USING UNDERGRADUATE TEACHING SCHOLARS IN A LABORATORY COURSE FOR NON-SCIENCE MAJORS

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Although laboratory instruction for non-science majors is a major goal of higher education, its implementation is often difficult in practice. Non-science students are often uncomfortable with a laboratory environment and require close supervision for the laboratory instruction to be effective. To address this problem, support from the New York Collaborative for Excellence in Teacher Preparation (NYCETP) was used to recruit and train undergraduate Teaching Scholars to assist in the instructional laboratories of NYU's core science program. The Teaching Scholar was paired with a graduate student laboratory instructor to create a "teaching team." Responses on student evaluations show that the arrangement enhanced student learning in the laboratory because both instructors were present during the laboratory session to provide assistance and answer questions. New initiatives in the project include recruiting students from both science and science education programs, thereby fostering interaction on methods of effective laboratory instruction.

Introduction

Science instruction for undergraduate students who are not science majors is a challenging goal of higher education [1]. Since 1995, we have embarked on an ambitious project at New York University (NYU) to offer laboratory-based science courses for non-science undergraduates. This has been achieved through the creation of the *Foundations of Scientific Inquiry* (FSI) program, a component of the Morse Academic Plan that constitutes NYU's new core curriculum. A central motivation for designing this new curriculum arose from dissatisfaction with the previous distribution requirement, in which most science courses did not have a laboratory component. The FSI program was created with the conviction that non-science majors could not properly understand the process of scientific investigation without the opportunity to experience it first-hand in a laboratory environment. NYU's commitment to laboratory-based science in the general education curriculum is in accord with national trends in science education reform. The National Science Foundation's influential report on *Shaping the Future* promoted the central goal that students learn science by "direct experience with the methods and processes of inquiry." [2] Similarly, a recent report on undergraduate

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Science, Mathematics, Engineering, and Technology (SME&T) education, commissioned by the National Research Council, recommended that science courses include "laboratory rich experiences." [3] A focus on laboratory instruction for all students has been promoted by reports from Project Kaleidoscope [4] and the recent study of education in research universities by the Boyer Commission [5].

The *Foundations* curriculum consists of three sequential courses: Quantitative Reasoning (mathematics), Natural Science I (physical science), and Natural Science II (biological science). These courses are currently offered in three or four different versions each semester, thereby enabling students to select a course that best matches his or her interests. For example, course offerings in Natural Science I include *Einstein's Universe*, *Energy and Environment*, and *Exploration of Light and Color*; whereas, courses in Natural Science II include *Human Genetics*, *Brain and Behavior*, and *Human Origins*. Each of the Natural Science I and II courses is taught in a lecture size of about 120 students, who are then separated into six laboratory sections of approximately 20 students each. Laboratory sessions are taught by trained graduate students who are each responsible for two laboratory sections. These instructional sessions are only 1 hr. 40 min. in duration, which is unusually short for a science laboratory. The FSI program began in the College of Arts and Sciences and has now expanded to include students from the School of Education, the Stern School of Business, and the School of Continuing and Professional Studies. The enrollment of education students in the program was considered essential for improving instruction in mathematics and science for the future generation of teachers. Participation by the business school reflects the belief that future graduates need scientific knowledge and comprehension to become effective leaders in the corporate world. The FSI program currently provides courses for over 1400 students each semester, with a projected increase to 1700 for the 2000-2001 academic year.

Operating with a program of this scope and scale has provided us with experience in developing and implementing effective educational strategies when teaching laboratories in a general education curriculum. One key observation is that non-science undergraduates are often inexperienced and uncomfortable in a laboratory environment, thereby requiring more direct assistance as compared to science students. Consequently, one laboratory instructor often cannot offer the necessary degree of close

attention that is required for non-science majors to gain a significant educational benefit from the laboratory experience. In order to address this problem, we initiated a pilot project to train and utilize undergraduate teaching scholars in the FSI laboratories, which was initiated and funded by the NYCETP collaborative. The goal of the project was to pair the Teaching Scholar with an experienced graduate student to create a "teaching team" that would be more effective at promoting student learning in the laboratory session. The initiative began during the Spring 1999 semester and is being repeated during the Spring 2000 semester. This paper describes the implementation and outcome of the project, together with its impact on curriculum development at NYU.

