Bioscene

Journal of College Biology Teaching

Volume 31(4) **Dec 2005**

A Peer-Reviewed Journal of the

Association of College and University Biology Educators

Editor:

Stephen S. Daggett
Avila University

An archive of all publications of the Association of College and University Biology Educators (ACUBE) can be found at http://acube.org

Bioscene is normally published in March, May, August and December. Please submit manuscripts by Feb 1, 2006 for consideration in the next issue.

Cover image:
Photo of a Colorado marmot on lichen covered rocks courtesy of Ethel Stanley.

Articles:

News & Views:

Bioscene: Journal of College Biology Teaching

I. Call for Submissions to *Bioscene*

Bioscene: Journal of College Biology Teaching is a refereed quarterly publication of the Association of College and University Biology Educators (ACUBE). Suggestions for manuscripts include: announcements, web site and book reviews, labs/field studies that work, course development, technological advice, software reviews, curricular innovation, history of biology, letters to the editor, undergraduate research opportunities, professional school, funding sources, current issues, etc.

II. Submission Requirements

Manuscripts may be sent to the current editor, Stephen S. Daggett. Submissions can vary in length, but articles should be between 1500 and 4000 words in length. All submissions should be double-spaced, including figure and table legends, any footnotes, and references. All submissions should come with a cover letter. If the submission is sent attached to an email, please address the subject line as BIOSCENE. The cover letter should contain the complete mailing address (including the street), email address, telephone number, and fax number of the corresponding author.

The manuscript itself should contain the following:

- Manuscript in RTF (Rich Text File) to facilitate distribution of the manuscript to reviewers and to make revisions.
- Tables, graphs, and images should be submitted as individual electronic files. If it is not possible to provide an image in an electronic format such as TIFF for Macintosh or BMP for Windows, please include a clean, sharp paper copy for our use.
- Double space all text including references and figure legends
- Title
- Author(s)
- Name of authors' institution with the address
- Email address
- A brief abstract (200 words or less), followed by keywords
- Number all pages

III. Editorial Review and Acceptance

The manuscript will be sent to two reviewers as coordinated through the Editorial Board. Reviews will examine the submission for:

- **Suitability**: The manuscript relates to teaching biology at the college and university level.
- **Coherence**: The manuscript is well-written with a minimum of typographical errors, spelling and grammatical errors, with the information presented in an organized and thoughtful manner.
- **Novelty**: The manuscript presents new information of interest for college and university biology educators or examines well-known aspects of biology and biology education, such as model organisms or experimental protocols, in a new way.

Once the article has been reviewed, the corresponding author will receive suggestions and comments from the reviewers. Acknowledgement of reviewers' comments and suggestions must be made for resubmission and acceptance. Upon acceptance, the article will appear in *Bioscene* and will be posted on the ACUBE website.

IV. Editorial Policy and Copyright

It is the policy of *Bioscene* that authors retain copyright of their published material.

Deadlines for Submissions

February 1, 2005 March, 2006 Issue **April 1, 2006 May, 2006 Issue**

Assessment of the use of the Jigsaw Method and Active Learning in Non-majors, Introductory Biology

Donald F. Slish
Dept. of Biological Sciences
SUNY, Plattsburgh
101 Broad Street
Plattsburgh, NY 12901
Donald.Slish@plattsburgh.edu

Abstract: This project involved the use of two small, closely matched non-majors introductory biology classes to test the use of the Jigsaw method of teaching vs. a passive, instructor-oriented model of teaching. In this study, the Jigsaw method was used as a jumping off point for the teaching-learning of the material. Students were to learn the concepts of the chapters through the Jigsaw method and their understanding of the material was then reinforced by active learning techniques in which they would use these concepts by applying them to solve problems as a group in active learning exercises. These students were compared to students in another, equally matched section of the class, who were taught exclusively by passive learning. In this study, there was no major difference between the sections taught by active learning or passive learning. One potentially important difference that did arise was that the active learning section did significantly better on a posttest, however, this result may be an artifact of the different way that the posttest was given in the two sections. Further study needs to be done to refine the technique to include group and individual goals aside from the individual performance on exams.

Keywords: Jigsaw method, assessment, active learning

Introduction

This project involved the use of two small, closely matched non-majors introductory biology classes to test the use of a variation of the Jigsaw Method of teaching against a passive, instructor-oriented model of teaching.

I originally undertook this project because of my experiences trying to use active learning techniques in the class. Studies have shown that students learn better when they are actively involved in the teaching-learning process (Ebert-May et. al. 1997, Paulson, 1999, Johnson et. al. 1998, Udovic et. al. 2002). There are many different types of active learning, all of which involve the students engaged with the material, rather than passively listening to lectures. Most active learning techniques involve some form of cooperative learning in which students work together in groups toward some goal.

The idea behind the active learning technique in the present study is the belief that the students can learn the content of the chapters on their own by reading the chapters in the book. Class time should be dedicated to active learning exercises that help the students to learn and understand the material better. However, this system breaks down when the students don't read the chapters before coming to class. This course is a general education elective that is designed for first semester freshmen. As such, most of the students have poor study skills and low interest in the material. For this reason, attempts at teaching via active learning are hampered because the majority of students come to class unprepared. The content of the subject is often unlearned and the activities fall flat because of the students' inability to participate. In the end, half the class time is spent lecturing to impart the necessary content and the other half doing active learning exercises. As a result, both content and active learning suffer.

In the present study, the Jigsaw Method was used as a way to engage the students with the content in the text before it was discussed in class. The Jigsaw Method is a cooperative learning technique that was originally developed by Aronson et. al. (1978). It involves dividing content into 4 sections and assigning a subgroup of the class to each section. These subgroups then meet and become "experts" in their assigned material. These subgroups are then broken up to form four person teams that have one person from each subgroup. The teams are therefore composed of an expert from each of the four areas; this expert teaches the others on the team the material. Various studies have shown that learning improved (Lucker et. al. 1976, Aronson et. al. 1978) or showed no difference (Moskowitz, et. al., 1985, Palmer and Johnson 1989, Thomsons & Pledger, 1998) using this method. Better results were obtained when it was modified (Jigsaw II) to include a reward for a group goal and public accountability for each member's contribution to the goal (Mattingly & VanSickle, 1991). Further modifications of the method (Jigsaw II, Jigsaw IV) enhanced the academic achievement (Holliday 2000).

The teaching method used here was somewhat different from the way that the Jigsaw Method has been used in the past. Previous studies have used this method as the end point of the teaching model; in this study, the Jigsaw Method was used as a jumping off point. Students were to learn the concepts of the chapters by taking notes and teaching each other the important content. Their learning by this method was then reinforced by active learning techniques in which they would use these concepts by applying them to solve problems as a group in active learning exercises. Exam scores of students in this section of the class were compared to the exam scores of students who were taught the same material by a traditional, lecture-style approach (i.e., passive learning).

Methods

Class Comparisons

Two sections of Concepts in Biology (BIO103) were tested in this study. Section A (25 students) had 9 freshmen, 5 sophomores, 6 juniors, and 5 seniors. Section B (27 students) had 13 freshmen, 9 sophomores, 2 juniors, and 3 seniors. Section A met Monday, Wednesday and Friday from 9:00 to 9:50 and Section B met Tuesday and Thursday from 9:30 to 10:45. The students who agreed to participate in this study were asked to sign an informed consent waiver that stipulated that the information that they gave was confidential, and that their anonymity would be preserved. . The absentee rates for the two classes were not significantly different (3.6±0.4 and 3.1±0.6 absences per student, per semester).

Course content

Concepts in Biology is a one-semester introductory course. The content was organized around the theme of "Information flow: DNA → RNA → protein → trait." The textbook used was Essential Biology, (Campbell et. al., 2004). The first exam was on the scientific method, biochemistry, and cell biology and covered Part of chapter 1 (Introduction: Biology Today) Chapter 4 (The Molecules of Life), and Chapter 4 (A Tour of the Cell). The second test covered cell division (Chapter 8, The Cellular Basis of Reproduction and Inheritance) and Mendelian genetics (Patterns of Inheritance). The third test was evolution and it covered microevolution (Chapter 13, How Populations Evolve), macroevolution (Chapter 14, How Biological Diversity Evolves) and human evolution (part of chapter 17, The Evolution of Animals). For the final test, I gave them the option of choosing 2 chapters from among the physiology chapters in the textbook. They chose Nutrition and Digestion (Chapter 22) and Circulation and Respiration (Chapter 23).

The Jigsaw Method

The Jigsaw Method used in Section B was a variation of Jigsaw methods used in the past. First the class was taught how to take good notes. They were shown that the chapters are organized into an outline format, how to determine the most salient information in the text, and how to fit the material into the general outline format. This was done through in-class note taking of one chapter of the first test material to ensure that everyone was familiar with this method. For this reason, most of the first test material was presented in a passive way, i.e., notes were taken in the class and the time in class was spent primarily on course content.

