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Service-Learning in Physics: The Consultant Model

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Abstract

Problem solving, both theoretical and practical, is the underlying skill developed through the physics curriculum. Service-learning has been integrated into engineering curricula, but programs proposed for that field often do not fit well into the structure of physics departments. A consultant-based approach to service-learning offers physics students the opportunity to apply their problem-solving skills for the benefit of others. As service-learning consultants, physics students provide technical and managerial support to groups that are participating in technically oriented educational enrichment activities.

Introduction

The physics curriculum is centered on the development of solid analytical and practical problem-solving skills as applied to the understanding of all types of physical systems. Throughout their studies, physics majors develop mathematical, analytical, and laboratory techniques of increasing sophistication while studying such topics as Newtonian mechanics, electricity and magnetism, thermodynamics, quantum mechanics, and relativity. Although the content of these subjects is critical to those students interested in graduate school or careers in technical industries, it is the emphasis on analytical skills that has led to the employment of many physics majors in unrelated industries, such as the financial sector. Many physics majors report that their main employment tasks, such as developing software systems, building all types of analytical models, and performing other design work *(Mulvey and Langer 2001)*, require the skills they acquired during their studies even though they are not directly related to the content of physics courses. Thus, students studying physics have a set of skills that are transferable and applicable to groups involved in all types of activities that require problem solving and analysis.

Although there are clear models for service-learning in related fields, such as engineering, there is no clear model for implementing service-learning in physics. Physics is the scientific basis for many branches of engineering, but the differences in the structure of the academic departments and the curriculum make it difficult to employ engineering service-learning models in physics classes. One of the most significant differences between physics and engineering departments is their size. In 2004, some 5,010 bachelor's degrees in physics were conferred by 767 departments in the United States. In fact, almost half of the students, 2,168, earning a bachelor's degree in physics in 2004 graduated from the 515 physics departments at institutions that grant only bachelor's degrees *(Nicholson and Mulvey 2005)*. Thus, most of the physics departments around the country graduate about four majors each year. In contrast, the 340 colleges and universities in the United States that offer programs leading to a bachelor's degree in engineering *(U.S. Department of Labor 2004)* graduate over 70,000 students each year *(Colvin 2005)*. This is an average of approximately 205 students per institution per year. This disparity in the number of students and the size of the academic departments makes the programs designed to integrate service-learning into the engineering curriculum *(Tsang 2000)* impractical for most physics departments to implement.

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In addition to the size discrepancy, differences in the way the physics and engineering curricula are delivered make it difficult for physics departments to implement the engineering models of service-learning in their classes. Because physics is a branch of science that deals with the fundamental concepts used in understanding interaction of matter and energy at all levels throughout the universe, the focus of the curriculum is on developing the general analytical skills needed to analyze a physical system. Physics students usually begin focusing their studies in their junior or more likely their senior year, when many students perform physics research with a faculty member as a capstone experience. In engineering, which focuses on the practical applications of the sciences, students usually focus their studies in a particular branch of engineering in their sophomore year, and many departments use a project-based curriculum to give their students the opportunity to repeatedly apply their skills to real-world situations. Thus, most service-learning programs in engineering, like those described in Projects That Matter *(Tsang 2000)*, are initiated, managed, and funded by the engineering departments to provide students with projects for their courses. These projects are intended for a large group of students working on a particular problem to provide a service or device for a group in need.

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Because of the differences in size and focus of the classes in engineering and physics, these service-learning in engineering projects are not applicable in most physics classes. This is unfortunate, because participation in service-learning projects offers physics majors benefits in several arenas. The physics curriculum is sound in its development and does often stress synthesis of the skill set in a senior year research project or internship, but students would benefit from more opportunities throughout their academic development to assess their skills in applications outside the classroom. In addition, since many of those graduating with degrees in physics will apply their skills at jobs that may not be directly connected to the content of the classes but require the skills developed through the curriculum *(Mulvey and Langer 2001)*, service-learning would provide the opportunity for all physics students to expand their employment horizons earlier in their college careers. Communities also stand to benefit from service-learning programs for physics majors, because many liberal arts colleges have physics departments but not engineering departments. In the absence of such programs, these institutions' home communities lack a technically literate group of students that could support enrichment program participants.

