad Blood: The Tuskegee Syphilis Experiment* by James H. Jones preceded the discussion of sexually transmitted disease (M. F. Lux,

TABLE 2. Percentage of students retained through the 16-week semester

Semester	Lecture (BIO 2923) % students retained			Laboratory (BIO 2921) % students retained		
	Week 1	Midterm	Final	Week 1	Midterm	Final
Fall 1998	100 (n = 31)	58 (n = 18)	48 (n = 15)	100 (n = 31)	65 (n = 20)	48 (n = 15)
Spring 1999	100 (n = 26)	62 (n = 16)	58 (n = 15)	100 (n = 26)	62 (n = 16)	54 (n = 14)
Fall 1999	100 (n = 30)	83 (n = 25)	80 (n = 24)	100 (n = 30)	83 (n = 25)	80 (n = 24)

TABLE 3. Laboratory activities and lecture topics for control groups and test group

Session	Control group laboratory activity	Control group lecture topic	Test group laboratory activity	Test group lecture topic
1	Introduction, safety	Introduction, taxonomy	Introduction, safety	Introduction, viruses
2	Microscopic proficiency	Biomolecules	Introduction to the microscope, observe pond water	Binomial taxonomy, algae, protists, parasites, eucaryotic cell
3	Smear preparation, Gram stain	Cell structure	Read mold slides, Gram stain yeast	Fungal structures, mushrooms, molds, yeasts
4	Gram stain proficiency	Test Begin metabolism	Introduction to media, inoculate plates for isolation, inoculate broth for sugar and salt concentrations, perform UV light experiment	Test Introduction to bacteria, growth requirements, biochemistry
5	Survey of microorganisms, various cultures, smears	Continue metabolism, genetics	Observe microbial growth and effect of UV light, streak on differential media, perform catalase and oxidase tests	Bacterial metabolism (glycolysis, citric acid cycle, electron transport), genetics
6	Lab test	Genetics	Interpret differential media, prepare smears for Gram stain, perform KOH slime test	Fermentation, nitrogen fixation, <i>Archea</i>
7	Introduction to media, aseptic technique, streaking technique, sterilization technique	Viral replication, microorganisms and human disease	Perform Gram stains on fixed slides, observe various bacteria under microscope	Bacterial cell components
8	Colonial morphology, effect on growth	Test Continue human disease	Test	Test
9	Interpret results of colonial morphology and effect on growth Set-up environment plate	Nonspecific immune response	Gram stain unknown	Introduce various organisms (Gram stain, morphology, pathogenic potential)
10	Read environment plates	Specific immune response	Phagocytic experiment, Present <i>Man and Microbes</i>	Immune system
11	Body site cultures	Diagnosis of human disease, viral disease	Gram stain samples for nose and mouth; set-up cultures on nose, throat, hair, hands Present <i>Cobra Event</i>	Normal flora, respiratory tract infections and pathogens
12	Interpret body site cultures	Test Continue viral diseases	Test Read cultures, set-up plates for antimicrobial agents	Test Epidemiology, skin infections
13	Lab test	Bacterial and eucaryotic diseases	Read antimicrobial agent plates	Antimicrobial agents
14	Set-up antimicrobial susceptibility testing (AST)	Continue diseases	Present <i>E. coli O157: A Mother's Story</i>	Infectious diseases of the gastrointestinal tract
15	Interpret AST	Industrial and environmental microbiology	Present <i>Bad Blood</i>	Sexually transmitted diseases and urinary tract infections
16	Final exam	Final exam	Final exam	Final exam

Abstr. 7th Annu. Undergrad. Microbiol. Educ. Conf., abstr. 1-06, p. 5, 2000). Copies of these books were purchased by the campus branch library and were available for student use. The book presentations served as a mechanism to increase student participation and to introduce a topic that continued throughout the evening.

RESULTS

Retention of enrolled students both at midterm and at the end of the course was markedly higher in the test group as compared with the control group (Table 2). Approximately half of the class had dropped the course by midterm in the control groups, but at the same point in the semester, the test group had 83% retention of students enrolled. At the end of the course, the control groups had retention levels of 48% and 58%. The test group demonstrated 80% retention of enrolled students. Most students who withdrew from the course had failed the first of four major tests. In the control groups, two students who completed the course failed lecture, and one student failed laboratory. For the test group, one student failed lecture and all students passed laboratory (M. F. Lux, Abstr. 100th Gen. Meet. Am. Soc. Microbiol., abstr. W-2, 2000).

DISCUSSION

Retention data suggested that correlation between laboratory experiments and lecture topics and use of laboratory activities to introduce lecture topics improved retention of enrolled students in a community college microbiology course. Other factors may have impacted the increased retention of enrolled students. Active participation in lab was probably more engaging than sitting in lecture digesting a meal hurriedly consumed during the drive between the workplace and the campus. In the test group, hurrying through laboratory activities was not rewarded with early departure from campus since 3 hours of lecture followed the laboratory activities. Therefore, students were more likely to maximize their learning in the laboratory. The various experiments, manipulations, and activities introduced students to