For the second and third tests, the students took notes from the chapter as homework before the class met to discuss it. To do this, the class was divided into 4 Teams of 6 to 7 students each and the chapter was also divided into 4 sections. Each Team was assigned one section of the chapter from which to take notes. In the next class, Groups of 4 students were formed with one student from each of the original 4 Teams. In this way, each Group had a complete set of notes for the chapter. For the first half-hour of this class, each Group passed shared notes from the chapter and the note taker from each Team discussed the important points of that section. This was followed by active learning exercises in the remainder of the class and for the next two class periods.

For the fourth test, Section B was taught in the same passive manner as Section A.

Active Learning exercises

The most common active learning activity was to have the Groups work jointly on problem sets. These were essay questions similar to what they would eventually see on the test. After a period of time for Group discussion, the quizzes were discussed as a class. Often one member from a Group would be chosen to make a short presentation of the answer to the class. A similar exercise was to ask them to come up with good essay questions from the chapter being discussed. These were then written on the board and answered by the groups.

Another active learning technique used was to have the students meet in a computer lab to do on-line activities related to the course material. There are many activities available for some topics (especially genetics) that are very useful in this setting.

A personal response system was also used in this class. This is system where the students have infrared transmitters that emit a signal to a receiver in the front of the class. Software on the computer analyzes the responses and displays a histogram of the results. Using this system, students would work in groups and compete against each other while taking a multiple-choice quiz.

Passive Learning

Section A was taught strictly by passive methods. Students were lectured on the material and given copies of the notes via email. Any quizzes given to Section B were also given to Section A, however they were given as uncollected homework or as un graded in-class quizzes. When quizzes were given in class, the students worked individually and were given the correct answers by the lecturer after the quiz. On-line exercises done by Section B were also given to Section A, but were to be offered as self-study

Testing

A pre-test was given on the first day of class. The pretest consisted of 9 essay questions covering the variety of biological topics that were to be covered in the class during the semester. This was graded, although their performance did not affect their grade in the class. During the semester they were given 4 regularly scheduled tests. Half of each test (50%) was multiple-choice (20 questions) and half of each test was essay (six to eight questions). At the end of the semester, a post-test was given that was identical to the pre-test. The students in each class also filled out a subjective assessment questionnaire after the class to determine their impressions of the class and the teaching method.

Results

Scheduled Exams

The inherent abilities of the two sections of this class were evaluated by comparing the test results when they were treated the same. Neither class was aware that they would be given a pretest and therefore did not prepare for it.. Also, for Exams I and IV, both classes were taught by passive lecturing. The results of both the pretest and these two exams showed that the two sections were evenly matched in ability (figure 1).

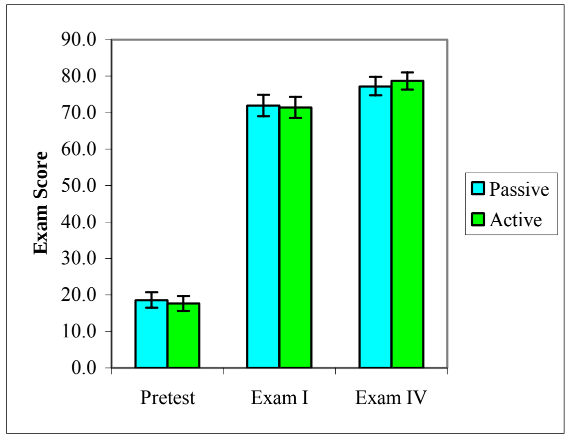
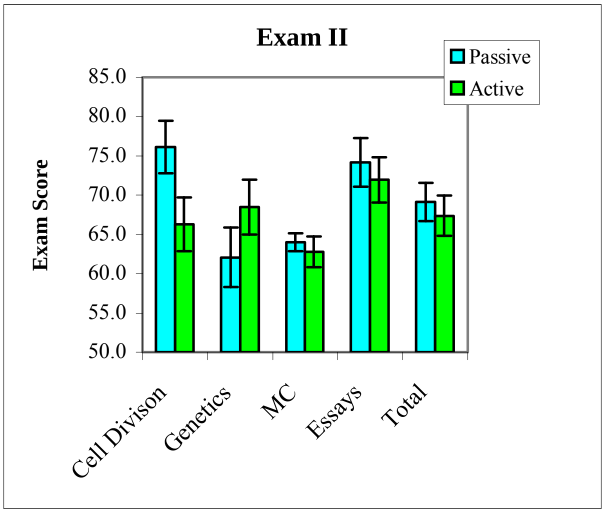


Figure 1. Comparison of the two sections irrespective of the teaching method. The two sections are compared via a pretest and when they were both taught by passive lecturing. There was no significant difference between the sections.

Exam II was the first exam in which section B was taught exclusively by the Jigsaw Method and active learning techniques. The chapters covered were on cell division and Mendelian genetics. The exams were broken down and analyzed for differences between the sections in content (cell division vs. genetics) format (multiple choice vs. essay) and for total grade on the exam. As shown in figure 2, the only criterion that showed a significant difference between the groups was the cell division portion of the test; the section taught by passive learning did significantly better in this section ($P<0.02$). The active learning section did slightly better in the genetics section, although this difference was not significant ($P=0.15$). There was no difference in the overall scores on this exam.

The third exam covered evolution and was divided into microevolution, macroevolution and human evolution. Again, section A was taught passively and section B was taught by the Jigsaw method. There were no significant differences between the passive and active sections in any of the criteria analyzed (figure 2).



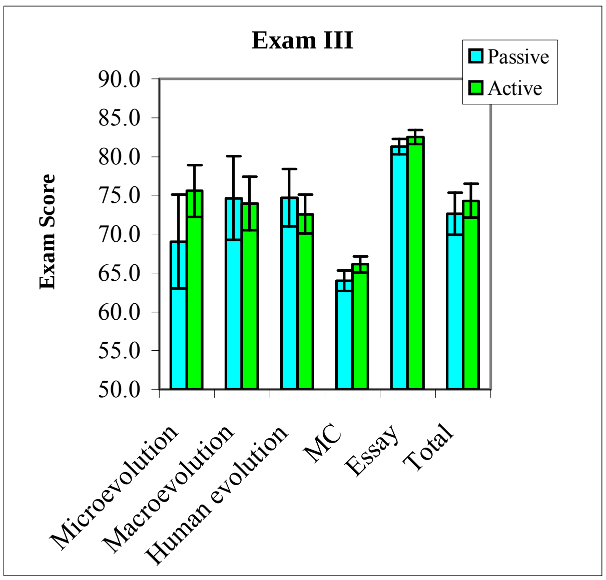


Figure 2. For Exams II and III, Section B was taught exclusively by the Jigsaw Method and Section A by Passive learning. The exams were analyzed for differences between the groups in content, format (multiple choice vs. essay) and for total grade on the exam. The only criterion that showed a significant difference between the groups was the cell division portion of the Exam II; the section taught by Passive learning did significantly better in this material ($P<0.05$).

Pretest/Posttest

At the end of the semester a posttest was given that was identical to the pretest. Both sections did significantly better on the posttest than on the pretest (figure 3). However, section B, which was taught by active learning, improved more on its pretest score and its score on the posttest was significantly higher than that of the passively lectured section ($P<0.01$). However, there was a discrepancy in the way the posttests were given in the two sections. In section A (passive) the posttest was given directly after the fourth exam. In section B (active) the posttest was given on the last day of class, the week before the fourth exam. This was not planned, but was due to a logistical problem.

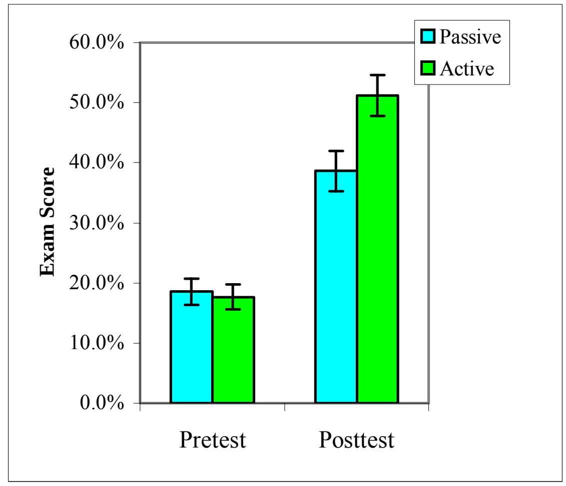


Figure 3. Identical pretest and posttests were given. Both sections did significantly better on the posttest than on the pretest ($P<0.00001$). However, the Active learning section scored significantly higher than the passively taught section on the posttest ($P<0.01$).

