

## **Soft skills enhanced project-based pedagogy in the community college reflecting apprenticeship and industry need**

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# Soft Skills Enhanced Project-Based Pedagogy in the Community College Reflecting Apprenticeship and Industry Need

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## Abstract

Apprenticeship is a way of learning that combines traditional classroom learning and on-the-job training experience. New York City Jobs CEO Council (<https://nyjobsceocouncil.org/>) provides an apprenticeship program to community colleges in the City University of New York by incorporating businesses and education leaders to establish a bridge between employers' needs and practical job training for community college students. The authors of this paper have participated in the NYC Job CEO Council's Educator Program which provides opportunities to interconnect community college faculty and various employers directly to fill the gap between employers' demands and college teaching. The employers pointed out that new college graduates lack soft skills including oral and written communication, digital fluency, problem-solving, critical thinking, time management, leadership, and teamwork. These soft skills are also required for students who participate in the apprenticeship program. However, teaching technical knowledge is the general and primary focus of the conventional methods in engineering technology colleges, and teaching soft skills is mostly not included in the curriculum and assessment. Therefore, preparing engineering technology students for apprenticeship and their future career start is essential. The authors learned that project-based pedagogy is an avenue for teaching soft skills to students. Thus, we designed and implemented the project-based pedagogy including soft skill training. In this paper, multiple project-based projects in different disciplines of engineering technology for both in-person and virtual classroom settings are presented including methodologies of teaching soft skills, pedagogical limitations in a community college setting, assessment, and learning outcomes.

Keywords: Project-based learning, soft skills, community college, apprenticeship

## Introduction

An apprenticeship provides traditional classroom learning and hands-on job training. It often is a paid job where students learn knowledge while they gain practical experiences. Alongside on-the-job training, apprentices spend part of their working hours completing classroom-based learning with a college, university, or training provider which leads to a nationally recognized qualification or certification. Employers commonly point out that new college graduates lack soft skills, which are essential when they are hired at an entry-level or in the apprenticeship program. While teaching technical knowledge is the general and primary focus of the conventional

methods in engineering technology colleges, teaching soft skills is mostly not included in the curriculum and assessment. Therefore, in order to better prepare students for apprenticeship and early careers in the industry, faculty have incorporated Project-Based Learning (PBL) pedagogy to improve academic courses at the Department of Engineering Technology of Queensborough Community College, The City University of New York (CUNY). The pedagogy simulates an industrial job environment and trains students in learning soft skills, including oral and written communication, digital fluency, problem-solving, critical thinking, storytelling, presentation, time management, leadership, and teamwork. In addition, the PBL provides training students in acquiring and applying engineering knowledge in the learning process. Soft skills are of paramount importance for students to advance their careers in the future. This paper presents implementations of PBL in various engineering technology courses; Electrical Engineering Technology, Mechanical Engineering Technology, Internet and Information Technology, and Computer Science and Information Security. Assessments and challenges of PBL are also discussed.

## Background

### 1) Apprenticeship

The U.S. Department of Labor estimates there is a huge gap between job opening and available workers currently. However, companies are not able to find capable candidates to fill the position since most available workers are lacking the proper skills. The apprenticeship focuses on changing educational practices to prepare local underrepresented students and filling the skill gaps for many companies. The apprenticeship program is a new pedagogical approach to combine traditional learning with training during working process to help students get mentorship and professional training for the targeted areas. The apprenticeship program also provides students earn and learn during program and could obtain a fulltime position from sponsoring company upon completion the program [1].

The Dimon Fellowship was founded for supporting faculties in CUNY community colleges to become leaders in expanding and strengthening apprenticeships programs in NYC area. The majority of students in CUNY community colleges are low-income and underrepresented, which gives them multiple barriers. The apprenticeship program supported by the Dimon Fellowship will link community college faculty with employers so it can aid students in the transition from college to workplace. Furthermore, it allows faculties to work on research and develop strategies for preparing students both academic and soft skills with learning in real-world practices [2].

