

ATINER CONFERENCE PRESENTATION SERIES No: PHY2019-0135

ATINER's Conference Paper Proceedings Series

PHY2019-0135

Athens, 31 July 2019

**Assessment of the Effect of Service Learning in Introductory
Physics Course on Students Learning and Critical Thinking**

Elena Flitsiyan, Costas Efthimiou, Talat Rahman

Athens Institute for Education and Research

8 Valaoritou Street, Kolonaki, 10683 Athens, Greece

ATINER's conference paper proceedings series are circulated to promote dialogue among academic scholars. All papers of this series have been blind reviewed and accepted for presentation at one of ATINER's annual conferences according to its acceptance policies (<http://www.atiner.gr/acceptance>).

© All rights reserved by authors.

ATINER's Conference Paper Proceedings Series

PHY2019-0135

Athens, 1 July 2019

ISSN: 2529-167X

Elena Flitsiyan, Associate Lecturer, University of Central Florida, USA
Costas Efthimiou, Associate Professor, University of Central Florida, USA
Talat Rahman, Professor, University of Central Florida, USA

**Assessment of the Effect of Service Learning in Introductory
Physics Course on Students Learning and Critical Thinking**

ABSTRACT

The project “**Physics of the Car Accident: Building a Safe Campus by Solving Physics Problem**” was developed as a Service Learning component of the General Physics I course for Scientists and Engineers. The project is focused on analyzing the Physics of a car accident. The service activity is fully integrated and designed to facilitate a course identified learning goals, as opposed to being an add-on activity. An important aspect that sets course-related Service Learning apart from simple service is that participants are expected to learn as much from reflecting on their service as they do from performing the actual activity. Reflection often includes student-to-student discussions, journaling, or writing a report/ paper describing the impacts of the service activity. Implementing service learning elements in introductory physics course results in improving the interactive learning component and also educates the student community about how to prevent car accidents.

Keywords:

Introduction

It is difficult to find a universally accepted definition of course-related service-learning. However, most sources agree, that “Service-learning is a pedagogy or educational methodology that directly and intentionally integrates classroom learning with service to the community”.

I believe that the subject I am teaching, namely physics, has a social and civil component, helping to better understand the role of the science in the community.

The course-related Service Learning Project: “Physics of the Car Accident: Building a Safe Campus by Solving Physics Problem” was developed and implemented into an existing introductory physics course (Physics for Scientists and Engineers I, PHY 2048) and is focused on analyzing the Physics of car accidents. The project was supported by UCF Police Department, UCF Office of Service Learning, and Faculty Center for Teaching and Learning. The project pursues the double role: to show the students how the laws of physics can help them to build a safer campus and to stimulate their interest in study physics by bringing it closer to everyday life.

The project is integrated to meet pre-defined course objectives. In other words, the service activity is fully integrated and designed to facilitate a course identified learning goals, as opposed to being only an add-on activity.

The development of this active engagement curricula was based on the constructive model of student thinking and learning which allowed diversity in approaches to suit student/instructor styles, provided a data base for the assessment of comparative gains in student learning, and at the same time help address the specific issue – to improve the safety of young community members driving skills.

The objectives of the project are:

- To integrate theory, problem-solving and experiments in mechanics course with an emphasis on car motion related topics;
- To optimize student engagement (by fostering collaborative learning, providing immediate feedback, adapting activities to students’ state of knowledge, and shifting the focus of control from teacher to students);
- To optimize integration of technology into the physics curriculum by using the active in-class demonstrations, animated figures, student’s presentation posted on Youtube, etc.

An important aspect that sets course-related Service Learning apart from simple service is that participants are expected to learn as much from reflecting on their service as they do from performing the actual activity in the class. Reflection often includes student-to-student discussions, journaling, or writing a report/paper describing the impacts of the service activity.