Because of the difference in the way the posttest was given to each class, further analysis of the pretest/posttest data was done to determine if the results above were an artifact. An unplanned aspect of the pretest/posttest allowed for this analysis. Three of the nine questions included on the pretest concerned topics that were not covered in class because of time constraints. These served as an internal control of the testing method. Any increase or decrease in scores on these questions should not be due to the way material was presented during the class (since it wasn't), but rather may be due the discrepancy in the way that the tests were given in the two sections. Figure 4 shows the comparison of the results of each section on material covered in class and not covered in class. The active learning group did significantly better than the passive group on questions from material covered in class ($P<0.05$) as well as questions on material not covered in class ($P<0.01$). However, when pretest vs. posttest data for the passive group is compared, this group did significantly worse in the posttest on material not covered in class ($P<0.000005$). In addition, there were more questions left totally blank on the tests in the passive group (2.4 ± 0.35 per test) than in the active group (1.3 ± 0.31 per test); this difference was statistically significant ($P<0.05$).

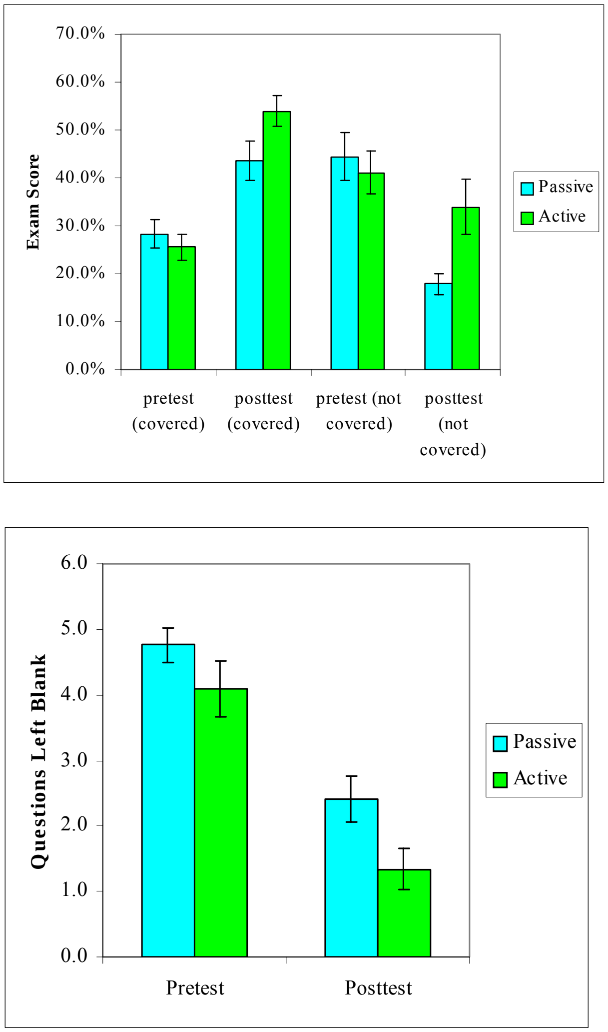


Figure 4. Assessment of the Pretest/Posttest Data. The two sections were compared based on questions from material covered vs. not covered in class. On questions from the test on material that was covered in class, that active section did slightly better ($P<0.05$). On material that was not covered in class, the active section did better than the passive section ($P<0.01$). There was no difference between the pre- and posttest results of the active group on this material, but the passive group did significantly worse on the posttest ($P>0.000005$). Also, there were twice as many blank questions on the passive group's tests compared to the active group's tests (2.4 ± 0.35 vs. 1.3 ± 0.31 per test, $P<0.05$).

Subjective Assessment

The class that was taught by the Jigsaw Method was resistant to the change in format at first. The students generally disliked working in groups because slackers tended to take advantage of the students who did the work. This is especially a problem in the Jigsaw Method because a group with one or two slackers misses out on important material. This problem was partially rectified by segregating slackers into their own group, which took the notes during class instead of sharing pre-written notes. However, absenteeism and lack of initiative had an effect on the morale of the groups.

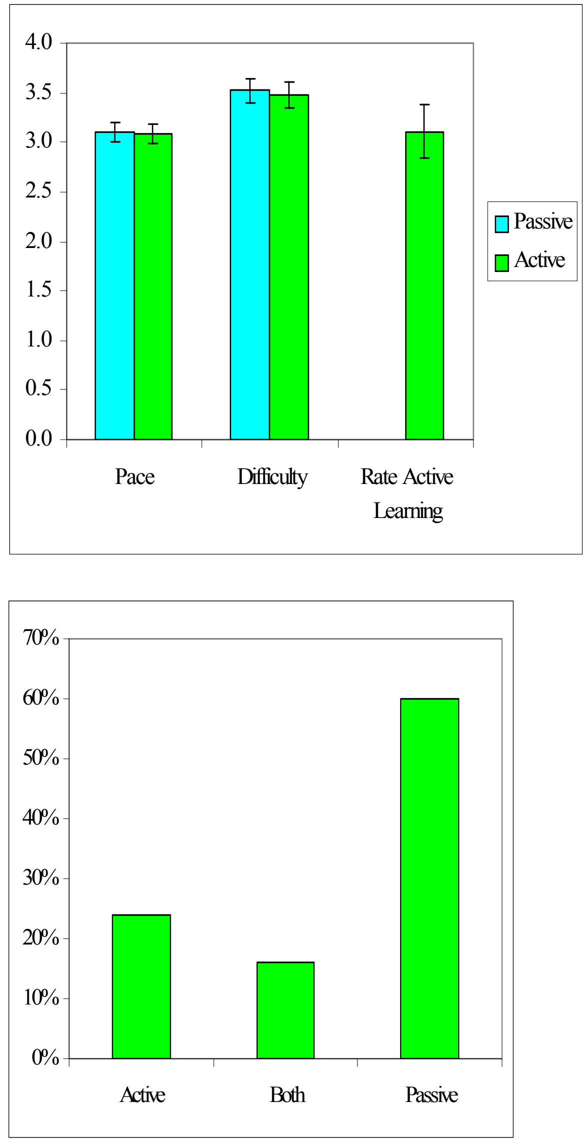


Figure 5. The students were asked to fill out a questionnaire on their feelings about the class, rating it on a scale of 1 to 5. There was no difference between the two sections in their perceived pace of the material or the difficulty of the class. The active learning section was asked how they would rate the active learning approach on a scale of 1 to 5. This section was also asked whether they preferred active learning, passive learning, or a mix of both.

learning group. This is a potentially important result, however it may be an artifact of the different way that the posttest was given in the two sections.

After taking the fourth exam the students were asked to fill out a questionnaire on their feelings about the class (figure 5). Two questions were the same in the two sections and pertained to the pace of the material and the difficulty of the class on a scale of 1 to 5, (1 the lowest, 5 highest). There were no differences between the sections in their responses to the first two questions. They saw the pace of the material to be average (3.1± 0.1) and the difficulty of the class to be slightly above average (3.5± 0.1). The active learning section was asked two questions that specifically pertained to their manner of instruction. When asked how they would rate the active learning approach, the average response was 3.1±0.3. When what type of instruction they would prefer, 24% chose active learning, 60% chose passive lecture, and 16% chose a mix of both.

Discussion

Comparison of the two groups on the pretest and on Exams I and II (i.e., when they were treated the same) show that they were equally matched (figure1). During the experiment, when they were treated differently, the only exam score that showed a significant difference was in the cell biology section where the passive learning section scored higher. This may be because this was the first chapter when Section B used the Jigsaw Method and they were unfamiliar with the method. All other scores, whether assessed by content or type of question (essay vs. multiple choice), were the same. This showed that, although the Jigsaw Method showed no improvement in learning, at least it did no worse.

Analysis of the posttest data showed that both sections increased their scores from their pretest results, suggesting that they retained some of the knowledge gained during the semester. One important difference that did arise between the scores of the two sections was on the posttest. The two sections did the same on the pretest but the active learning section did significantly better on the posttest. One interpretation of this is that the active learning section retained more that the passive learning group. This is a potentially important result, however it may be an artifact of the different way that the posttest was given in the two sections.

In an analysis three questions on the posttest that pertained to material that was not covered in class, the passive class did significantly worse than the active class; also, the passive class did significantly worse than they had on the same questions in the pretest and left more questions entirely blank than the active class. This suggests that the passive class wasn't trying as hard and that they were giving up easily. This calls into question the conclusion that there were long-term gains by the active class over the passive class.

The subjective assessment of the course showed that both sections saw the class as equally challenging. Active students said that, while they rated the Jigsaw method about average (3.1±0.3 out of 5), only 24% preferred to be taught that way and 60% preferred the passive lecture model. In written responses, many students paradoxically said that they felt that they learned more by the active method, but preferred passive learning. One of the problems is that students, in general, dislike working in groups; the main complaint is that slackers take advantage of students who do the work. For this reason, care must be taken to hold each student responsible for the work.