### 2) Project-Based Learning (PBL)

Project based learning is an instructional method that provides knowledge and skills through “an extended inquiry process structured around complex and real-life questions” [3], [4]. PBL focuses on teaching students to learn how to ask questions, find and answer the questions their own way by conducting investigations, and apply what they have learned to unfamiliar problems [5]. The effectiveness of PBL varies by discipline. In engineering technology fields, the project involves creating a product technically or deliverable for a client. By giving realistic projects to the students, the objective of PBL – teaching technical and 21<sup>st</sup> century skills can be achieved

[6]. Other previous study [7] showed that PBL does not significantly improve students' standard coding skills and its effectiveness has been debated in computer programming courses [8]. However, we are focusing on developing soft skills through PBL, and how we incorporate teaching soft skills at community college environment is discussed in this paper. The soft skills that industries are seeking commonly are the mature level of communication, teamwork, critical thinking, time management skills, resilience, etc., especially from just graduated young entry-level employees.

### Project-Based Learning in Electrical Engineering Course

One of the courses that PBL has applied to enhance soft skills was Computer Aided Analysis for Electrical Engineers (EE-103). This course provides an introduction level to MATLAB<sup>®</sup> computer programming with analysis techniques that are fundamental for most engineering disciplines. In the class, students were given a project to fabricate an optimal solution for engineering system design. The project is to design a solar- powered vehicle that has multiple constraints such as limited budget, limited physical areas, and required minimum electrical power. The problem was given to the students before necessary knowledge was taught instead of giving a lecture first for required programming functions. Students were asked to team up with three to four people in a group. It was an online class setting, thus the breakout rooms from the meeting platform (e.g., ZOOM<sup>®</sup>) were utilized for group discussion. The first day of the project was spent understanding and discussing the problem among the group members. The students were asked to write a note of their discussions and ideas. It was recommended to take a role for each group member to distribute their responsibilities – team leader, programmer, reporter, and presenter. In the next class, students shared their ideas of how problems could be solved. The solution was driven by student inquiries not by following instructions which helped them develop critical thinking skills. Then, the functional programming skills were introduced in the lecture and the students were asked to solve the problems by running a MATLAB<sup>®</sup> computer program. Finally, the class had group presentations. Yet, instead of focusing on the solutions, they were asked to present how they approached the problems and what the most challenging parts were. The instructor discusses with the students how they will be assessed in terms of communication skills and critical thinking skills throughout the presentation.

### Project-Based Learning in Internet and Information Technology Course

Computer Network Security (ET-725) course introduces the fundamentals of network security, including compliance and operational security; threats and vulnerabilities; application, data, and host security; access control and identity management; and cryptography. The course covers new topics in network security as well, including psychological approaches to social engineering attacks, Web application attacks, penetration testing, data loss prevention, cloud computing security, and application programming development security.

The purpose of this study was shifting the focus of this course from theoretical learning to PBL by integrating small projects throughout the semester. In one of the projects, students were given the opportunity to experience inquiry-based questions about the network footprinting. In

computer language, the process of finding information on a company's network is called footprinting. The different term for footprinting is "reconnaissance" and is a process of collecting data over time to make a targeted cyberattack. An important concept is that footprinting is passive, or nonintrusive. In other words, one is not accessing information illegally or gathering unauthorized information with false credentials [9].

The project description is given below:

There are four methods of Internet footprinting:

1. Web searching,
  2. Network enumeration,
  3. Domain Name System (DNS)-based reconnaissance, and
  4. Network-based reconnaissance
- **Question:** What information is beneficial to learn about the target organization/network?
  - **Objective:** Using different methods of Internet footprinting, students will be able to discover about their target domain and network
  - **Benefit:** Development of specific skills that students accomplish in this project

By applying the different methods, students will investigate appropriate questions, analyze the results of the investigations, discuss the evidence, build a knowledge of concepts, and apply the theories.

