PROJECT REPORT

Integrating an Elementary School Service-Learning Component into a College Physics Course for Non-Majors

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Motivation

While service-learning courses have experienced great success in many disciplines (NSLC, 2010; Prentice and Robinson, 2010), including many sciences (SENCER, 2010; Middlecamp et al., 2006; Broverman and Ogwang-Odhiambo, 2005), there have been few efforts to fully integrate service-learning into standard physics courses. There is increasing alarm that our country's scientific literacy is falling behind other developed nations (Augustine, 2005). In today's technological world, scientific literacy is invaluable; it provides citizens with analytical skills to solve problems, to decipher truth from nonsense, and to better compete in a global economy.

It is advantageous to learn concepts and skills needed to approach the physical sciences in elementary school (Dykstra and Sweet, 2009). Sadly, science is often taught as a mélange of disconnected facts or methods to be memorized for a standardized test. There is thus an educational demand for concept-based science outreach at the elementary-school level.

Physicists and physics students have implemented many excellent outreach programs directed towards K–12 education, particularly in the form of lectures, demonstrations, and workshops for K–12 teachers and students (e.g. SPS, 2010; Alford Center, 2009). Some colleges have formalized these outreach efforts by offering college credit for service-learning projects (Purdue, 2010; Morningside, 2009). Other physics service-learning courses focus on high-school outreach (Netter Center, 2009), require physics prerequisites, and/or have course learning goals related to pedagogy (Finkelstein, 2003). As far as we know, we present the first course models that integrate elementary-school outreach into pre-existing introductory physics courses with traditional content learning goals.

Our non-majors physics courses aim to build students' confidence and analytical abilities to question and synthesize new ideas and to apply science to understand and predict phenomena. However, most students expect to simply memorize facts for exams. Service-learning programs invest students more deeply in rediscovering fundamental concepts, and student engagement can significantly improve physics learning gains (Hake, 1998; Iverson et al., 2009). By applying their understanding, students not only learn physics content better, but also acquire skills to help them succeed as decision makers in a complex universe governed by physical laws. Our programs were grounded in the belief that if one truly understands something, one can explain it in simple everyday language.

We propose that a community-based–learning model for non-major physical science students can be much more effective and powerful than traditional lectures and homework problems. We compare and contrast two separate models we created and implemented independently, focusing on the practical details of implementation. In both models, college students teach basic physics concepts to elementary-school students by designing and conducting science workshops. In one case, college students visit an elementary school classroom (the "during-school model"); in the other, they visit an after-school program (the "after-school model"). In both cases, our community partners served children from under-privileged socio-economic groups. Our hands-on activity approach is especially helpful for elementary-school students who speak English as a second language (Laplante, 1997; Amaral et al., 2002; Lowery, 2003).

Selecting a Community Partner

Many universities have a service-learning or community-based-learning (CBL) coordinator or office to help faculty find an interested and committed community partner. We both established a partnership at least one month prior to the start of the semester. Convenient and safe transportation between the college and the partner is important.

Establishing a Partnership

We each worked with our community partner to shape the collaboration.

After-school Model

The after-school program had no set curriculum, which allowed the flexibility to cover any topics in any order. The lessons and activities had to be accessible to children ages six through thirteen and structured so that the elementary students could begin the activities at different times as they finished their homework. The summer preceding the CBL course, the professor conducted two practice science activity sessions with the physics-major mentors for the CBL course. This gave them experience working with the children before supervising the general-education physics students in the fall semester.

During-school Model

The professor who partnered with an elementary school presented the school principal with a proposal detailing the motivation, the benefits to the school students, the background of the prospective college students, and the schedule. The enthusiasm and commitment of the principal and teachers to such a partnership is essential. Fourth-grade classes were chosen to participate in the CBL collaboration because of state science testing at the end of the fourth-grade year, and the topics covered in second-semester college physics were compatible with the fourth-grade learning units. A few weeks before the semester began, the professor met with the fourth-grade teachers to discuss schedule logistics, the topics to be covered, and special events such as meetings with the college students and the culminating event of the semester (a visit by the fourth-grade students to the college campus).