Although the Jigsaw Method was not shown to be superior in this study, previous studies have shown increased learning using the method (Lucker et. al. 1976, Aronson et. al. 1978, Mattingly & VanSickle, 1991, Holliday 2000). One difference between those studies and the present one is that the more successful studies included group and individual goals and accountability after each exercise. While there were group goals in the present study (preparing good notes from the chapters for the exams and working through answers on a quizzes), there was no accountability of the individual to the group (slackers were allowed to take advantage of the group) or of the individual to a daily standard of achievement (i.e., quizzes weren't graded). These aspects need to be addressed in order to see gains by this method.

References

Aronson, E., Blaney, N., Stephen, C., Sikes, J., & Snapp, M. (1978). The Jigsaw Classroom. Sage Publications, Beverly Hills, CA

Campbell, N.A., Reece, J.B., & Simon, E. J. (2004) Essential Biology with Physiology. Benjamin Cummings, San Francisco, CA

Ebert-May D. Brewer CA and Allred S. 1997. Innovation in large lectures - Teaching for active learning through inquiry. BioScience 47(9): 601-607.

Holliday, D.C. (2000) The Development of Jigsaw IV in a Secondary Social Studies Classroom. U.S.; Indiana; 2000-00-00

Johnson DW, Johnson R, and Smith K. 1998. Active learning: Cooperation in the College Classroom. Edina, Minn. Interaction Book Company.

Paulson, D.R. 1999. Active learning and cooperative learning in the organic chemistry lecture class. Journal of Chemical Education 76(8): 1136-1140.

Lucker, G.W., Rosenfield, D., Sikes, J., & Aronson, E. (1976) Performance in the interdependent classroom: A field Study. American Educational Research journal, 13: 115-123

Mattingly, R.M., and VanSickle, R.L. (1991) Cooperative Learning and Achievement in Social Studies: Jigsaw II. Social Education 55(6) p392-95

Moskowitz, J.M., Malvin, J.H., Schaeffer, G.A., & Schaps, E. (1983) Evaluation of a cooperative learning strategy. Improving College and University Teaching, 32:87-90

Palmer, J. & Johnson, J.T. (1989) Jigsaw in a college classroom: Effects on student achievement and impact on student evaluations of teacher performance. Journal of Social Studies Research 13: 34-37

Udovic D, Morris D, Dickman A, Postlethwait J, and Wetherwax P. 2002. Workshop Biology: Demonstrating the effectiveness of active learning in an introductory biology course. BioScience 52(3): 272-281.

(See page 24 of this issue!)

Writing & Speaking to Learn Biology: An Intersection of Critical Thinking and Communication Skills

Karen Curto and Trudy Bayer*

Department of Biological Sciences
University of Pittsburgh
L4 Clapp Hall
Pittsburgh, PA 15260
Email: curtok@pitt.edu

* Department of Communication
University of Pittsburgh
CL 1117
Pittsburgh, PA 15260
Email: tbayer@pitt.edu

Abstract: A collaborative effort between biology and communication instructors to facilitate speaking skills for senior biology majors resulted in improved organization, clarity and confidence in delivering an oral scientific presentation. But this instruction also favorably impacted students' scientific writing. This benefit seems best attributed to additional opportunities for students to talk about science, to critically evaluate the quality and structure of their arguments and evidence, and to express in their own words a clear resolution to a biological controversy.

Keywords: biology, communication, writing, speaking.

Introduction

The Boyer Commission Report on *Reinventing Undergraduate Education* concluded that "The failure of research universities seems most serious in conferring degrees upon inarticulate students" (Boyer Commission 1998). Having these findings about the failure of higher education to promote students' ability to speak and write supported a decade of complaints from corporate and government leaders about the declining writing and speaking skills of college graduates (Schneider, 1999; Zernike, 1999). These communication deficits have triggered a movement to promote *communication across the curriculum,* prompting many universities to redesign core requirements to include communication in writing and speaking for all students, regardless of their discipline (Cronin, Grice, & Palmerton, 2000). As stated in the Boyer Commission Report, "Every university graduate should understand that no idea is fully formed until it can be communicated, and that the organization required for writing and speaking is part of the thought process that enables one to understand material fully" (Boyer Commission 1998).

The impetus for the current study arose from the Biology instructor's prior experience in a course entitled "Writing in the Biological Sciences." When I (KC) graded my students' biology writing assignments, I often found myself at the end of a sentence, puzzled about what the student intended to say. I anticipated that certain types of information would occur in a certain place in the sentence, but I failed to receive a logical flow of ideas or clear explanation of the material. In general, my "reader expectations" had not been met (Gopen, 2004a,b).

In one-on-one instructor/student conferences, students would patiently explain "What I meant to say" in a problematic sentence or section and we would work to revise that section. Even though students struggled to express their thoughts using the language of science, they reported in surveys at the end of the semester that these discussions with the instructor were vital for improving their final drafts. It occurred to me that if *talking* about the science was helpful, the addition of a short oral presentation might be another opportunity for students to talk about their topics, receive additional feedback, rework their ideas into a sharper focus and become more adept in speaking and writing the language of biology.

That was the beginning of an effort to include an oral component in a required two-credit biology majors' course entitled "Writing in the Biological Sciences." This small class (typically 14) consisted initially of formal lectures on writing a scientific document to resolve a biological controversy, peer review of other students' writing, accessing and discussing data in figures/tables from primary literature resources and a skill workshop on electronic database searching. One lecture was added on the specifics of an oral presentation during which biology instructors explained that a talk should have three sections consisting of an introduction, body and conclusion; it should focus on a single idea and include clearly visible data slides to support the verbal commentary. In response to this direction, students tended to simply condense information on the resolution of a biological controversy into a six–minute talk and, although based on a topic they had been researching all semester, these one-time presentations had many problems. Talks were poorly organized and too long, visuals were difficult to see and students lacked a sense of confidence with both the science and their presentation skills. While the limited pre-oral directions resulted in poor one-time presentations, students recognized their shortcomings and expressed a desire to improve their talks in a follow-up presentation. Thus, future versions of the course allowed for an initial and final oral presentation of students' research. Although adding the second presentation did result in an improvement in students' speaking and writing, the quality of both genres continued to fall well below the norm of effective writing and speaking in the biological sciences.

It was becoming apparent to the instructors that if the oral presentation assignment was to be beneficial, then something beyond a brief lecture would be required. Thus, a more intensive treatment of the oral component was introduced in Fall/2003 and Spring/ 2004 when this study was conducted to examine the following question: What impact, if any, on student writing and speaking would occur from specialized instruction on translating a written scientific document into an oral presentation? To answer this research question, the current course revision included a formalized treatment of the oral component, through a collaborative effort with the director of the university's Oral Communication Lab--a center to promote speaking across the curriculum.

Preparing for the Communication Lab

The Oral Communication Lab director (TB), a faculty member in the communication department, conducted an initial survey of students enrolled in "Writing in the Biological Sciences," to measure their level of instruction, experience, and self-perceived abilities and challenges as "speakers."

Of the 68 participants completing this initial survey, 49 had *never* taken a course or workshop in public speaking or other type of oral communication. In addition, only 16 of them engaged in oral presentation/communication activities such as discussions, presentations, running or participating in meetings, teaching/tutoring, giving campus tours, etc., on a regular basis.

Students were asked to indicate their level of understanding about constructing a talk, comfort in public speaking, and self-perceived competence as a speaker by circling a number on a Likert scale. For all three questions, a score of 1 represented the low end of the scale and 10 represented the high end of the scale. The mean responses are reported in Table 1 and are similar for both semesters of the course. The values fell toward the midpoint of the scale suggesting that students could benefit from specialized communication instruction. Twenty-five percent of the students admitted to a marked lack of understanding about preparing a talk, and nearly half of the students reported considerable discomfort and uncertainty about their current speaking abilities.

Finally, the students were asked to identify *specific* aspects, issues, or questions about developing an oral presentation that they wanted to explore in their forthcoming communication workshops. Responses to this question were grouped into thematic categories with two dominant challenges emerging: learning about organizing a presentation and learning about delivery (including speaking anxiety). Of the students who responded to this question, 18 identified some element of organization such as "making message clear," "organization process in presentations directed towards biology," "organization," "how to present clearly," "how to structure introduction and conclusion," and "how to decide what's important." Twenty-five identified delivery/anxiety issues such as "how to keep audience interest," "how to relax," "how to be effective and not look nervous," "tips on calming nerves," "some relaxing exercises," "how to slow down and relax when standing in front of an audience," and "how to deal with anxiety." Eight students listed wanting to learn "everything."

The results of the initial survey were strikingly similar across all six sections of biological science students. This seemed particularly significant since students completed the surveys in class without any advance knowledge or opportunity to discuss it.