Overall, it is because of the systemic differences in the departments and curricula presented that the service-learning in engineering projects are not applicable to most physics departments; this may also be why there is no model of service-learning in physics. In fact, the service-learning in engineering monograph referenced above *(Tsang 2000)* is one of a series of twenty published by the American Association for Higher Education.

These monographs describe service-learning projects for disciplines ranging from accounting to peace studies and biology to Spanish, but there is no monograph on service-learning in physics.

In an effort to fill this service-learning gap to provide physics students the opportunity to synthesize the analytical skills they are developing through their studies, a consultant-based approach to service-learning has been developed and implemented in the Physics Department at Saint Anselm College. As service-learning consultants, students in their sophomore and junior years provide technical and managerial support to groups participating in scientific educational enrichment activities that may not otherwise have access to technical expertise. In the consultant model, an outside agency has already established the technical project; the physics students provide support. In practice, these service-learning consultants are acting as engineers in an area that may be outside the aegis of the academic department. This is a valuable lesson for many students, since about a quarter of the physics majors in the United States find employment as engineers upon graduation *(Mulvey and Langer 2001)*. In fact, many faculty members from both physics and engineering departments involve themselves in research and development programs initiated by another group from either the private or the public sector through the same consultant model.

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Initial Organization

To begin establishing the consultant model of service-learning, a supervising faculty member must first assess the skill set of the group of students that will participate in the service-learning activity. In itself this is a valuable activity, since it provides students with a list of the skills they are developing through their studies. For the students from the Saint Anselm classes that have participated as service-learning consultants, the following set of skills was established.

1. Technical reading skills: Students should be able to read and understand technically challenging statements, such as the directions included with a piece of equipment or software.
2. Problem-solving skills: Students should develop their own problem-solving techniques that they can apply to all types of situations.
3. Analytical models: Students should be able to develop analytical models of all types of systems.
4. Software Analysis: Students should be able to analyze analytical models using software packages.
5. Mathematics: Students should be proficient in the mathematics used in the study of physics.
6. Fundamental understanding of the course material: Students should be able to explain the course material in their own words.
7. Managerial skills: Students should have developed managerial skills for their own time and for managing a group project.

The next step in the process is to find organizations that are participating in technically oriented enrichment projects and are open to support from outside agencies. Middle schools and national support groups, such as Girls Incorporated, often participate in technically challenging enrichment activities for which the classroom teachers or supervisors may not have the training necessary to develop and operate needed equipment. One specific middle school project in which teachers may need support is the GLOBE Program. Students participating in this international network of over fourteen thousand middle schools throughout the world collect atmospheric data and publish it on the Web. The GLOBE Program Web site (GLOBE Program) can be used to locate schools participating in the program. Most of the data collection does not require technical expertise, but some associated activities, such as building haze detectors, require certain specialized skills that most physics majors have. In one particular project, students from the Saint Anselm College Physics Department built several haze detectors that were given to middle school students to test and evaluate for use in the GLOBE Program *(Guerra, Cordella, and Bracy 2002)*.

Another service-learning project, which is the example used throughout the rest of this article, was conducted in conjunction with the Manchester, New Hampshire, chapter of Girls Incorporated, a national empowerment program for girls in high-risk, underserved areas. For this project the service-learning consultants provided support to a group of middle-school-aged girls who were participating in the national Lego League Robotics competition. Given this client group, a series of services to be provided by the consultants was established. In support of the girls participating in the robotics competition, the six service-learning consultants from a dynamics class provided several forms of support.

1. Technical information through weekly brainstorming sessions
2. Analytical support in the form of structural analysis
3. Support in the development of the robot control software
4. Managerial support by introducing the girls to milestone charting.

