Implementing Student Research in a Biology Course for Nonmajors

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Inspired, or rather, shaken by reading *The Liberal Art of Science* (1990), two Sigma Xi Wingspread Conference Reports (1989; 1990), the Project Kaleidoscope Report (1991) and one of many articles in the popular press (Leslie, 1990) but decry mind-numbing methods of teaching science in college courses, I responded by altering my approach to the introductory biology course for nonmajors. This was accomplished by incorporating student-generated research into the laboratory. Over the past eleven years I had provided sound laboratory exercises, yet the spirit of discovery was simply not a part of the laboratory component of the course for students who did not major in biology. For them the introductory biology course was yet another difficult hurdle on the road to a baccalaureate degree in a liberal arts college which requires two laboratory courses in the natural sciences. Two other members of the Biology Department had begun experimenting with investigative biology laboratories for nonmajors the previous year and had reported great success with the process and the outcomes. After much hesitation, reading, and comparing notes with college biology instructors at the 1990 Biology Curriculum Conference held at Butler University, I decided that a laboratory in which the students conducted their own research was a logical approach to address student understanding of the process of science; I could delay no longer.

Several years ago, in answer to the question “What could be done to improve this course?” one student wrote: “Let us do our own research.” I was baffled then by the logistics of implementing such a request and by my perception that students did not have a great enough knowledge base to allow them to do research. These objections persisted in my mind for several years, but I put them aside after realizing that students must have many unanswered questions that their research could address. After all, students in poetry classes write poetry although they are not poets (Tobias, 1990), so why shouldn’t students in a science class do science? As a result, I reorganized the laboratory component so that a student-generated research project became an integral part of the introductory biology course.

At present, lecture/laboratory sections of the nonmajor biology courses at Elmhurst College are taught by one instructor and include a maximum of twenty-four students. Each instructor can choose the format of the laboratory exercises and is not bound by a common laboratory syllabus. Nevertheless, all of the instructors have chosen variations of the same format. This approach will be more difficult to implement in courses that will require major changes in the use of staff, namely; those courses with multiple sections of laboratories and hundreds of students per term. Under some circumstances, the investigative laboratory approach may not be feasible for a variety of reasons.

Laboratory Organization

To begin, I divided the laboratory component (fourteen two and one-third hour meetings) into equal halves based on the work to be done. During the first seven weeks of the semester, students worked in groups of three or four on laboratory exercises chosen to allow them to become familiar with laboratory equip-
ment, metric measurement, graphing, reading and following laboratory directions. To enable the students to become familiar with some basic statistical tests, groups of two students taught one statistical test to the others in the class. Another goal of the laboratory exercises was to give students the opportunity to meet and work with others who were potential collaborators in the upcoming research project. For these exercises, the students were encouraged to work with different laboratory partners each week. Written reports on the exercises were collected from each student and evaluated so that students could learn what was expected of them in a written laboratory report.

When the laboratory exercises were short enough to allow other activities, the students met in groups to discuss research projects. To assist with the discussions, each received a handout listing organisms suitable for an introductory biology experiment and the titles of experiments carried out by students in other classes. These were helpful in the decision-making process. Whenever possible, students were given time to hold research group meetings during laboratory or class. Some of the time was also used to tour the department’s greenhouse and other laboratories in our Science Center to see the facilities available for student research.

During the second half of the semester, groups of two or three students worked on their research and used library resources to gather information. From this point, the scheduled laboratory meeting times were used for data collection, research group meetings, library research, writing or preparation for the oral presentation. As a result, non-major students became involved in the process of biological research from hypothesis formation and experimental design, to data analysis and presentation.

All in all, the logistics of securing, providing and moving supplies proceeded quite smoothly. Each student research group submitted a research proposal two weeks before beginning the experiments. The proposal included the purpose of the experiment, the null hypothesis and alternate hypotheses, an outline of the experimental design, and a complete list of materials needed for the work. An undergraduate assistant and I then used the lists to assemble materials in the laboratory. The students were informed that I would be available during the scheduled laboratory time each week to provide technical assistance with experiments as well as during my regular office hours. After the first hectic laboratory meeting I divided the time into twenty minute intervals which research groups could reserve. Thus I could give each group undivided attention for a concentrated period of time.

The organizational framework of the laboratory and research was based on the Handbook of Biological Investigation (Ambrose and Ambrose, 1987), which not only provide the basic steps in beginning a research project, but also include statistical tests and clear examples for student use. The text includes an outline of experimental design, the mechanics of writing a scientific paper and gave excellent examples for each step in the process. There is no doubt that this type of laboratory could be conducted without a text, but I thought that the book allowed the students more independence in their work by providing a ready reference for them during all stages of the work.