Logistics of the Community-based Learning Component

An overview of the student populations participating in the CBL programs is given in Table 1. The after-school model

TABLE 1. Overview of Organization

	After-school Model	During-school Model
College course	General Education ; Conceptual Physics	Physics for Non-Majors
Course structure (hours/week)	Lectures, 3	Lectures, 3; recitation, 1.5; Lab, 3
Number of students (college)	28	4
Project target audience	Elementary-school students (ages 6-13) in after-school program	Elementary school students in 4th-grade science class
Number of students (elementary)	20-30	~25 × two classes
Guidance	1 professor; 4 mentors*	1 professor; 1 elementary-school science teacher; 2 4th-grade teachers
College student groups	10 groups, 2-3 students each	2 groups, 2 students each
College student participation	Mandatory	Optional†

*College junior and senior physics majors. † All four students in class chose to participate.

allows more freedom with respect to the topics covered (see Table 2); the during-school model has the advantage of supervision provided by the elementary school teachers.

The logistics and schedule of visits to the community partner site are illustrated in Table 3 and further explained below. In both models, half the class participated in each visit.

After-school Model

The six hour-long sessions at the after-school program each focused on a different topic in physical science. For each visit, five groups of college students created their own "station" of hands-on activities. Each station focused on a different aspect of the topic. After a very short introduction, led by the professor or a physics-major mentor, the after-school children divided into groups and rotated around the five activity stations, spending about ten minutes at each station. Thus, each college student helped develop three different stations during the semester, and a total of thirty activities were conducted with the children.

During-school Model

Each team of college students developed four different one-hour workshops during the semester (for a total of eight workshops conducted with each elementary-school class), and each workshop was presented twice per visit (as there were two fourth-grade classes participating in the program). In addition, the during-school model had two planning sessions (one for each unit) where the college students, professor, and elementary school teachers decided which experiments and demonstrations would best satisfy the learning goals of both the college and fourth-grade curriculum.

Grading

The grading structure is highlighted in Table 4. Both models emphasized conceptual understanding and effective communication of scientific ideas. Students must truly understand the concepts underlying the physics to explain them without equations to elementary-school students. In the after-school model, the projects replaced three exams and thus counted for a significant portion of the final grade.

Curriculum

It was important to find topics appropriate both for the college course and for the workshop experiments/demonstrations; see Table 2.

After-School Model

The after-school model incorporated CBL into a general-education physics class with more curriculum flexibility. The course focused on six broad topics that lent themselves to hands-on activities at the elementary-school level. Topics were discussed in class before each session, and traditional reading (from Hewitt's *Conceptual Physics* textbook) and homework questions were assigned. Each student group chose a subtopic as the focus of their activity station, and connections between neighboring stations were encouraged.

During-School Model

The during-school model matched the established curriculum for second-semester, algebra-based, introductory college physics with the established fourth-grade curriculum. Of the college physics topics, all but optics were compatible with learning units covered in the fourth grade. Optics was

TABLE 2. Science Workshops

	After-school Model		During-school Model	
	College course workshops		*College course*	*Compatible 4th-grade unit*
Topics Covered	Motion and gravity Simple machines Sound and music	Phases of matter Electricity and magnetism Light and optics	Electromagnetism Fluids Thermal physics	Electricity and magnetism Properties of water
Session Outline	Introductory station run by mentors 5 demonstration stations (related to the day's topic) that students rotate through		Introduction (including vocabulary review) Demonstration Various experiment stations that students rotate through Discussion and conclusion	

incorporated into the CBL project via the culminating event of the semester, in which the fourth-grade students visited the college physics laboratory where students had prepared optics demonstrations as an enrichment activity.

Outcomes

After-School Model

Multiple methods were used to assess the effectiveness of the course.

We received positive feedback from the program director at the YWCA, and a post-survey of the after-school students, loosely based on the Test of Science-Related Attitudes (Fraser, 1981), confirmed their enjoyment of the activities and positive science-related attitudes.