For example:

- Holding a mock crash on campus is service;

- Sitting in a science classroom and analyzing the laws of physics applied to the objects in motion and objects at rest, is learning;
- Taking lessons learned in a physics course regarding laws of motion, inertia, velocity, momentum and energy, and using this knowledge to predict and understand the danger of auto accidents is service-learning;
- Exploring theories through a mock crash and sharing with the wide student community what is now understood about impacts at varying speeds is service-learning.

For this project we conduct an assessment study in which the progress of the project attendees was compared to a control group from the same class section of the previous semester.

Course Description

The **PHY2048** course traditionally consists of three 1-hour lectures per week, and 3-hours concurrent laboratory sessions.

The **SL** mode will retain the three 1-hour lectures, but will infuse activities to be carried out by the students during the lecture.

It will be accompanied by a 3-hour discovery type laboratory intertwined with problem solving and discussion sessions. Students from the lectures will be assigned to about ten mini-studios in groups of 30. In the mini-studios, students will work in groups of 3-4 (present capacity). Here problem-solving will be intermingled with hands-on activities. This approach will help integrate the learning process and make the course coherent.

The course format will consist of interactive lectures and mini-studios which integrate guided discovery experiments with cooperative problem-solving activities and discussion sessions. Lectures will be offered in class size of about 300 students. To keep the students attention “alive”, each lecture will contain 2 or 3 “live” demonstrations. Demonstrations will be coupled with problem-solving to make the concepts more concrete.

Students from the lectures will be assigned to the mini-studios in groups of 30. The theme in the mini-studios will be coordinated with that in the lectures and governed by a set of fourteen modules (one for each week) that will be specifically developed for the course.

In each module the discovery type experiments will have direct relation to the set of problems to be solved by the students collectively in small groups guided by the instructors (a faculty member and a GTA).

Lectures and mini-studios will be offered with the aid of multimedia tools including digital projectors, laptop docking stations, projectors, and audio-video consoles. The technological efficiency of this supplemental time, coupled with its incorporation of conceptual problems, allows the module’s content to be closely linked to the lecture material. A modified web-based pre-lab activity and lab report submission model will be invoked. The ability to

interact with the electronic laboratory report shifts the student's energy from generating a standardized report to quickly collecting data and proceeding with conceptual analysis.

Implementing Service Learning elements in the modified course structure resulted in improving the interactive learning component and also educated the student community about how prevent the car accidents. SL activities benefit students and faculty in many ways including:

Benefits to Students:

- Opportunity to see course theory in action;
- Deepen understanding of course assignments;
- Strengthen critical thinking, information retrieval and technology, quantitative reasoning, oral and written communication skills;
- Gain a deeper understanding of themselves and their community;
- Strengthen self-confidence;
- Test potential career paths;
- Fill important leadership roles;
- Develop closer ties to the community;
- Opportunity to improve the driving skills using the hand-on information obtained in the class.

Benefits to Faculty:

- Reinvigorate teaching;
- Enhance professional development;
- Improve relationships with students;
- Enhance student learning (more engaged students);
- Research/publishing opportunities.

This work examines the merit of the program designed to improve students learning through the enhanced engagement with the material and special projects. The target population is a group of students, mostly in science and engineering disciplines, who must take the calculus-based introductory physics sequence as part of their majors' core curriculum. For the calculus-based physics group, a large issue is retention within the major. Many students change to non-science majors before the completion of their degree. An improved understanding of the material in the introductory Physics and real life applications should help alleviate this problem.