Another major hurdle to overcome was the students’ lack of facility in using the library for research on technical topics. At my request, one of the reference librarians organized and presented an introduction to finding technical information in the college library. Her approach was to assume that she was a student in the course, so she chose a topic of interest - acid rain - to “investigate". She then detailed the steps of information gathering for the students. After spending just one class period in this introduction to the library’s science resources, the students reported feeling more confident of their ability to find information during the library research portion of their work.
The projects chosen by the students varied widely based on personal interests (gardening, raising goldfish), an experiment remembered from high school (effect of various chemicals on the heart rate of *Daphnia*), or simply choosing an organism from the list, reading about its life cycle, and devising an experiment (effect of temperature on mealworm pupation rate). One group chose to study the effect of acid rain on bean plants as a result of the library presentation.

During the final laboratory period, each research group was allotted twenty minutes to present their work in the format of a scientific meeting. For this assignment many of the students produced their own overhead transparencies or posters to present data. While data sharing and discussion of the results and conclusions were expected among the members of a group, each student was required to write a scientific paper detailing the work of the experiment. Some of the students learned word processing or used word processing skills acquired in other classes to write the research papers. Several students learned to use a computer graphics program to prepare graphs of their data for the presentation and for the paper.

**Conclusion**

When class evaluations were collected at the end of the semester, several students remarked that although they had not especially liked science before taking introductory biology, they had found the laboratory interesting and "actually liked it". I had never seen this type of response to the course prior to using the student-generated research. I also think that another benefit of the research-oriented approach to the introductory biology laboratory was that it allowed more of the students to get to know one another. After giving two presentations, talking with other class members about the research and working in the laboratory or greenhouse with others in an informal setting, they were able to get better acquainted with each other, thus allowing more of a "community spirit" to develop within the class.

Because students had to carry out experiments in groups, they learned to rely on each other, and to trust their own observations and conclusions. They discovered that they could learn new concepts both from their own and other students' work. They also learned that experiments often produce unexpected results or ones which were difficult to interpret. Many of them also realized that they were required to explain those results in a manner consistent with some of the basic biological principles which they had learned in the course. Several of the students also gained insight into changes in the experimental design that would have allowed them to better focus on the question under investigation.

Implementation of a student research component in a biology course for nonmajor students requires a considerable amount of organization and time available for consultation with the students. The first two weeks and the last week of the experimental phase probably require the greatest amount of faculty input. Just before the presentations I did show several students how to use a computer program to generate graphs. I will to incorporate that work into the first half of the laboratory when I teach the course again. Several students handed in their papers early for comments and suggestions on the work. Reviewing these papers took less time than I had anticipated because of my close involvement with the planning and execution of the experiments.

I intend to continue to use the research-oriented laboratory for nonmajor students. I also think that some of the principles involved in this type of course can be applied to make required laboratory courses for biology majors more appealing by allowing them to experiment and discover some of the excitement of biology very early in their academic careers.
1991-1992 Election Results

At the October annual meeting in Kansas City, Cathy Hunt of Henderson Community College (Kentucky) assumed the Presidency for the 1991-1992 year. The highlight of the meeting was the presentation of Honorary Life Membership to Edward S. Kos of Rockhurst College (Missouri). Congratulations from all of us, Ed. Sister Marion Johnson of Saint Xavier College (Illinois) was elected President-Elect for the 1991-1992 year. President Cathy Hunt appointed Robert Wallace of Ripon College (Wisconsin) as the Program Chairperson for next year and thus he will serve as First Vice President. Harold Wilkinson of Millikin University (Illinois) and Edward S. Kos were both re-elected as Secretary and Executive Secretary, respectively. Newly elected members of the Executive Board as Members-at-Large are Patricia Bowne of Alverno College (Wisconsin) and Leland Hansen of Highland Community College (Illinois). Continuing members of the Board are Timothy Mulkey, Malcolm Levin, Ben Dolbeare, and James Waddell. Sister Marion Johnson and Stan Boyer, both of Saint Xavier College (Illinois), will share duties as local arangements chairpersons next year; thus, Stan Boyer will serve as Second Vice President. John R. Jungck will continue on the Board as Past President and Editor of Bioscience. The next meeting of the Board will be at Saint Xavier College in late February 1992. If you have business to go before the Board, please inform either or both Executive Secretary Edward S. Kos or President Cathy Hunt in time for them to send the agenda out to all Board members.