The Future of Engineering Education
2024 Annual Conference & Exposition
Oregon Convention Center
Portland, OR . June 23 - 26, 2024
ASEE
Paper ID #43836

Board 37: Integration of Project-based Learning in a Surveying Course

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Integration of Project-based Learning in a Surveying Course

Abstract
Surveying is a fundamental discipline with far-reaching implications for land management and infrastructure development. This paper presents an approach to include project-based learning in surveying courses specifically tailored for civil engineering, in order to match education with the changing demands of the industry and societal values. Project-based learning has the potential to effectively equip students with the essential skills and mindset required for success in the dynamic field of civil engineering, while also adequately preparing them to tackle real-world issues.

The Civil and Environmental Engineering Department at Rowan University adopted project-based learning within their surveying course. The curriculum is structured into two distinct phases. During the initial phase, students are introduced to the fundamental principles of surveying, while the subsequent part focuses on the actual implementation of these principles in laboratory settings and real-world projects. By engaging in practical application, students learn the skills necessary to operate surveying equipment, identify underutilized sites for potential improvement, and formulate detailed plans for enhancing these areas. Additionally, this procedure encompasses the compilation of reports and the presentation of their work, including concepts of surveying and drafting skills. During the course of the project, students actively participate in the process of generating ideas, employing critical thinking skills, and conducting an in-depth examination of pre-existing solutions implemented in comparable project locations.

The outcomes of project-based learning in the surveying course are multifold. It not only prepares students for internship opportunities but also provides valuable training for future professional licensure. In addition, the program fosters the development of leadership and entrepreneurship skills by engaging students in project-based learning, thereby preparing them to excel in the ever-evolving domain of civil engineering.

Introduction

Engineers reflect on their actions in the workplace, suggesting these skills are best learned in design studios rather than classrooms [1, 2]. Project-Based Learning (PBL) is praised for fostering teamwork, problem-solving, and leadership within a student-controlled framework. It originated in McMaster University's medical faculty 40 years ago and has since spread across various disciplines [3]. PBL features ill-structured, real-world problems, student-centered active learning, small group work, facilitator-led teaching, and increased self-assessment.

Civil engineering activities primarily occur within project-based environments, necessitating collaboration among professionals with diverse expertise [4]. These requirements reflect future societal demands on students and professionals. With PBL, it is feasible to structure civil engineering courses around a single overarching project, facilitating deeper learning and the application of theory to practice. Selecting a real project tailored to the subject's time and effort constraints underscores this approach.

Surveying has historically been associated with civil engineering. Many civil engineering programs in the USA still require students to take a course that introduces them to surveying. However, this is not an ABET requirement.

Traditionally, surveying courses have emphasized lecture sessions covering surveying principles and methodologies, complemented by laboratory exercises particular to various surveying methods and utilizing surveying instruments [5]. However, alongside this conventional approach, PBL is being introduced, offering students hands-on experience in applying theoretical knowledge to real-world scenarios [4]. PBL encourages critical thinking, interdisciplinary collaboration, and the development of essential professional skills such as problem-solving, communication, and project management. Prince and Felder present strong evidence that inductive teaching methods are more effective than traditional deductive teaching methods in engineering [6, 7]. Their review of inductive methods includes case studies, discovery learning, and project-based learning. Their case for project-based learning throughout the engineering curriculum is compelling. It has been proven that students participating in PBL show more enthusiasm for the course, are highly motivated, demonstrate better communication and teamwork skills, and develop critical thinking skills to apply their learning to realistic problems [8,9].

Considering the advantages of PBL, this paper describes an approach to integrate PBL into a sophomore-level course, Surveying, at the Civil & Environmental Engineering Department of Rowan University. By incorporating PBL into the curriculum, this study explores the benefits associated with its implementation in this specific course.

Surveying Course Curriculum at Rowan University

Background of the Curriculum

Surveying is a two-credit course in our Civil & Environmental Engineering Department at Rowan University. The class is required for all students and is typically taken by sophomores, along with transfer students who may have junior/senior standing. In its original format, the course was a traditional lecture and lab course focusing on technical content. For many years, this course was taught in a traditional manner with lectures and laboratories. The laboratories were conducted by a team of four to six students. The course deals with the measurement of existing and man-made land profiles. The topics include measurements of drainage areas, distances, angles, and elevations; closing traverses; topographic surveys; and highway alignments. The current course content is indicated below in Table 1.