In response to the initial survey data, I (TB) developed two two-hour communication workshops. I began the first workshop by explaining to students that good public speaking is *audience-centered* and that effective presentations begin with trying to understand the knowledge, attitudes, and needs of a specific audience about a specific topic. From that understanding, a speaker can meaningfully begin to think about developing a presentation. To provide an example, I explained the rationale behind the initial survey as *my* attempt to understand and analyze my audience. I discussed the survey data and highlighted that through the survey they had essentially defined their own learning objectives. As a result, the first workshop would focus on organizing a presentation, and the second workshop would focus on delivery/speaking anxiety.

Students were asked to prepare a preliminary outline of their presentations in advance of the first communication workshop. After presenting material and exercises on developing a specific purpose and clear thesis statements, students formed two groups with approximately seven students and a communication instructor. They discussed their research topic and data, preliminary speaking outlines, and engaged in a discussion of their research questions with the Communication Lab director. Students received feedback and input from both the Communication Lab director and peer group members. This format provided both sustained individual attention and multiple examples of organizing ideas as each student worked through his/her topic, specific purpose, and thesis.

This beginning transformation from the written to the oral genre required students to reevaluate and reorganize their presentations. It was a critical thinking process with the goals of abstracting and defining a focus from a complex array of data and articulating the main ideas and essential supporting material to effectively communicate this complex message to a particular audience within prescribed time limitations. Although initiated and guided by direction from the Communication Lab director, the transformation from the written to oral genres prompted students to grapple differently with the ideas and evidence collected from their research.

To begin the process of moving from the written draft to the oral presentation, the Communication Lab director posed questions such as the following: "What conclusion have you reached about your scientific controversy? " and "What do you feel is most important for your audience to know about your controversy?" Using their written outlines, students usually responded with a restatement of their topic assignment or a list of information compatible with outline headings such as introduction, background, experimental studies and conclusion. They replied, for the most part, with *the words of others.* Thus, a restatement of the topic assignment was essentially in the words of the biology instructor, while the lists of information came from the words of their primary refereed literature or published review sources.

A rephrasing of the question by the Communication Lab director attempted to elicit students' *own thoughts* about their research analyses rather than their resources. Thus, the Lab director would continue with questions such as, "Given the problem and what you now know about its background and alternative solutions, what solution are you advancing for your audience in your paper?" After some pause for thought, discussion and a few glances at the written outlines, a very different statement typically began to emerge. It was a single idea, a focus, which was the raw version of the student's assimilation and synthesis of a resolution. Although tentative, this initial "step away" from the written word required that the information be articulated *in their words*. In place of stating information in a list-like fashion, students formulated a preliminary "specific purpose" and the thesis or main ideas and support to develop that purpose. After each student expressed his or her focus, the Communication Lab director requested that this new idea become the basis or thesis for a revised outline assigned for the following week.

The development of focus fits well into the paradigm of critical thinking, which Chaffee defines as "the organized cognitive process that we use to carefully examine our thinking and the thinking of others, in order to clarify and improve our understanding" (Chaffee, 1999). By the second draft, students are familiar with the background of their problem and typically decide on its resolution. Yet, when initially asked by the Communication Lab director what the focus of their talk would be, they had difficulty answering. They were able to talk about their topic and list ideas regarding the issues around the controversy, but they lacked an integrated focus. The challenge question required that they *critically rethink* this information to recognize a salient feature to drive their argument toward a resolution for audiences with varied science backgrounds.

At the conclusion of this session, students were asked to revise their outlines with greater organizational detail and clarity prior to the next communication workshop. Students were also asked to evaluate the usefulness of this workshop on a scale of 1 – 10 with 10 representing "Very useful." Of the 68 students participating in the first tutorial, 51 rated it 8 or higher with an average rating of 8.5.

The second communication workshop focused on delivery/speaking anxiety. As the Lab director, I provided information, handouts, exercises on delivery, and tips for coping with anxiety, while emphasizing that speaking anxiety is a common predicament that declines with knowledge and practice. Students were then asked to do an impromptu presentation on a "place we all ought to visit" that included a thesis statement comprised of two clearly stated main points and support for each point. This gave students another opportunity for individual and group practice on organizing ideas, illustrating the competence they had already acquired in oral communication, and demonstrating the confidence with which individuals can stand and speak about something they genuinely understand.

In addition, the revised speaking outlines were reviewed. In the second communication lab workshop, students more readily replied with an organized answer to questions about the content of their talks. They had "figured out" the quality and organization of information in response to the Communication Lab director's query and their target audience. The second oral outlines differed from the first versions and attested to a revisiting and rethinking of their information.

Initial and Final Oral Presentations

Students delivered their oral research presentations on two occasions. The first presentations were videotaped. Students received written and oral feedback from their biology instructor on organizing, managing, and delivering their presentations and using appropriate scientific language. In addition, students reviewed the videotape of their initial presentations and developed concrete plans for improving them. Not surprisingly, given the volume and variety of feedback, their final oral presentations were greatly improved (Jerde & Taper, 2004).

Follow-up Survey

A follow–up survey was developed by the Communication Lab director to measure the degree of change in students' perception of their ability to organize and deliver an oral research presentation. These surveys were administered in class without any advance notice to students or opportunity for them to discuss them. The results of the follow-up survey, described in Table 2, are striking when compared to the initial survey data. Mean responses for the two semesters were similar and, unlike the scores recorded prior to the communication instruction (Table 1), responses occurred well above the midpoint of the scale. In fact, the percentage of scores of "5 and below" now fell to the single digit range.

Table 1

Mean Likert Scale Responses to Initial Survey Questions 3, 4, and 5

	Mean Response Fall Classes n = 31	Mean Response Spring Classes n = 36	Overall Mean	Percentage of Scores 5 & Below
3. On a scale of 1 – 10, how well do you understand the process of preparing a talk?	6.6	6.4	6.5	25%
4. On a scale of 1 – 10, how comfortable are you in speaking in front of either a small or large group?	5.5	5.9	5.7	48%
5. On a scale of 1 – 10, how would you rate yourself as a speaker?	5.7	5.6	5.7	45%

Table 2

Mean Likert Scale Responses to Follow-up Survey Questions 5 and 6

Question	Mean Response Fall Classes	Mean Response Spring Classes	Overall Mean	Percentage of Scores 5 & Below
5. On a scale of 1 - 10, how clearly do you feel that you communicated your message (i.e., rate how well you organized your FINAL presentation)?	8.4	7.9	8.2	3%
6. On a scale of 1 –10, how comfortable did you feel in delivering your FINAL presentation?	7.6	7.7	7.7	6%

Table 3
Responses to Follow-up Survey Question 1

Question	Themes	% Students Expressing Theme	Sample Quotations
1. What do you feel were the strengths of your *FINAL* presentation?	Statements of Confidence in Organizing Ideas	50	"transitions," "it flowed well," "was able to narrow it down to specific points that were better supported," "clear," "organization," "I feel my final presentation effectively condensed my paper into a few main points," " the main strength of my presentation was organization," "I felt that I was more prepared in delivering my speech and that it was more organized."
	Statements of General Confidence and Improved Delivery	58	"I was calm and spoke clearly and slowly," "less nervous," "addressed class in confident tone," "more comfortable," "more confident," "confidence," "I think I battled back the nervousness." "much less nervous," "ease of talking in front of class," "eye contact & confidence," "talked slowly."
	Statements of Confidence about Data	13	"good knowledge of materials," "data," "knew the material well enough to talk about it," " I was confident about the material that I was presenting," "presented the data well," "greater comfort with the material," "explained slides well," "knowledge of the slides," "confidence in the ability to get across my major points."

When asked to specifically identify the strengths of the final presentation, students' comments were rewarding. Almost all of the 66 students who completed the follow-up survey listed several strengths within the themes of organization, confidence about understanding the data, and confidence in delivering their presentations. Table 3 is representative of students' characterization of the strengths of their final research presentations.

IV. Written Component Results

In addition to the follow-up survey conducted by the Communication Lab director in Spring 2004, the biology instructors conducted their own survey to identify what students perceived as the most and least helpful assignments/exercises in "Writing in the Biological Sciences." Twenty-three out of 38 students surveyed identified the oral communication workshops and exercises as among the most helpful, while none of them identified them as among the least helpful.

While the oral presentation itself improved from the additional communication instruction, an original intention was to improve the quality of the science writing as well. From an assessment perspective, the overall quality of the final written document did improve, even though different instructors taught course sections. This was especially true for the average (C grade) students, who without the additional attention to the material necessitated by the oral preparation, tended toward minimal revision. For one instructor, as a rough estimate of improvement, the number of "C's" dropped by nearly half (from 29% to about 18%), while for another instructor the frequency decreased from 38 to 31% in a comparison to the earlier versions of the course. Most encouraging was the fact that the number of "A's" increased from an average of about 7% to 24% for all sections (see Appendix for grade determination).