### Project-Based Learning in Computer Science and Information Security Course

Object-Oriented Programming course (ET-580) is an undergraduate programming course which teaches object-oriented programming principles and techniques in C++ platform. In this course, the author assigned a series of mathematical puzzle projects with software engineering concepts in mind. There are a total of 8 parts in this project, and each part is based on the previous part. Students need to finish the previous part to start the next one, and students can develop software engineer mind during this project. The project requires students to apply knowledge, technical skills, and modern tools of mathematics. In order to incorporate soft skill development, the project asks students to explain what and how the project was processed in the class. The project also requires students to analyze the time complexity and space complexity of their approach. These processes will help students develop their communication, time management and critical thinking skills.

The project that is described here is distinguishable in three ways compared to other regular assignments. First, the system of how students do the projects is designed distinctively. Students must finish the given part of project to start next part since the earlier part is the starting point of the next part. Second, students control the pace of projects, which enables students to get trained in time management skills. Lastly, students need to write reports and present their results to class and instructor, which trains their communication and writing skills. Communication, time management and critical thinking skills are embedded in this project.

Detailed instructions of the project related to the 8 queens puzzle are shown in Figure 1.

- Step 1: Use brute force to place 8 queens to chessboard
- Step 2: Use 2D backtrack method to place 8 queens to chessboard
- Step 3: Use 1D backtrack method to place 8 queens to chessboard
- Step 4: Use recursive method to place 8 queens to chessboard
- Step 5: Use recursive method to place N queens to chessboard
- Step 6: Use bottom-up (non-recursive) to place 8 queens to chessboard
- Step 7: Place 8 queens to pretty chessboard
- Step 8: Use the backtrack method to solve 8 number, and stable marriage problem

After finishing each step, students are required to write a report and prepare a presentation at the end of semester.

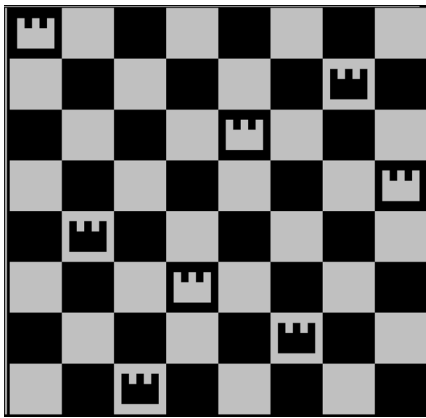


Figure 1: Object-Oriented Programming course project example: Queens Puzzle

### Project-Based Learning in Mechanical Engineering Technology Course

Introduction to Virtual Automation course (MT-492) is a required course in the Mechanical Engineering Technology Associate in Applied Science (A.A.S) degree program at Queensborough Community College, City University of New York. The course is a study of the principles and practices involved in conceiving, designing, producing, and measuring products quickly and effectively using additive manufacturing processes or three-dimensional (3D) printing and coordinate measuring machine technology.

A PBL pedagogy is assigned to student groups for (1) designing a three-dimensional model consisted of required geometric shapes using a 3D modeling software, (2) manufacturing the model using a 3D printer, (3) presenting a presentation of the project, and (4) writing a technical report in a team.

The project is an integrating or capstone experience utilizing skills and knowledge acquired from MT-111 and MT-293 courses. Students design a solid model with maximum dimensions of four inches in width, three inches in depth, and two inches in height. Required features and minimum quantity of each feature are listed below. Additional features are allowed.

- I. 4 curved surfaces (Figure 2)
- II. 2 cylinders (Figure 3)
- III. 4 through holes or blind holes (Figure 4)
- IV. 4 counterbores or countersinks (Figure 5)