Table 1: Surveying Course Content

	Topics
Week 1	Course Introduction; Intro to Surveying; Measuring Horizontal Distance
Week 2	Measuring Horizontal Distance; Distance Corrections; Indoor Demo on Horizontal Measurements
Week 3	Leveling; Indoor Demo on Levelling

Week 4	Measurement of Angles; Direction of a Line
Week 5	Traverse Surveys
Week 6	Horizontal & Vertical Curves; Construction & Land Surveying
Week 7	Topographic Surveys and Earthworks
Week 8	Midterm Exam
Week 9	Spring Break – No Class – Project Assigned
Week 10	Lab 1 – Field Operations with a Theodolite Measurement of Horizontal Distances
Week 11	Lab 2 – Leveling
Week 12	Lab 3 – Traverse Survey
Week 13	Lab 4 – Topographic Survey
Week 14	Project
Week 15	Project
Week 16	Finals Week – Project Presentations

Overall, the course curriculum is currently structured as follows:

1. **Learning Stage Division:** The curriculum divides the learning process into two main stages. In the first half of the semester, students acquire knowledge about surveying principles, and in the second half of the semester, students transition to applying this knowledge in practical settings, including laboratory sessions and real-world projects.
2. **Hands-on Learning with Survey Equipment:** Throughout the laboratory sessions, students gain practical experience in operating survey equipment. This hands-on approach enhances their understanding of the equipment's functionality and application in surveying tasks.
3. **Site Selection and Improvement Plans:** Following the laboratory sessions, students select an underutilized site for improvement. They then develop plans aimed at enhancing these spaces, incorporating their knowledge of surveying principles.
4. **Project Implementation and Reporting:** Subsequently, students implement their plans, executing the proposed improvements on the chosen site. They compile a comprehensive report detailing their project, showcasing their understanding of surveying principles and drafting skills. Additionally, students pitch their work, presenting their findings and recommendations to relevant stakeholders.

5. **Continuous Engagement and Critical Thinking**: Throughout the project duration, students engage in brainstorming sessions, fostering the generation of innovative ideas. They apply critical thinking skills to evaluate existing solutions and explore creative approaches to improving similar project sites.

Integration of Project-Based Learning and Current Structure of the Course

In 2018, the Surveying course was revamped to introduce a course content that made it possible to allow students to understand the value of a diverse and inclusive curriculum. The history of surveying from around the world was added to the course. Exploring the history of surveying provided opportunities for students to have cultural context, allowing learners to establish connections between classroom content, their profession, and the rest of their lives. The history not only focused on the contributions of famous Western surveyors like US Presidents Lewis and Clarke but also included the contributions of Egyptians, Romans, and Asians in the development of surveying tools and making monumental progress in building roads and other historic civil engineering structures. These include the Pyramids, the Roman bridges, aqueducts, the Asian Silk Route, and the Grand Trunk Road. Teams were also assigned a project that investigated how a certain civil engineering project was completed with the aid of surveying. The project required them to make a team presentation and write a report. The course content was evaluated by the students using online surveys. Three questions were posed to understand students' reactions to the inclusive curriculum, as shown in Figure 1.

Curriculum Survey

Question 1: Do you think the course adequately covered the following topics?
(1 = Not Covered 5 = Adequately Covered)

(a) Global Issues
(b) Societal Issues
(c) Ethical Issues
(d) Problem Solving Techniques
(e) Engineering Design
(f) Diversity & Inclusivity

Question 2: The course (1 = Strongly Agree 5 = Strongly Disagree)

(a) Included socially relevant examples of engineering work
(b) Increased my interdisciplinary knowledge
(c) Exposed me to the arts, social sciences and humanities as relevant

Question 3: The course (1 = Strongly Agree 5 = Strongly Disagree)

(a) Used various types of graded work
(b) Used open-ended problems
(c) Provided opportunities for collaborative work

Figure 1: Survey Instrument Developed for Course Assessment

The average course evaluations during 2018 and 2019 are indicated in Figures 2 and 3, with all students participating in the responses (n=90). There was a gap in data collection due to the COVID-19 pandemic when classes went remote or were in person with limited contact. The y-axes represent the percentage of students who responded favorably to the questions (Strongly Agree and Agree). The number of students participating in these surveys was always at 85% of the total # of students.