What accounted for this improvement? Increasing the number of times students rethought, revised and reworked the scientific information helped them to learn more about the material and *speaking and writing like a biologist* (see Summary of Feedback in Appendix). Now, in the revised course, along with three written draft assignments, students returned to their research on five occasions in conjunction with the oral presentations as they prepared, practiced, critiqued and revised their six-minute talk. Condensing their information into a PowerPoint format also served as an exercise in organizing ideas into clear and concise visuals to support an explanation.

But more intriguing to the biology (writing) instructor was what happened between the speaking outline, generated as a guide for discussion at the first Communication Lab workshop, and the final written document. The initial speaking outline, based on the students' organization of information from the second revision of their written drafts, typically had one of the two following forms: a "bare bones" listing of the section headings from their papers or a "detailed outline" that listed many facts under each heading. It rarely, however, resembled the order and organization of either the *final* talk or written document.

From the biology instructor's perspective, this exercise in the Communication Lab was a pivotal point linking the oral presentation instruction to the final written document. Although anecdotal in nature, a statement such as, "I really didn't know where my paper was going, until I had to develop a focus for my talk" was a typical unsolicited student comment. Verbalization of that focus was the beginning in creating a clear perspective of what they needed to express, not only in their talk, but in the written format as well.

V. Critical Thinking, Writing, and Speaking to Learn Biology

In addition to clarifying focus, which was initiated in the oral outlines, other parts of the oral communication preparation impacted the writing assignment. Two broad intersecting categories of *organization* and *audience* from the oral preparation process were particularly important, not only in improving speaking abilities, but also in improving student writing and understanding of the science. Table 4 highlights the specific writing issues that appeared to benefit from the oral instruction component.

Table 4
Writing Problems Likely Improved by the Oral Communication Process

Writing Problem	Oral Preparation Process Benefit
1. Multiple main points confused readers about the document's primary recommendation.	Identified a dominant focus, purpose, and main points supported by background and data.
2. Uncertainty regarding how to write about data derived from the primary literature resulted in lists of one author/data followed by the next author/data.	Working with the data to support a main focus resulted in selecting the clearest examples to support ideas.
3. Uncomfortable with the language of science.	Multiple and varied opportunities to practice using the language of science promoted greater student understanding and comfort in both written and spoken genres
4. Lack of logical flow of information that missed reader expectations.	The clear organization and movement of information/evidence and the use of linguistic devices such as parallel sentence structure, repetition and internal summaries made information easy to follow.
5. Uncertain about the quality and quantity of detail to provide a reader.	*Audience* is at the center of one's talk; data and presentation are "geared" toward them.
6. Not confident about the information	Discussing and presenting material promoted greater understanding of it. Being "ready" for questions after the talk challenged students to know their information. See point #3.
7. Exceeding assigned page limits	Strict adherence to the allotted speaking time forced selection of essential information

The critical thinking process of abstracting and synthesizing complex material into a clear oral form seems to have positively influenced the common problems in student writing described above. Identifying a specific purpose, thesis, main points and essential evidence, and the clear movement of information essential to the oral genre translated into greater clarity in students' writing. The tedious listing of evidence, not well tolerated by a listening audience, characterized many early *written* drafts. This problem in discussing primary literature data appeared as a tendency for students to list evidence in a one-author/one-paragraph style in their writing. However, the oral presentations required students to "talk about" the data--to explain, discuss, and clarify it, thus demonstrating an understanding of the material rather than a simple listing of concepts. Data examples were chosen to accommodate the time limitations. Making the connections for the listener in the oral genre translated into data selections in speaking and in writing that typically defined the focus of an entire section as opposed to simply being mentioned in a paragraph alone. In this process, students also acquired greater expertise and confidence in using the language of science. This deconstructing and reorganizing of information is an important effort toward becoming an "expert" or as Florence and Yore (2004) describe, "gaining control over the knowledge."

The process of organizing an oral presentation includes targeting a message toward a *particular* listening audience, whose characteristics have been defined in the topic assignment. This assignment also ascribed a professional role to the student as a researcher asked to interpret the science for the audience and selecting background material on his/her problem tailored for a specific knowledge level. The necessity of *speaking to a defined audience* (a group of physicians, a local governing community board, or entrepreneurs interested in investment potential) prompted students to reconsider how to organize the quality and presentation of information for their audience, instead of targeting it toward the traditional academic audience, the biology instructor. Thus, the first oral presentations provided a chance for the student to test for an appropriate level of detail and background information. Peer comments after the talk quickly identified gaps in logic, a weak argument or disorganized thoughts. In response to this feedback, in their second presentations, students showed greater attention to the organization of material to *both* enlighten and convince an audience about the credibility of the recommendation for their biological solutions.

The immediate feedback from instructor and peers, particular to the oral presentation genre, is an important component in the critical thinking process. In the cycle of integrating information, the opinions of others contribute toward reevaluation and establishing or reinforcing connections among topic information. As Zull reports, we learn by moving from copying information (sensing information) to integrating and reflecting on that information (Zull, 2002). Confronting a listening audience provides additional signals regarding how the information is presented and what is being presented. Nearly every student expressed in one form or another some version of self- critique immediately upon completion of the first talk. Their statements reflected a reconsideration based on perceived audience reception and reaction, *before* the instructor or peers made any comments. The oral exercise clarified the notion of being sensitive to one's audience, evidenced to the speaker from the listeners' body language, facial expressions or lack of attention. In contrast to a written document, even though encouraged by the writing instructor to write with their "reader's expectations" in mind (Gopen, 2004a, b), a writer is removed from knowing what the reader's reactions are for the most part, and they miss the impact of his/her message provided by a live listening audience.

The oral exercise is initially perceived with dread. Students expressed high levels of uncertainty about developing and delivering a presentation and anxiety about speaking in public. They worried that they would not "sound as if they knew what they were talking about." But as they learned about organization, audience, and the oral communication process and revised their talks in response to peer and instructor input, they learned more about their subject and gained greater confidence in discussing its science. Student communication improves when it is based upon scientific understanding generated by ongoing critical thinking processes, which is challenged by peer and instructor feedback.

> [Individuals who aspire to become experts] must then submit their conversations and text to the scrutiny of their peers and subsequently be able to use peer criticism to refine and reconstruct their ideas. In accomplishing these goals, they are able to situate their work within existing scientific knowledge by addressing conceptual voids and expanding boundaries of canonical science, and to situate themselves within the science community. (Ziman, 2000; Florence and Yore, 2004).

With multiple opportunities to write and talk about science and to revise and practice *speaking like a biologist* (using the biological terminology), the inclusion of instruction in oral communication, improved students' writing and speaking, but equally promoted their learning of science and critical thinking (Palmerton, 1992).

Many college teachers are reluctant to admit the importance of communication skills or do not understand the field of communication and dismiss its academic and theoretical rigor. Even when instructors realize the importance of communication skills, they often claim that communication assignments and activities "steal" time from more important lab or lecture work and refuse to revise their curriculum to include communication assignments. In addition, even when a professor is willing to be more innovative, he or she may lack the specialized know-how required *to teach* the fundamentals for communicating effectively, thus requiring students to perform an assignment for which they are unprepared.

Given the results of our research, interdisciplinary efforts between communication and science faculty may provide a highly expedient and effective method for undergraduate science students to acquire fundamental communication skills and, in that process, greater knowledge about discipline-specific content since s*peaking* about material is itself an exercise in critical thinking and learning (Bayer et al., 2005). Our experience from modifying this class to include more opportunities for students to talk, write, and visually present scientific material highlights, communication, not only as an area of skill acquisition, but as a method to promote critical thinking and knowledge.

REFERENCES

Bayer, T., K.A. Curto, and C. Kriley. (2005). Acquiring Expertise in Discipline-Specific Discourse: An Exercise with Speaking in the Biological Sciences. *Across the Discipline*s 2: no page, 26 June 2005. www.http://wac.colostate.edu/atd/articles/ bayer_curto_kriley2005. cfm.

Boyer Commission on Educating Undergraduates in the Research University. (1998). Reinventing Undergraduate Education: A Blueprint for America's Research Universities, NY: State University of New York.

Chaffee, J. (1999). Critical Thinking, Thoughtful Writing, Boston, MA, Houghton Mifflin Co.

Cronin, M.W., G.L. Grice, and P.R. Palmerton. (2000). Oral Communication across the Curriculum: The state of the art after twenty-five years of experience. *Journal of the Association for Communication Administration* 29: 66-87.

Florence, M.K. and L.D. Yore. (2004). Learning to Write Like a Scientist: Coauthoring as an Enculturation Task. *Journal of Research in Science Teaching* 41(6): 637-668.

Gopen, G.D., (2004a). Expectations: Teaching Writing from the Reader's Perspective. New York, N.Y., Pearson Education Inc.

Gopen, G.D., (2004b). The Sense of Structure: Writing from the Reader's Perspective. New York, N.Y., Pearson Education Inc.