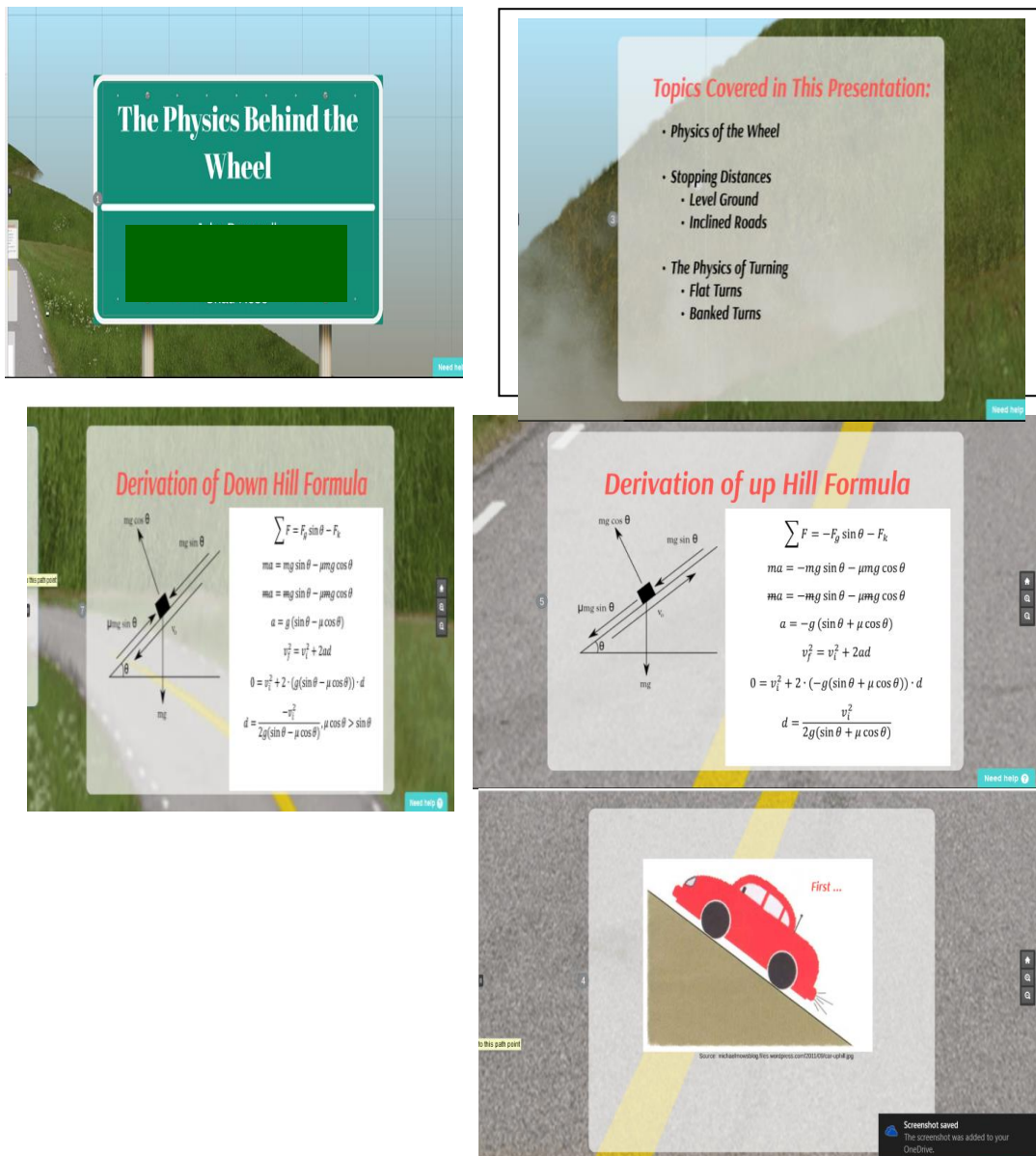
Results and Discussion

The service learning component of the course is designed in the form of the projects that were done in groups of 3-4 students. In the summer pilot project, a class of 120 students presented 37 projects. The presentations were

done in the in the front of the class. They were also presented at different times in the student's dorms and on the Department Open House event for the high school students.

The effectiveness of the service learning approach is studied using pre- and -post tests, and effects on class performance and retention within the major are examined. The same questions was offered in the second week of the semester and in the last week. Fig.1. illustrate one of the projects.

Figure.1. Service Learning project in PHY 2048, Physics I class. The project analyzes the safety situation for a car approaching a hill in different weather conditions



The project evaluation form is presented in Figure 2.