Figure 2: Curved surface

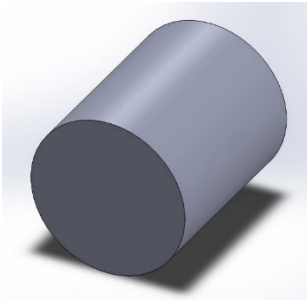


Figure 3: Cylinder

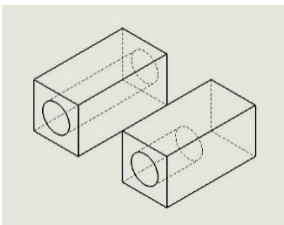


Figure 4: Through Hole and Blind Hole

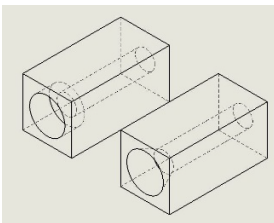


Figure 5: Counterbore and Countersink

The model is a representation of a device that is useful in everyday life. Students are divided into groups. Students work together as a team to design a model using SolidWorks<sup>®</sup> software. Team members are required to communicate with each other, cooperate with each other, and work as a team on the project. Team tasks include designing the best model, creating model drawings using SolidWorks<sup>®</sup>, saving the CAD drawing as a STL file format for 3D printing, manufacturing the

model using a 3D printer, presenting the project in class, and writing a report. Report writing requires that each team member is responsible for writing a part of the report. Student names and his/her responsible section/sections is/are listed in the report. The report covers all pre-assigned topics. Microsoft PowerPoint presentation of the project requires that each team member is responsible for creating parts of the presentation. Student names and his/her responsible section/section is/are listed in the presentation. The presentation includes all pre-assigned topics. The entire team presents the presentation as a group in front of the class at the end of the project. Students evaluate presentations of their peer groups during their presentations.

### Assessments

For the assessment, a student-centered method is adopted to evaluate students' learning by putting more weight on soft skills development. For example, students evaluate their peer's group presentations on what they have performed well and what can be improved among the same group members. Each student is also required to fill out an evaluation form to grade student group presentations. An example of student group presentation by peer grading form of MT-492 course is showed in Table 1. Yet, instructors still need to provide standard values to evaluate students' performance objectively. An example of assessment of group presentations is showed in Figure 6. The figure presents the scores of student group presentations of MT-492 Project #1 in fall 2022 semester, and the presentations were graded by student classmates.

Table 1: MT-492 Student Group Presentation by Peer Grading

Group Number: _____	SCORE (from 1 to 5: 1 being the lowest score and 5 being the highest score)
1. Group presentation in front of the class	
2. PowerPoint presentation	
3. Design of the model	
TOTAL SCORE	

In the case that there are two parts of grade for the projects, one from report and the other from presentation, the report grade is given by the instructor, and the presentation grade is given by both students and instructor.

In addition, rubric [10] is used as a tool to assess subjective students' soft skills objectively. The criteria of the soft skills assessments are shown in Table 2 as an example.

To evaluate the entire course based on pre-determined student outcomes, a rubric is established for the evaluation. Course assessment of ET-725, for example, is showed in Table 3.



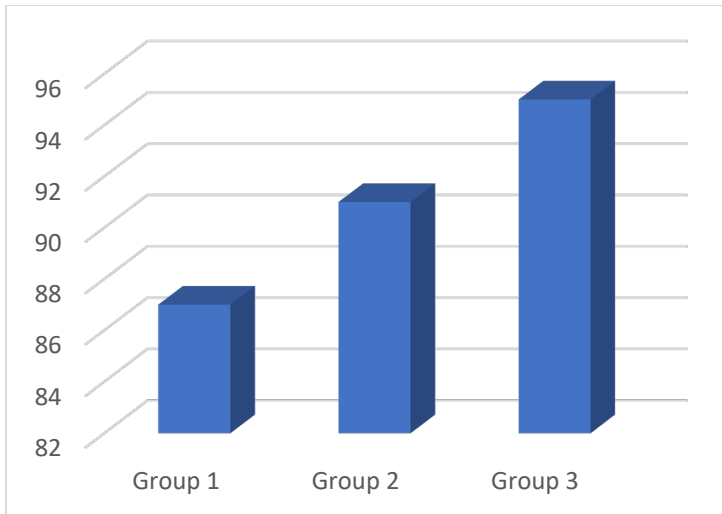


Figure 6: MT-491 Project 1 Group Presentation Grades by Peer Evaluation in Fall 2022 Semester