The college students' performance on the final exam compared well with the performance of traditional sections of the same course taught by the same professor. On the individually completed portion of the final exam, the performance of the CBL section on identical questions was similar (i.e., within a standard deviation) to the performance of other classes, despite taking no other in-class tests during the semester. Their performance on a collaborative part of the exam was outstanding (an A+ average), and exceeded that of other classes. The Student Assessment of Learning Gains (SALG, 2010) survey indicated that doing activity stations helped the college

TABLE 3. Logistics

	After-school Model		During-school Model	
Class time taken	CBL replaces 2 classes per week for 6 out of 14 weeks](i.e. a total of 12 classes out of 42)		CBL replaces 7 out of 14 weekly lab sessions for each college student*	
CBL Sessions	*Wednesday*	*Thursday*	**CBL Sessions**	
1st session	Group A practices; Group B is audience	**Group A visit 1**	*1st session*	**Groups A and B Planning Session 1**
2nd session	Group B practices; Group A is audience	**Group B visit 1**	*2nd session*	**Group A visit 1**
3rd session	Group A practices; Group B is audience	**Group A visit 2**	*3rd session*	**Group B visit 1**
4th session	Group B practices; Group A is audience	**Group B visit 2**	*4th session*	**Group A visit 2**
5th session	Group A practices; Group B is audience	**Group A visit 3**	*5th session*	**Group B visit 2**
6th session	Group B practices; Group A is audience	**Group B visit 3**	*6th session*	**Groups A and B Planning Session 2**
			7th session	**Group A visit 3**
			8th session	**Group B visit 3**
			9th session	**Group A visit 4**
			10th session	**Group B visit 4**
			11th session	Elementary school visit to lab on college campus
Visit length	1 hour: 10-minute activity repeated 5 times + set-up and clean-up		One-hour workshop, repeated for 2 different 4th-grade classes	
Class information	Lectures held only on Mondays during CBL visit weeks Lectures held on Mondays, Wednesdays, and Fridays on other weeks Groups practice in front of classmates on the Wednesday before a Thursday visit		While Group A is visiting the elementary school, Group B is in a traditional lab at the college, and vice-versa. Each student completed 7 traditional labs during the semester	
Semester information	Length: 14 weeks; weeks not shown on this table met according to a traditional schedule: lecture three times a week		Length: 14 weeks; weeks not shown on this table met according to a traditional schedule: 3 hours of lecture, a 1.5-hour recitation, and 3-hour lab every week	

Notes: Group A = one-half of college class; Group B = other half of college class. Bold color text = college students at an off-campus location to run or plan workshops.

* The four visits by each group, plus the two planning sessions, plus the elementary school visit.

TABLE 4. Grading

	After-school Model	During-school Model
Percentage of final grade	55	20
Grading rubric and requirements	1. Activity Stations Significance and relevance to topic of session Encouragement of questions Challenge to assumptions Physics accuracy Clarity of explanations Engagement Originality References used and cited 2. Online journals Reflect on session; possible improvements	1. Notebook Research and ideas on appropriate experiments with citations Key concepts and vocabulary Complete lesson plans 2. Journals Reflect on class; both science content and communication Different ways of explaining the same concept 3. Presentation How program affected learning
Notes	Each station was videotaped which facilitated later grading	Elementary school teachers provided feedback to professor on performance of students in classroom

students' learning more than any other assignment or aspect of the pilot class, with more than one-fifth of respondents answering that the projects were a "great help" compared to fewer than one-tenth for other course aspects. It also indicated steps to improve the course. Physics-major mentors could become more invested in the course by giving them credit as an independent study course for their involvement. To avoid the difficulties of switching group members every session, student groups should be kept constant for the semester. The instructor could provide sub-topics and activities for the first activity session, while students get accustomed to the expectations and nature of the CBL course. Then, the groups could gradually be given less and less guidance as the course progressed, and later activity sessions would be weighted more heavily in the final grade. The course would also be more effective if fewer topics were covered, spending more time and going deeper into each topic.

During-School Model

The teachers and principal at the elementary school were very pleased with the science classes given by the CBL students and regarded the program as a "resounding success." Pre- and post-surveys indicated an increase in positive attitudes towards science amongst the elementary-school students. All of the participating college students would recommend the CBL option to other students and responded affirmatively to questions about better understanding the course material, feeling more scientifically creative, and having an improved ability to communicate scientific ideas in a real-world context, all as a result of the CBL component of the course.

Conclusion

Having college students develop science workshops for elementary-school students is a simple but effective community-based–learning model for a physics class aimed at non-majors. We have independently piloted such CBL models at two different colleges. These models can help meet standard physics course objectives for college students, while better engaging different learning styles and benefiting elementary students. We hope that colleagues at other institutions will consider adopting and adapting such course models and look forward to hearing your experiences and suggestions.

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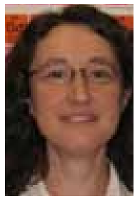
About the Authors

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