Figure 2. *The Service-Learning project evaluation form*

Project Evaluation Form			
Department, Course _____			
Group # _____			
Evaluation Committee			
Member _____			
Semester/Year _____			
Date _____			
Rate Group Performance as functions of the work done:			
Criteria	Ratings		
	Low	Acceptable	Hi
Understanding of the Problem			
Course Theory application			
Practical problem solution			
Oral and Written Communication Skills			
Technical Formalization			
Overall Performance			

Examples of some questions from the Standard Force Inventory Test, related to the topic of the project offered to the students are as next:

1. Question 1: Two tennis balls are projected horizontally from a tall building at the same instant, one with a speed of 100 miles per hour and the other with a speed of 50 miles per hour. Please choose the correct answer:

- A. The ball with the speed of 100 mph will hit the ground first;
- B. The ball with the speed of 50 mph will hit the ground first;
- C. Both balls will hit the ground simultaneously;
- D. There is not enough information to decide

The student's answer and student's confidence in correct answer are illustrated in Figure 3(a, b).

Figure 3a. *Students' Answers to Question on Projectile Motion*

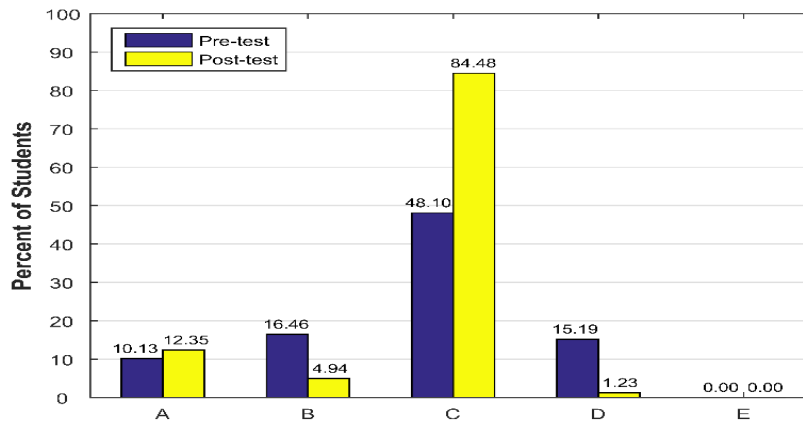
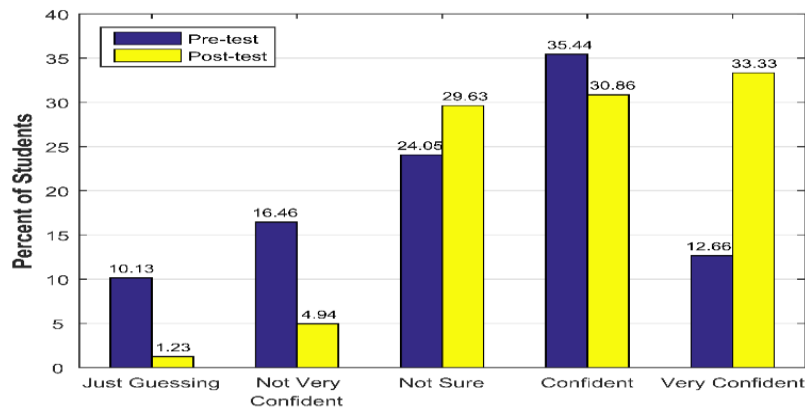


Figure 3b. *Student's Confidence in Answers to Question Regarding the Understanding of Projectile Motion*



2. Question 2: A gun of mass 10 kg fires a bullet of mass 0.1 kg with a muzzle speed 200 m/s. What is the final momentum of the gun? (All answers are in the SI units):

- (A) 2000;
- (B) 200;
- (C) 20;
- (D) 10;
- (E) We cannot find it since its speed is unknown.