Jerde, C. L., and M.L. Taper. (2004). Preparing Undergraduates for Professional Writing: Evidence supporting the benefits of scientific writing within the biology curriculum. *Journal of College Science Teaching* 33 (7): 34-37.

Palmerton, P.R. (1992). Teaching Skills or Teaching Thinking? *Journal of Applied Communication Research* 20: 334-341.

Schneider, A. (1999, March 26). Taking Aim at student incoherence: Spread of speech programs across the curriculum irks some communication professors. *Chronicle of Higher Education* A16.

Zernike, K. (1999, January 31). Talk is, like, you know, cheapened: Colleges introduce classes to clean up campus 'mallspeak.' The Boston Globe, p. A1.

Ziman, J. (2000). Real science: What it is, and what it means. New York: Cambridge University Press.

Zull, J.E. (2002). The Art of Changing the Brain. Sterling, VA, Stylus Publishing, LLC.

APPENDIX

Grade determination

Semester grades were based on the number of points earned out of a total of 330. Several smaller written assignments, worth a total of 85 points, comprised the early part of the coursework. The first, second and final drafts were worth 30, 60 and 100 points respectively. The first and final oral presentations were weighted at 15 and 40 points respectively. Thus, early work did not carry as much grade value as later work.

Summary of Feedback for
Oral and Written Assignments
Fifteen-Week Course

Topic Assignment

↓ Biology instructor's approval of student's topic choice

First draft

↓ Peer verbal and written feedback

First revised draft

↓ One-on-one biology instructor's verbal & graded rubric feedback

Second draft

↓ One-on-one biology instructor's verbal & graded rubric feedback

First oral outline

↓ Workshop by Communication Lab instructor on organizing an oral scientific presentation
Communication Lab instructor & peer feedback on 1st oral outline

Second oral outline

↓ Workshop by Communication Lab instructor on delivering a scientific presentation
Communication Lab instructor & peer feedback on 2nd oral outline, and a brief two-point impromptu presentation by all students

PowerPoint Lab

↓ Instruction in computer lab on creating a PowerPoint presentation
Biology instructor's feedback on slide format and content

First oral presentation

↓ Biology instructor's verbal & graded rubric evaluation
Peer written feedback
Student self-critique of videotaped talk

Final Oral presentation

↓ Biology instructor's verbal & graded rubric evaluation

Final draft

Heart Rate and Stress in a College Setting

Nancy L. Elwess and F. Daniel Vogt
101 Broad Street
Department of Biological Sciences
State University of New York, Plattsburgh, NY 12901
Plattsburgh, NY 12901
nancy.elwess@plattsburgh. edu
f.vogt@plattsburgh.edu

Abstract: Conditions producing stress are present in all colleges and universities. In this paper we report on an investigation utilizing heart rate as an indicator of stress in students when participating in activities encountered in a college classroom or laboratory. The activities included presenting an oral report, taking an exam, and participating in a competitive laboratory exercise. Increased change in heart rate was observed in students participating in these activities. These heart rate responses provide some insight into the factors in the classroom, which produce stress in our students.

Introduction

The demands of college can be challenging and stressful even to the best of students. Pressure to succeed academically, pay for college bills, make career choices, and to maintain a healthy and enjoyable lifestyle are normal parts of college life. Variation in heart rate can be influenced by psychological and physiological stress (Fontana et al., 1999). In the classroom, taking a written exam or giving an oral presentation are two experiences that may be particularly stressful to most students and may cause extensive nervousness and anxiety leading to a cascade of physiological events (release of adrenaline and other hormones) that stimulate increased heart rate (Booth-Kewley & Friedman, 1987). Currently several universities are having their students learn how to deal with stress because later it will often occur in relation to their job. An example of this is a surgical technology course at the University of Cincinnati. In this course, students spent time learning how to deal with the high stress levels that go along with working in an operating room where they often will have to make quick decisions on the job (Forgrave, 2004). Because exposure to stressors in college students is associated with anxiety (Craske et al., 1995), one purpose of this investigation was to assess the extent to which students experience stress when participating in activities encountered in a college classroom or laboratory. A second purpose was to engage students in the collection and analysis of data. The relationship between heart rate and stress is well documented in sports, scientific, and medical journals; and the recent development of wireless heart rate technology has made it possible to design experiments to measure this relationship that can easily be implemented by students in the classroom. Our general hypothesis is that there will be an increase in heart rate when the students are exposed to specific stressors in the classroom or laboratory.

The heart rates of student volunteers in upper level biology courses were recorded by wireless heart rate monitors (non-invasive chest strap and wristband; Polar HRM USA, Levittown, PA), which are available for purchase at most sporting goods stores. Each volunteer secured the monitor equipment at the beginning of class and, when prompted, read his/her heart rate to the instructor during a particular classroom or laboratory activity. Heart rate was recorded in students participating in the following classroom activities:

1. A junior level genetics course when the student was
   a. sitting and listening to a lecture.
   b. sitting and taking a written exam.
   c. sitting and waiting for his/her graded exam to be returned.

The students predicted that heart rate would be higher during an exam than when listening to a lecture; however, there was uncertainty as to how elevated the heart rate would become during the exam. Additionally, most students did not expect their heart rates to increase substantially when their graded exams were returned to them.

2. In an upper level biology elective course (behavioral ecology) when the student was:
   a. sitting, not scheduled to give an oral report that day, and listening to other students deliver oral reports during of the class.
   b. sitting and scheduled to give an oral report later during the class period.

c. standing, after being introduced by the instructor and poised to begin delivery of his/her report.

d. sitting immediately after completing his/her oral report.

The students predicted that heart rate would be highest when a student was sitting in the class and scheduled to give an oral report later during the class.

3. Heart rate was also monitored in students in an upper level biology elective course (winter ecology) who voluntarily participated in a laboratory exercise that simulated competitive foraging behavior for a resource in three environments at different ambient temperatures. Each volunteer stood facing a water-filled, 15 liter bucket placed on a laboratory bench top. Upon the instructor's signal to begin the 90 second contest, each of three participants competed to harvest the most dimes (simulating a food resource) from the bottom of the bucket in front of him/her by plunging only his/her favored hand into the water and retrieving one dime at a time. The competitive nature of the exercise was incorporated into the exercise to induce psychological stress. The stress caused by the different environmental temperatures was investigated by experimenting with the water temperature of each of the three buckets at different temperatures: near 0^oC (cold), near room temperature (approximately 24^oC, cool), and near body temperature (approximately 37^oC, warm). This experiment was repeated 8-10 times at each water temperature (20 volunteers participated in the study).

Results are reported as the mean (±S.E.) and significanct differences between means were determined by the students' t-test for all pairwise comparisons made throughout the study.

Taking a written exam induced increased heart rate. The mean heart rate of students taking written exams in a genetics class was significantly higher ($p< 0.001$) than when sitting and listening to the instructor deliver a lecture (Figure 1). The heart rates monitored during three different exams given on different dates were about 35% higher than heart rates taken during lecture on non-exam days. Individual student heart rates ranged from 84 – 115 beats/minute during exams versus 65 – 84 beats/minute during lecture.

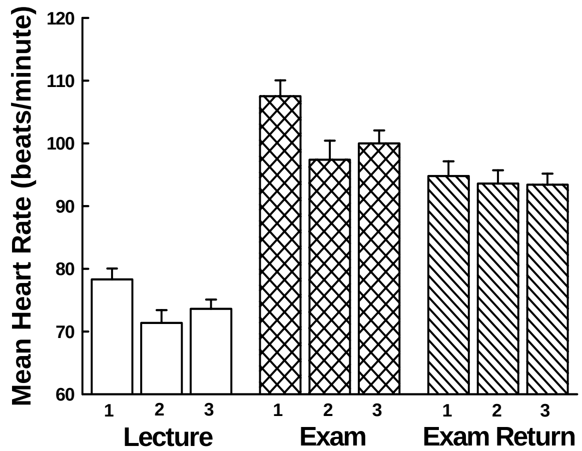


Figure 1. Mean heart rate from 10 student volunteers who were monitored during three classroom lecture periods (**Lecture**), three written examination periods (**Exam**), and three lecture periods when graded examinations were returned to students (**Exam Return**) in a junior level genetics course. The capped vertical line above each bar represents one standard error from the mean.

Delivering an oral report was about as stressful as taking a written exam or having a graded exam returned. Students presenting oral reports in a behavioral ecology class had heart rates that were about 34% higher and significantly different ($p<0.001$) than those of students in the classroom who were not scheduled to deliver an oral report that day (Figure 2). Within less than 5 minutes after completion of an oral report, heart rate (84 beats/minute) returned to near the heart rate (78 beats/minute) of students not giving a report that day.