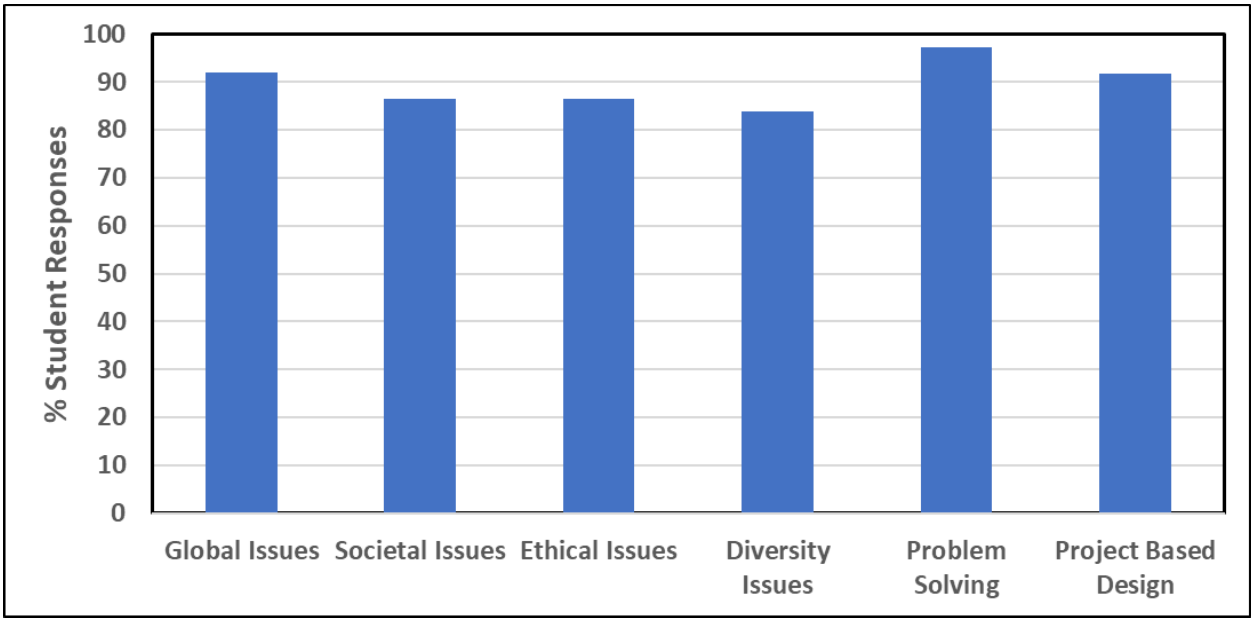

Figure 2: Responses to Question 1

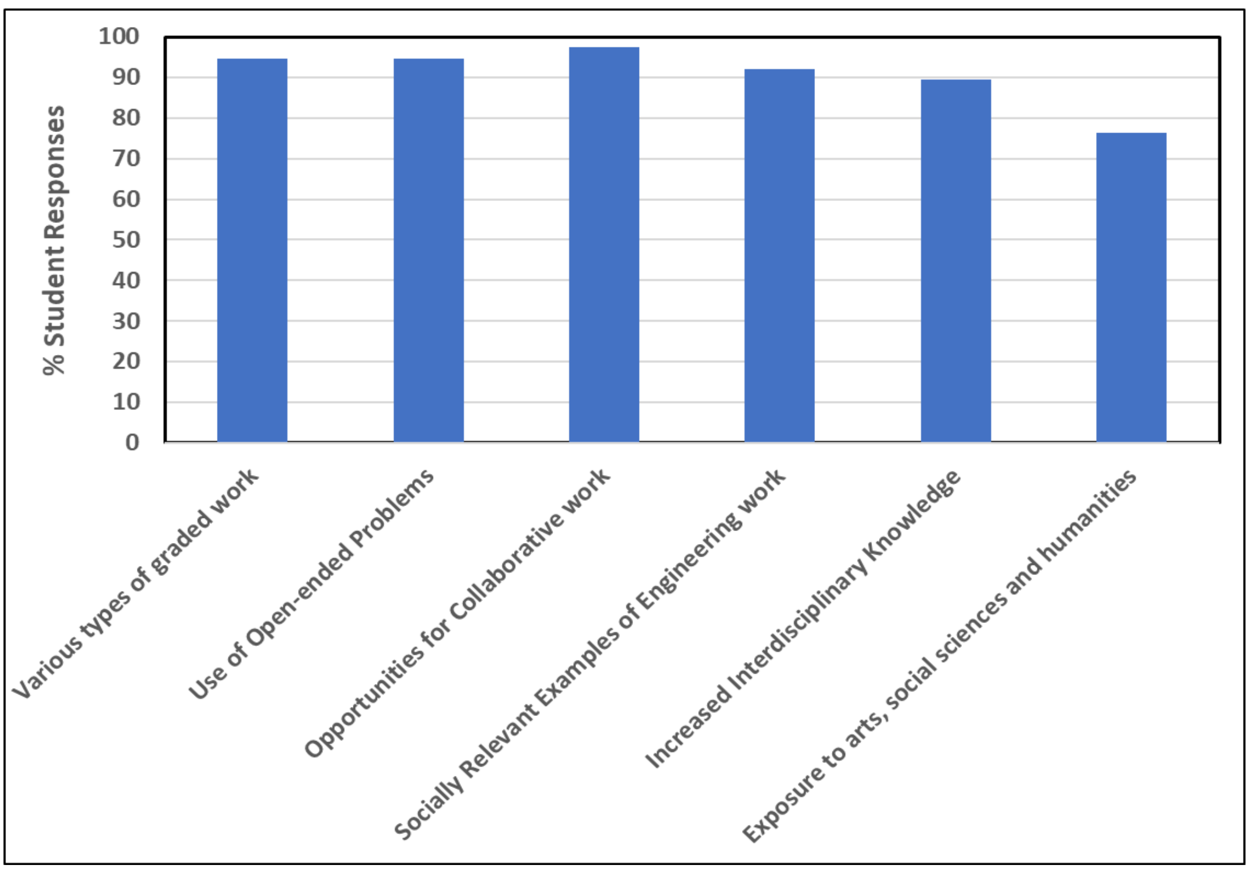

Figure 3: Responses to Questions 2 and 3

New PBL and Evaluation of the Current Course Content

Based on the positive feedback received from the inclusive curriculum, the department decided to also include PBL in the course. As mentioned in the previous section, the curriculum was structured into two distinct learning stages. In the initial stage, which focused on introducing surveying principles, student performance was assessed through various methods, including quizzes, homework assignments, and a midterm examination. Following this, in the second stage, laboratory activities formed a significant component of evaluation criteria. During the second stage, students were assessed based on their participation in group activities involving the handling of surveying equipment, data collection for assigned lab tasks, execution of calculations, and note-taking in field books. Subsequently, each group submitted comprehensive lab reports consolidating their findings and analyses. Regarding group formation, students had the opportunity to form their groups. Female students formed groups with the male students. Each member of the group had to decide their role for the project and had to submit a memo describing their role.

Additionally, the second stage included a project centered on developing plans to enhance an underutilized site. This project spanned multiple phases throughout the latter half of the semester. The following are the distinct phases of this project:

1. **Site Proposal:** As part of the site proposal, students had to select a location that showcases interesting changes in grades or topographical features, while also considering the existence of major features such as roads or trees. Using satellite imagery, specifically Google Maps, they identified the bounds of the site. They had to prioritize safety and accessibility during the site selection process to ensure the feasibility of the project. Additionally, they had to briefly outline the intentions of their project, focusing on primary goals without going into specific details.
2. **Project Proposal:** Moving on to the project proposal, students provided a comprehensive plan detailing the preconstruction work, particularly surveying, and the proposed construction activities. Expanding on the concept from the site proposal, they offered more detailed insights into the project, including a workflow plan outlining key tasks and assigning lead roles for each aspect of the assignment. Collaboration was emphasized, as it is crucial for the final report and presentation to reflect a cohesive team effort.
3. **Final Report and Presentation:** In the last phase, the students presented their project and submitted a final report. For the final report and presentation, grading criteria were developed by the instructor to ensure consistency and fairness in evaluation. Table 2 shows the grading distribution for the presentation. The final project report needed to contain the major components listed in Table 3 while reflecting the collaborative effort and expertise of the team members. A sample report was provided to the students to give an idea of the contents for each component in Table 3.