Figure 4a. *Students' Responses in Answers Requiring Calculation Using the Conservation of the Momentum*

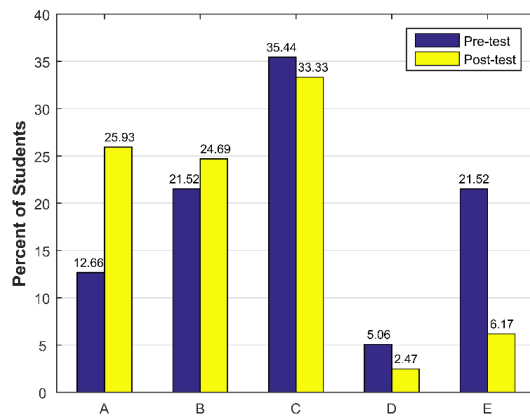
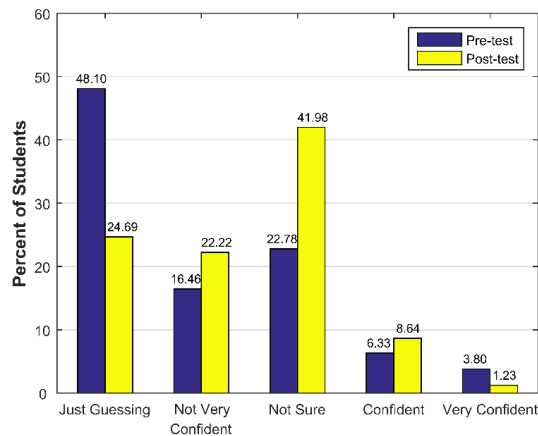


Figure 4b. *Students' Confidence in Answers Requiring Calculation Using the Conservation of the Momentum*



3. Question 3: Roads are made with a slope around the turn to help cars have:

- A. more friction;
- B. less friction;
- C. more centripetal force;
- D. less centripetal force;
- E. less air resistant.

Figure 5a. *Students' Answers to a Question about Banked Curves and Centripetal Force*

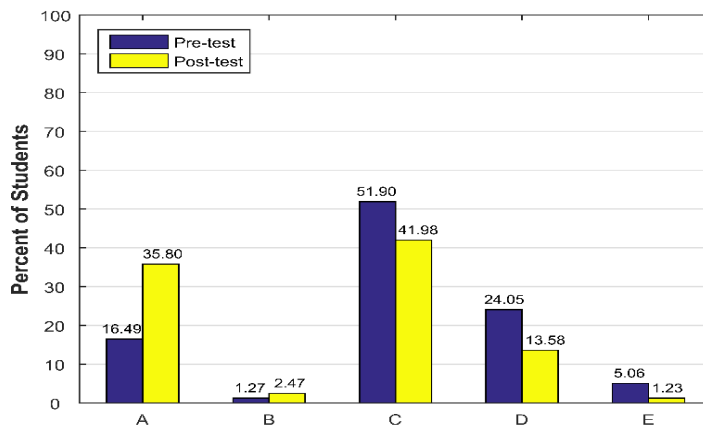
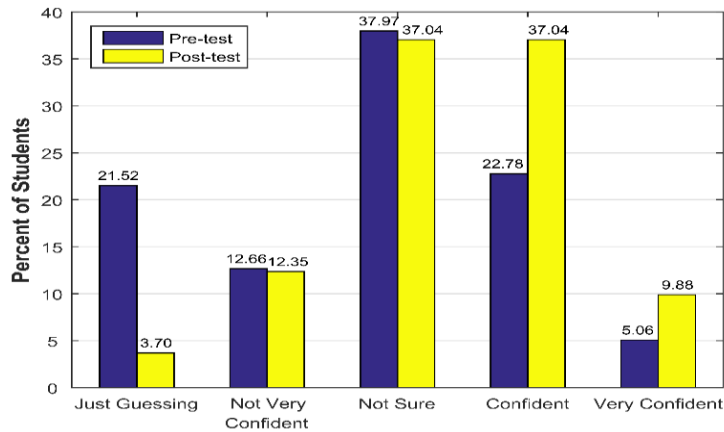


Figure 5b. *Students' Confidence in Answers to a Question about Banked Curves and Centripetal Force*



- 4. Question 4:** Conservation of some physical quantity means that the quantity
- A. Cannot be used in any calculations;
 - B. Should not be wasted;
 - C. Remains the same at all times no matter what happens;
 - D. Can be used to accelerate the system.