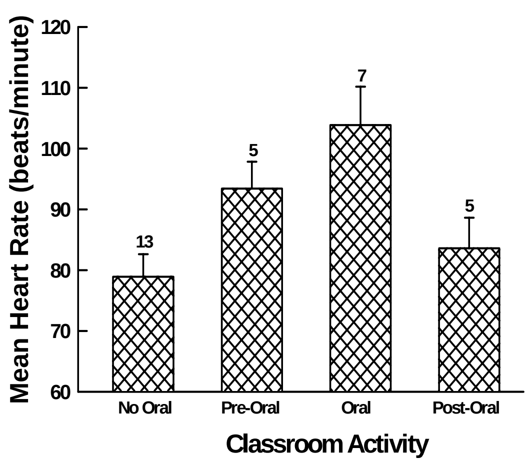


Figure 2. Mean heart rate taken from student volunteers in a biology elective course, behavioral ecology, when students were not scheduled to give an oral presentation that day and were sitting in class listening to the oral presentation of another student (**No Oral**), sitting in class awaiting their turn to give their oral presentation (**Pre-Oral**), giving their oral report (**Oral**), and sitting in class just after completing their oral presentation (**Post-Oral**). The capped vertical line above each bar denotes one standard error from the mean. The number above each bar denotes the sample size.

Student heart rate during the competitive foraging in the cold simulation increased at the onset of the competition and was most pronounced when foraging in cold water (Figure 3). The mean heart rates during the competition were near 95 – 105 beats/minute and significantly ($p<0.01$) higher than the mean heart rate recorded 10 minutes before the beginning of the competition (74 beats/minute). During the first 20 seconds of the competition, mean heart rate increased approximately 10 -15 beats/minute in each group; however, this increase was only significant for the group foraging in cold water ($p<0.05$). Foraging success was greatest in warm water and lowest in cold water. During the 90 second competition students foraging in warm water harvested twice as many dimes as students foraging in cold water (Figure 3), and the mean harvest taken at each foraging temperature was significantly different from the other, ($p<0.01$).

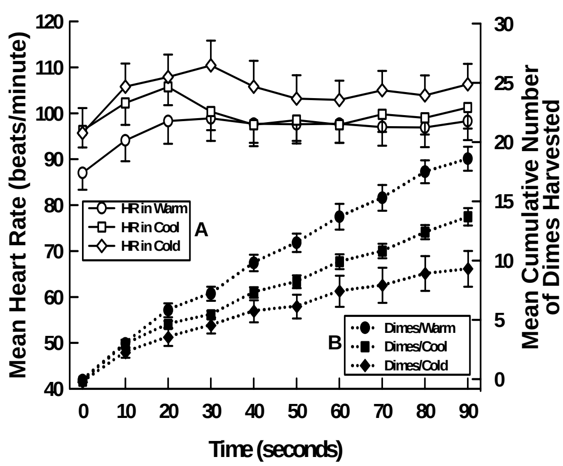


Figure 3. (**A**) Mean heart rate (**HR**) and (**B**) mean cumulative number of dimes harvested (**Dimes**) as a function of time during a competitive foraging competition by student volunteers in a biology elective course, winter ecology, when foraging in **Warm** (37°C; n=10 students), **Cool** (15°C; n = 8 students), and **Cold** (1°C; n = 10 students) water. The capped vertical lines above and below each symbol represent one standard error from the mean.

Discussion

Consistent with our expectations, students who participated in this investigation did experience different heart rate levels depending upon the activity. Students demonstrated about a 35% increase in mean heart rate between their lecture heart rate and their exam heart rate (Figure 1). However, of particular interest was the 26% increase in heart rate when graded exams were returned to the students as compared to their lecture heart rate (Figure 1). A slight reduction in heart rate (approximately 7-10%) was also observed in students on their second and third exams as compared to their first exam (Figure 1), suggesting some acclimation to the stress of examination. Even though there was a slight decrease in heart rate during the second and third exams, the participants still experienced a significant ($p<0.001$) elevation in heart rate that is likely due to exam-induced anxiety. This was of interest to us because the students in the genetics course thought that with each exam taken that their heart rate would drop (survey results not shown) as a result of being more familiar with the testing style of the instructor. When surveyed the students' felt that by the third exam their heart rate would be in the 80-90 beats per minute range.

One objective of this investigation was to ascertain to what extent college students' heart rates would be influenced by some of the typical demands of the classroom and the laboratory. This interactive investigation may help instructors and students gain some insight into how different activities serve as stressors in the classroom. While the results were consistent with our expectations, there were some limitations to the study. Only a limited number of students took part in the study (due to the number of available heart rate monitors) and only each specific classroom activity was assumed to have influenced the heart rates on individual students. Combinations of possible stressors are likely. For example, the 12-24 beats/minute increase in heart rate observed from 10 minutes before the laboratory foraging competition to the start of each competition suggests that the anticipation of a competition with peers induced psychological stress, in addition to the physiological stress induced when foraging in cold water (Figure 2). Also, the variations in heart rate due to other environmental factors (variation in sleep, caffeine consumption, exercise, previous preparation, etc.) were not assessed during this study. Future investigation should be designed to assess the influence of environmental factors from outside the classroom on student heart rate during classroom activities. Evaluation of the effect of gender and age on specific responses also merits investigation. Age is a particularly important factor to investigate, given the increased number of older, non-traditional students enrolled in college classes. Finally, it might be of interest to repeat the study this time testing the heart rate of faculty members prior to giving a lecture, a test, or while listening to student presentations, and compare the results with the student responses.

References

Booth-Kewley, S., & Friedman, H.S. (1987). Psychological predictors of heart disease: A quantitative review. *Psychological Bulletin,* **101:** 342-362

Craske, M.G., Brown, T.A., Meadows, E.A., & Barlow, D.H., (1995). Uncued and cued emotions and associated distress in a college sample. *Journal of Anxiety Disorders*, **9:** 125-137.

Fontana, A.M., Hyra, D., Godrey, L., & Cermak, L. (1999). Impact of a peer-led stress inoculation training intervention on state anxiety and heart rate in college students. *Journal of Applied Biobehavioral Research* **4, 1:** *45-63.*

Forgrave, R. (2004, June 3). Students learn de-stress method. *The Cincinnati Enquirer*.

Honorary Life Award

The **ACUBE Honorary Life Award** is presented to ACUBE members who have made significant contributions and/or service to ACUBE and the advancement of the society's mission. The award is presented at the annual fall meeting of the society.

If you wish to nominate a member of ACUBE for this award, send a Letter of Nomination citing the accomplishments/contributions of the nominee and a *Curriculum Vita* of the nominee to the chair of the Honorary Life Award committee:

Dr. William J. Brett
Department of Life Sciences Indiana State University Terre Haute, IN 47809
Voice -- (812) 237-2392 FAX (812) 237-4480
E-mail -- lsbrett@scifac.indstate.edu

John Carlock Award

This Award was established to encourage biologists in the early stages of their professional careers to become involved with and excited by the profession of biology teaching. The John Carlock Award provides partial support for graduate students in the field of Biology to attend the Fall Meeting of ACUBE.

The applicant must be actively pursuing graduate work in Biology. He/she must have the support of an active member of ACUBE. The recipient of the Award will receive a certificate or plaque that will be presented at the annual banquet; and the Executive Secretary will provide the recipient with letters that might be useful in furthering her/his career in teaching.

Applications, in the form of a letter, can be submitted anytime during the year. The application letter should include a statement indicating how attendance at the ACUBE meeting will further her/his professional growth and be accompanied by a letter of recommendation from a member of ACUBE. Send application information to Dr. William J. Brett above.

Science Center at Millikin University

ACUBE

Association of College and University Biology Educators

50th Annual Meeting

Millikin University
Decatur, IL
October 26-28, 2006

The Revolution and Evolution of Biology Education: Where 50 Years Can Take Us

Call for Abstracts

Please consider sharing your experiences, your knowledge, and your techniques with us at the 50th ACUBE Annual Meeting in Decatur, IL. Given the importance of this meeting, any type of presentation is welcome. We encourage you to submit a poster, paper or workshop but will gladly try to accommodate additional presentation formats.

Please send a 200-word abstract and the information below as e-mail attachments, by mail, or by fax by May 31, 2006 to

Conrad Toepfer, Brescia University, 717 Frederica St., Owensboro, KY 42301
Ph: 270-686-4221, Fax: 270-686-4222, e-mail: conrad.toepfer@brescia.edu

Proposed Title: ____

Presentation type: _____ 90-min workshop _____ 45-min paper _____ Poster _____ Other
(Rank in order of preference)

Equipment/facility needs: _____ 35 mm slide projector _____ Overhead projector

_____ Macintosh projection system _____ Macintosh computer lab

_____ PC projection system _____ PC computer lab

_____ Lab benches _____ Other (explain)

Name of presenter(s):____

Work address(es): ____

____

Presenter phone number: _____________________ e-mail: ________________________