Table 2: Grading Criteria for Project Presentation

Grading Distribution	
Introduction/Objective/background	20%
Methodology	20%

Findings/Results, Recommendations, & Summary	25%
Overall Content	15%
Presentation Style: Use of graphics/animation/media/etc.	10%
Time Control	5%
Appearance and Professional Behavior	5%

Table 3: Major Components of the Final Report

Components of the Professional Report
a) Title Page
b) Table of contents
c) Abstract (optional)
d) Background/Introduction
e) Objective(s) or scope(s) of the project
f) Method(s)
g) Results/Analysis and feasibility of the proposed improvements
h) Findings & Summary (you can also include any limitations or future works)
i) References
j) Appendix (if any)

The project titles for 2023 are provided below in Table 4.

Table 4: Titles of Student Projects

Engineering Hall Improvements
Triad Apartments Proposal
Engineering Field Renovations
Extended Parking Lot Engineering Hall

Some sample images related to the selected sites and proposed improvements from the final project report are provided in Figure 4.

Figure 4: Samples of Selected Sites and Proposed Improvements as Part of Final Project

After integrating the PBL into the curriculum in 2023, we did not do a survey to get feedback on the PBL-based learning from the students. This is the limitation of the current study. This will be addressed at the end of Spring semester this year. However, we had some statistics from the course evaluation for 2023. The evaluations from our IDEA Student Ratings of Instruction (SRI) course evaluation for 2023 are presented below in Figures 5 to 7.

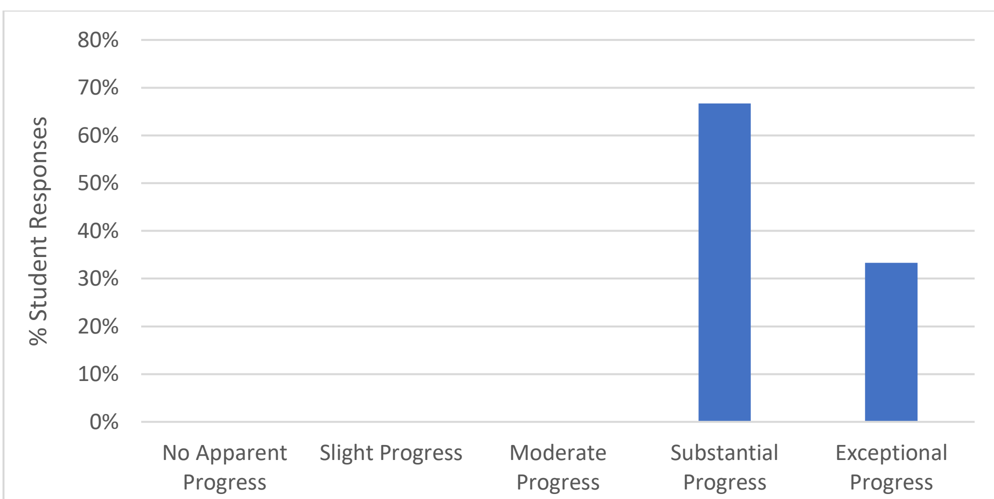

Figure 5: Students' Response to Learning to Apply Course Material (to improve thinking, problem-solving, and decisions)