concepts of growth, metabolism, structure, and normal flora. Another variable was the introduction of the class reading project. Students had the opportunity to read a book with a connection to the course topics and to participate in a group exercise to prepare a report for the class. An atmosphere of healthy competition developed among the groups as each group attempted to give a more effective presentation than the previous ones. This group participation may have impacted on students' satisfaction with the course, and perhaps functioning as part of a group encouraged the students to complete the course. All sections of both the laboratory and the lecture on which this study was based were taught by the same adjunct instructor, minimizing possible inconsistencies that may have been present with multiple instructors. It is possible that the enthusiasm with which the new format was presented by the instructor had a positive impact on the students (8). The grade distribution between groups was similar (Table 4). There had been a tendency of students to drop a course in which the individual expected a grade of D or F, and most students withdrew after failing the first major test in week four. One reason for this trend is that a grade of C in Microbiology is required for most allied health majors at PRCC. Simple retention of more enrolled students would not have been an honorable goal, if an increased number of students remained enrolled but earned grades that did not complete their programs' requirements. However, a comparison between the percentage of grades of A, B, or C for the control groups and the test group demonstrated that for the control groups 35% of students earned a grade of A, B, or C in lecture and 42% earned these grades in the laboratory component while 50% of students from the test group earned a grade of A, B, or C in lecture and 77% earned these grades in the laboratory component.

It was advantageous for students to complete the course. Lack of success in a course discourages students. Failure to complete the course delays the completion of the academic program or acceptance into the clinical phase of an allied health or technical program. A student who receives financial aid may jeopardize his or her eligibility for future awards. Many students in night classes make significant sacrifices to enroll in and attend class. Successful completion of the course builds self-confidence, accelerates progress though the course

TABLE 4. Final grade distribution

Grade	Lecture		Laboratory	
	% Students in control groups ^a	% Students in test group	% Students in control groups ^a	% Students in test group
A	7 (n = 4)	13 (n = 4)	17 (n = 10)	17 (n = 5)
B	14 (n = 8)	13 (n = 4)	23 (n = 13)	27 (n = 8)
C	14 (n = 8)	23 (n = 7)	2 (n = 1)	33 (n = 10)
D	14 (n = 8)	27 (n = 8)	7 (n = 4)	3 (n = 1)
F	4 (n = 2)	3 (n = 1)	2 (n = 1)	0 (n = 0)
W ^b	47 (n = 27)	20 (n = 6)	49 (n = 28)	20 (n = 6)
Total	100 (n = 57)	100 (n = 30)	100 (n = 57)	100 (n = 30)

^a Combination of two control groups.

^b Withdrew from course.

of study, and provides credentials for continuance of grants, loans, and scholarships.

General admission standards for PRCC include both a transcript from an accredited high school or the General Education Development (GED) Test and American College Test (ACT) scores. There is no published minimum for admission based on grades or scores, although remedial or developmental courses are required in some programs for entering students with low grades or scores. There are no prerequisites for Microbiology (9). With the policy of virtually open admission, many college-age students enroll in Microbiology with little background in scientific concepts and techniques, and adult learners often enroll with no recent science coursework at the high school or college level. This lack of preparation for a college-level science course may have impacted many of the students who withdrew from Microbiology. Recognition of the students' diverse educational backgrounds encouraged the instructor to develop modifications discussed in this study.

The connections made through the linking of concepts to activities may have been instrumental in both the levels of comprehension and satisfaction for students in the test group. The various strategies available to the test group encouraged these community college students in various associate degree allied health programs to complete the microbiology course with success.

Portions of this work were presented in poster sessions during the American Society for Microbiology 100th General Meeting and the 7th Annual Microbiology Undergraduate Education Conference.

REFERENCES

1. Aldridge, B. 1992. Project on scope, sequence and coordination: a new synthesis for improving science education. *J. Sci. Educ. Tech.* **1**:13–21.
2. Atlas, R. 1995. *Microorganisms in our world*. WCB/McGraw-Hill Publishing, New York, N.Y.
3. Bailey, C. A., K. Kingsbury, K. Kulinowski, J. Paradis, and R. Schoonover. 2000. An integrated lecture-laboratory environment for general chemistry. *J. Chem. Educ.* **77**:195–199.
4. Bergquist, W. 1991. Laboratory before the lecture. *Phys. Teacher* **21**:75–76.
5. Hairston, R., S. Herron, and B. Anderson. 2001. Comparing the cognitive level of three populations enrolled in a biology course. *J. Mississippi Acad. Sci.* **46**:82.
6. Klausner, R., and B. Alberts. 1996. Principles and definitions, p. 31. *In* National science education standards. National Academy Press, Washington, D.C.
7. Odubunmi, O., and T. A. Balogun. 1991. The effect of laboratory and lecture teaching methods on cognitive achievement in integrated science. *J. Res. Sci. Teaching* **28**:213–223.
8. Patrick, B. C., J. Hinsley, and T. Kempler. 2000. "What's everybody so excited about?" The effect of teacher enthusiasm on student's intrinsic motivation and vitality. *J. Exper. Educ.* **68**:217–236.
9. Pearl River Community College. 1996. Pearl River Community College catalog. Pearl River Community College, Poplarville, Miss.
10. Rutherford, F. J. 1990. Effective teaching and learning, p. 198–199. *In* American Association for the Advancement of Science (ed.), *Science for all Americans: project 2061*. Oxford University Press, New York, N.Y.
11. Thornton, R. K., and D. R. Sokoloff. 1998. Assessing student learning of Newton's laws: the force and motion conceptual evaluation and the evaluation of active learning laboratory and lecture curricula. *Am. J. Phys.* **66**:338–352.

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