Implementation

At each weekly meeting of the Girls Inc. robot team, a different service-learning consultant led the girls in a brainstorming session focused on a relevant topic. Topics included project management, forces and acceleration, torque and gears, programming basics, and robot control strategies. In addition to robotics-specific topics, the girls requested a brainstorming session on ice cores, which pertained to the research part of the contest. The girls clearly valued the information provided in these fifteen-minute sessions, in which a service-learning consultant presented a topic and asked the girls for input as it pertained to their tasks for the week. The service-learning consultants found much of the information they needed for the brainstorming sessions in their course text and on the Internet. The Physics Department also purchased a few books on robot design and a set of the equipment that the girls were using to help the service-learning consultants prepare for their brainstorming sessions. This turned out to be a small capital outlay that was helpful, but not necessary to the success of the project.

After the brainstorming session, the consultants worked with groups of the girls on different robot tasks required by the competition. During this part of the meeting the consultants provided hardware or software support when needed and evaluated the technical problems the girls were experiencing. This evaluation was a critical part of the service provided by the consultants, since it often led to the topic of the next brainstorming session.

Figure 1: Milestone Chart for the Girls Inc. Robotics Competition

Milestones (Dates)	**Oct. 14**	**Oct. 28**	**Nov. 4**	**Nov. 11**	**Nov. 18**	**Nov. 25**	**Dec. 2**	**Dec. 6**
Group #1 (Kyle, Nate, Kelly, Amanda, & Lena)	Work on computer & hardware	Research	Software & present research on ice cores	Complete both programs on computer	TEST	Adjustments	Adjustments Complete project	Competition
Group #3 (Alexia, Amanda, & Pedro)	Present research about ice cores from last week & brainstorm	Work on the hardware	Research	Hardward & present research on ice cores	Complete programs on computer	TEST and adjustments	Adjustments Complete project	Competition
Group #2 (Josh, Nichole, Stacy, & Reba)	Research	Software presentation research on ice cores	Hardware	Research	Hardware & present research on ice cores	Complete programs on computer	TEST and adjustments complete project	Competition
	St. A's present about ice cores	**All groups meet to review appliances** St. A's presentation on gearing and torque	**All groups meet about arms and appliances** St. A's present	St. A's present	St. A's present	**All groups meet to summarize ice cores** St. A's present	**All groups meet fine tune**	

For example, discovering that the girls didn't understand the concepts of direct control and feedback control for their robot led to a brainstorming session on control strategies. The service-learning consultants prepared by researching several types of control strategies with a simple Internet search. The presentation gave the girls valuable information and reassured the college students of their technical reading skills.

Another beneficial service provided by the service-learning consultants was managerial support. Through the use of Gantt charts *(Gantt Charts)*, a common managerial technique, the service-learning consultants helped the girls track the milestones in the project and remain on task as they participated in the robotics contest. One of the most valuable lessons for both the service-learning consultants and the girls was that the milestone chart, like the one seen in figure 1, was not written in stone but was a document that needed to be updated every few weeks to reflect the actual progress of the project. The college students and the girls were interested to learn that most scientific and engineering projects go through the same process of updating and reorganization.

Conclusion

Because the physics curriculum is focused on developing analytical skills, service-learning in this field must be focused on solving technical problems. The types of technical projects commonly taken on by engineering departments are not feasible for most physics departments because of their size and the way their curriculum is delivered. The consultant model of service-learning, however, presents an appropriate way for physics students to apply their skills while helping others achieve their goals.

The service-learning consultants from Saint Anselm College benefited from opportunities to apply their skills in support of another group's project; moreover, the humanization of physics proved to be an important lesson for all those involved. Unfortunately, physics is widely perceived as an abstract field of study with no application to people's daily lives. Although physicists have been aware of this perception for some time, few steps have been taken to correct this misconception. Service-learning in physics is a step in the right direction; it provides a concrete example in which the skills developed through the physics curriculum can be applied to solve real-world problems.

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