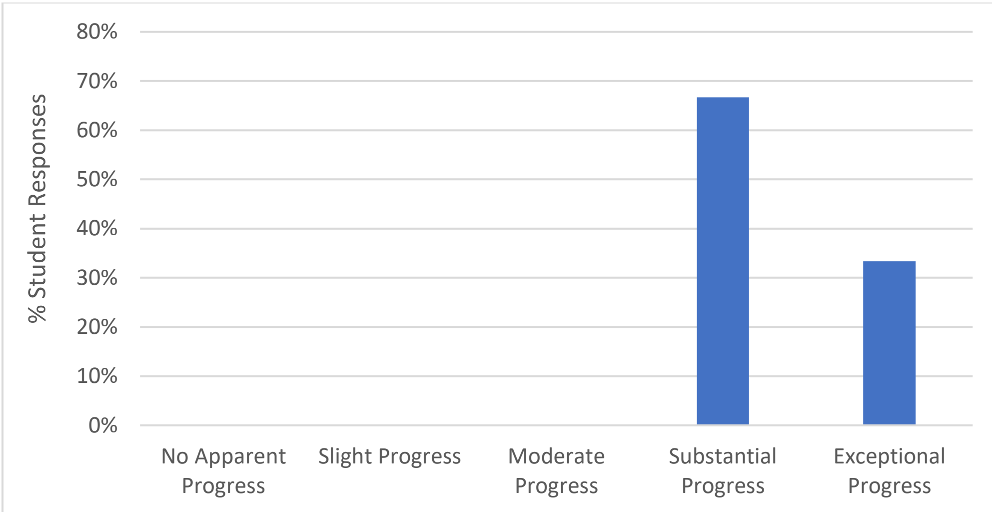

Figure 6: Students' Response to Developing Specific Skills, Competencies, and Points of View Needed by Professionals in the Field Most Closely Related to this Course.

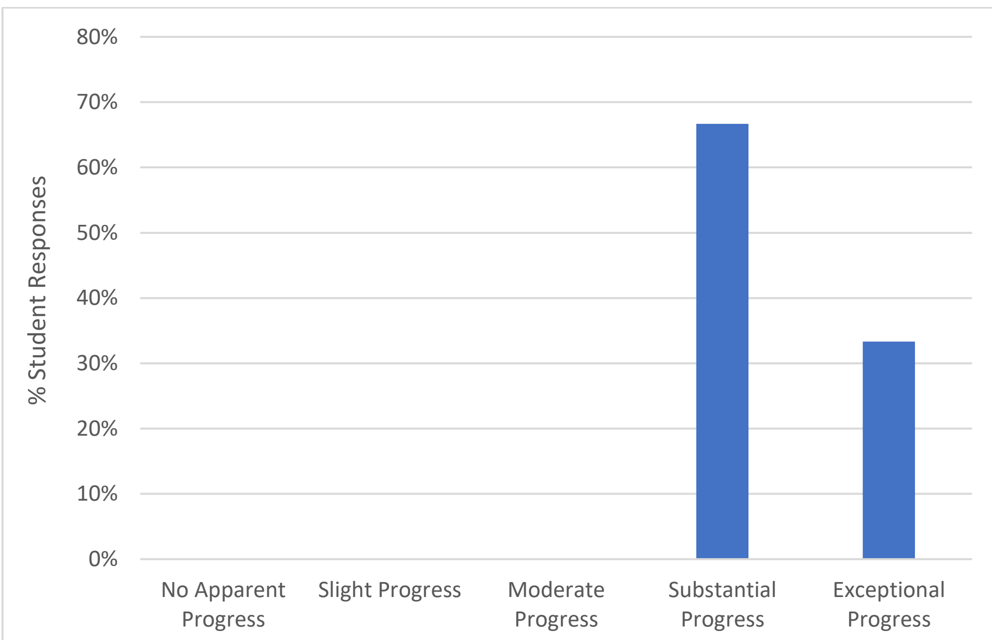

Figure 7: Students' Response to Acquiring Skills in Working with Others as a Member of a Team

One of the students' response from the project teams is quoted below. The response is from the qualitative assessment of IDEA course evaluations.

"This course gives you some experience of what a field surveyor does. The final project is great because you get to work in groups, and you get to design a plan that could be beneficial to other students and/or staff."

Conclusions

This article demonstrated an approach to integrate PBL in Surveying course curriculum. Even though we did not conduct a survey to measure the impact of PBL in Surveying course, we had some positive feedback through the course evaluation. Overall, integrating PBL into the surveying course allowed students to be more invested in the learning of course content. Projects selected by the students allowed them to directly apply their knowledge to real projects. Furthermore, this will allow students to use the project in their resumes when applying for internships. Our department is also partnering with a community college for a 4-year degree in Surveying Technology. Our students will benefit from this course if they aspire to become a professional licensed surveyor. For future work, we will collect students' feedback through online surveys and quantify the impact of PBL in Surveying course.

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