Figure 6a. *Students' answers to a question about the Meaning of "Conservation"*

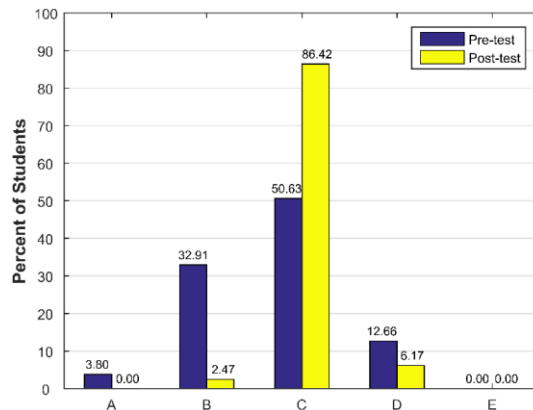
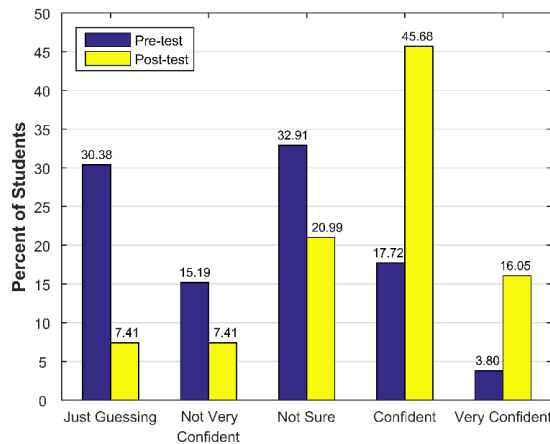


Figure 6b. *Students' confidence in answers to a question about the Meaning of "Conservation"*



Conclusions

Results from the pre- and post-tests show that students are definitely learning. There does seem to be a correlation between students' interest in the subject matter and their grasp and retention of the ideas. This argues in favor of the course, which aims to connect the curriculum with subjects of interest to the students. The more specific the "flavors" of the service-learning project can be made, and the more variety that can be offered each semester, the better the chance that more students will be reached.

As expected, the more mathematics that a question requires, the lower the average score is on the question. This is particularly true for actual calculations; it seems that students are able to understand and even make use of some practical relations in answering questions while also gaining the concept understanding from the project goals. The scores on confidence would seem to

support this. Confidence seems to rise or fall along with actual performance on the group project questions.

One of the main goals of the physics course, and the main motivation for the creation of alternative curricula, such as service learning approach, is to increase the science literacy of students graduating from universities. To this end, the course appears to reach the goal. A student understanding of the role of the Physics in everyday life has improved through the course. Student's attitude toward science has also improved greatly. This is in evidence in the large improvement of confidence rankings from pre- to post-test. Students leave the course with a sense of empowerment that they can recognize and understand real science.

References

1. R. Beichner, (2008), "The SCALE-UP Project: A Student-Centered, Active Learning Environment for the Undergraduate Programs", an invited white paper for the National Academy of Sciences.
2. J. Gaffney, E. Richards, M. B. Kustus, L. Ding, and R. Beichner, (2008) "Scaling up education reform," *Journal of College Science Teaching* 37 (5), 48-53.
3. <http://modeling.asu.edu/r&e/fci.pdf>.
4. Mazur, (1999), "*Peer Instruction: A User's Manual*", *Am. Jour. Physics* 67, pp. 359-360.
5. Douglas Duncan, (2005), *Clickers in the Classroom*, Addison-Wesley, ISBN-10: 0805387285
6. Guerra, D., (2005), "Service-Learning in Physics: The Consultant Model." *Journal of Higher Education Outreach and Engagement* Volume 10, Number 3: 143-151.
7. Finkelstein, N., (2004), "Teaching and learning physics: A model for coordinating physics instruction, outreach, and research." Department of Physics, University of Colorado, Boulder.