Undergraduate Teaching Scholars - Recruitment and Training

For the Spring 1999 semester, potential candidates for the Teaching Scholars positions were recruited through upper-level classes in science. All applicants were interviewed and the selection was based on both academic ability and statements of teaching objectives. For their involvement, each Teaching Scholar was paid a small stipend from the NYCETP grant. The first four Teaching Scholars were all science majors (one from physical anthropology, one from neural science, and two from chemistry). In order to focus the initiative, the Teaching Scholars were assigned to the FSI course on *Energy and Environment*, which provides an overview of the science and policy implications of contemporary environmental issues such as global warming, ozone depletion, acid rain, etc. Laboratory projects for this course include: Gases in a Breath; The Properties of Light; Molecular Models; Water Quality Testing; and Photovoltaic Solar Cells. Each Scholar was paired with a graduate student laboratory instructor who served as a collaborator and teaching mentor. We train our graduate laboratory instructors to engage the students by circulating within the laboratory room, offering assistance and asking questions to probe students' understanding of the experiment. In turn, the graduate student assisted the Teaching Scholar to interact with the undergraduates in the laboratory session. In addition to assisting with two laboratory sections, the Teaching Scholars also attended the weekly course meeting, together with the laboratory instructors, in order to run through the experiment for the following week and discuss how the scientific principles could be taught most effectively. My role was to provide general oversight of the Teaching Scholars, including attending laboratory sessions to observe their teaching in practice.

Evaluation

In order to evaluate the effectiveness of the Teaching Scholars, we conducted a survey in the final laboratory session of the semester. Students were asked to give a ranking of 1 – 5 for three numerical questions, which are shown along with the results in Table 1.

Table 1: Numerical Survey Results for the Teaching Scholars

Survey Question	Average Score[1]
Did the addition of the Teaching Scholar improve your learning experience in the labs (1 = no improvement, 5 = great improvement)	4.00
Did the Teaching Scholar collaborate effectively with the laboratory instructor (1 = not effective, 5 = very effective)	4.41
Did the Teaching Scholar assist with your understanding of the lecture material (1 = did not assist, 5 = greatly assisted)	3.94

[1] Average scores are given for a total of 136 responses.

In addition to the numerical scores, the survey form asked students to provide written comments on the effectiveness of the Teaching Scholar in the laboratory environment. Most of the comments were positive as illustrated by the sample quotes shown in Table 2.

Table 2: Quotations from Teaching Scholar Evaluation Forms

"Two of them floating around asking questions is definitely better than one."
"I would like to take this class again just for the Teaching Scholar."
"He was really helpful in the labs and in review sessions before tests."
"He was a very good Teaching Scholar and made the class better."
"It was a great benefit having him for the labs."
"I thought it was useful and helpful to have someone else in the room...She was always helpful when we had questions."
"Together they were very effective, since there wasn't only one instructor in the whole class."
"Two teachers were able to assist students better during labs."

"It was good to have an extra person around to explain and answer questions."
"It was helpful to have two instructors."
"There was more one-on-one help."
"It did help because there were two people to ask."

These evaluation results suggest that the Teaching Scholars were effective in meeting the central objective of the initiative, which was to provide enhanced instruction for non-science majors in the laboratory. The student comments often mentioned the beneficial effect of having an additional instructor to answer questions and assist students with the experimental procedures.

Revisions of the Project for Spring 2000

In the Spring 2000 semester, we are again using the Teaching Scholars in the *Energy and Environment* course, but this time we have made significant revisions to the project. The first change is to actively recruit students both from science programs and the science education program in the School of Education. This initiative grew from interactions between the FSI program and the School of Education in the context of the NYCETP collaborative, and was pursued in an effort to stimulate interaction between science majors and science education students. Of the three Teaching Scholars for the Spring 2000 semester, two come from the science education program.

The second change concerns the nature of the laboratory projects. One significant concern about laboratory instruction is that experiments tend to become formulaic, so that students focus only on getting "the right answer." We have introduced a new approach to laboratory instruction in which students participate in an inquiry-based project. Previous research has shown that a similar lab project approach proved effective in correcting students' misconceptions in a biology lab course [6]. Each project is designed to extend over five weeks and explores a particular aspect of local water quality; for example, "Can Hudson River Water be Made Safe to Drink?" and "What is the Effect of Acid Rain on Plant Growth?" During the project, students collect their own water samples, design experiments, plot their results using an *Excel* spreadsheet, and generate their own scientific conclusions. The culmination of the investigation is that students create a poster and present their results and conclusions to their Scholar students

in the laboratory group. Although the water quality projects were piloted during the Fall 1999 semester, we encountered major difficulties with their implementation because the undergraduate students require considerable assistance in designing and performing open-ended experiments. We believe that utilization of the Teaching Scholars to aid students in the laboratory during these projects will greatly enhance their effectiveness.

Conclusions and Future Directions

The NYCETP-sponsored Teaching Scholars initiative has considerably enhanced the quality of instruction in the FSI teaching laboratories at NYU. In addition to the beneficial effects for the undergraduates, the Teaching Scholars themselves have commented on how the experience has improved their skills in scientific communication. To improve the assessment of the project, evaluation is planned to determine the impact of the experience on the Teaching Scholars' chosen career paths. The success of the Teaching Scholar in fall 1999 was used as the basis of a grant to NYU's Curriculum Development Challenge Fund to extend the program throughout the 2000-2001 academic year. In addition, the Teaching Scholar model is currently being explored as a way to involve graduate students from NYU-affiliated medical schools as assistants in the FSI laboratories.

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Bio

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