Table 2: The Rubric Criteria of Soft Skills Assessments

Assessment Rubric	Poor	Marginal	Good	Excellent
<b>Communication</b> (Discussing information and ideas in ways that are appropriate to the situation purpose, and audience)				
<b>Collaboration</b> (Communicate about thinking with the group, Contribute resources, ideas, and efforts and support group members)				
<b>Presentation</b> (Presenting information, findings, arguments and supporting evidence clearly, concisely, and logically, audience can easily follow the line of reasoning)				
<b>Critical Thinking</b> (Demonstrates understanding by uncovering the interrelationships of topics and concepts) (explanation/analysis)				
<b>Creativity</b> (Novelty and Usefulness, Generating and Experimenting)				

Table 3: The Rubric Criteria of ET-725 Course in Spring 2022 Semester

<b>Indicator &amp; Exercise</b>	<b>Poor</b>	<b>Marginal</b>	<b>Good</b>	<b>Excellent</b>
<p>Performance Indicator Demonstrate understanding of the topic and present their findings to the class.</p> <p><u>Exercise Description:</u> Students use four different methods of <i>Footprinting</i> to discover the target domain and the network.</p>	<p>Students are able to:</p> <ul style="list-style-type: none"> <li>- use methods of <i>Footprinting</i></li> </ul> <p>But are not able to:</p> <ul style="list-style-type: none"> <li>- differentiate between different methods</li> <li>- explain the importance of their findings</li> <li>- present their conclusions properly</li> </ul>	<p>Students are able to:</p> <ul style="list-style-type: none"> <li>- use methods of <i>Footprinting</i></li> <li>- differentiate between different methods</li> </ul> <p>But are not able to:</p> <ul style="list-style-type: none"> <li>- explain the importance of their findings</li> <li>- present their conclusions properly</li> </ul>	<p>Students are able to:</p> <ul style="list-style-type: none"> <li>- use methods of <i>Footprinting</i></li> <li>- differentiate between different methods</li> <li>- explain the importance of their findings</li> </ul> <p>But are not able to:</p> <ul style="list-style-type: none"> <li>- present their conclusions properly</li> </ul>	<p>Students are able to:</p> <ul style="list-style-type: none"> <li>-use methods of <i>Footprinting</i></li> <li>- differentiate between different methods</li> <li>- explain the importance of their findings</li> <li>- present their conclusions properly</li> </ul>
<b>Headcount</b> (# of students in each category)	2	2	4	5

Challenges in Project-Based Learning at the Community College Class

It is challenging to train the soft skills of community college students with a small project in a short period (a semester) through one course, especially in an online classroom setting. For example, it was difficult to identify students that are not involved in the group work from the online breakout room. Some students were simply not able to get involved in the teamwork due to technical issues such as outdated devices, no camera, or no microphone. However, these issues can be easily addressed with the change of class modality. In computer science courses, a project requires a larger scale to help students practice programming skills they have learned thoroughly. However, for the first year first semester student, it is difficult to assign large projects. First year undergraduates are set to learn basic concepts of subjects, therefore, it is challenging to assign projects at individualized level to each student. For online classes, preventing cheating and fair grading are another huge challenge especially for team projects since one or few students do most of the work instead distributing equal amount of work to each team member. Most of all,

for community college classes, time constraint was the most challenging part of going through the project with students together while ensuring all the course contents from the curriculum were covered.

## Conclusion

Despite all the challenges mentioned above, PBL is beneficial for students as it is exposing close to real-life experiences through real-world projects and a learning environment that simulates the industrial environment. Although a classroom, especially in the community college, cannot duplicate the fast-paced industrial environment, daily communication in teamwork, immediate feedback on the project and demands from upper management, PBL has been proved to be an effective pedagogy that provides hard skills training and an environment where students can foster their soft skills such as communications, time management, leadership, critical thinking, and teamwork in various engineering disciplines. Furthermore, instruction-integrated, student-centered, process-focused project-based learning will provide an improved pathway for preparing students for apprenticeships and their future industrial careers.

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