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WiP : Comparing Programming Interest/Perceptions with Cornerstone Project Modifications

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WiP: Comparing Programming Interest/Perceptions with Cornerstone Project Modifications

All first-year students attending the University of Louisville JB Speed School of Engineering are required to take a two-course sequence that is an introduction to engineering. All engineering disciplines are required to take this sequence, and the courses are interdisciplinary. The first course of the sequence is *Engineering Methods, Tools, & Practice I* (ENGR-110), and it covers basic skills that are fundamental to the engineering profession. The second course is *Engineering Methods, Tools, & Practice II* (ENGR-111), and it has students expand on the skills learned in ENGR-110. ENGR-111 culminates with a semester-long hands-on cornerstone project. ENGR-111 has traditionally been taught in the university's 15,000 square foot makerspace. The makerspace has room to break the students into groups (teams) of 3-4 to work on the cornerstone project. Approximately 500 students take ENGR-111 during the spring semester across six sections. There are multiple cornerstone projects that the instructors have used in ENGR-111. The cornerstone projects incorporate many engineering skills such as programming, a basic introduction to circuitry, and teamwork. The cornerstone project is common across all six sections in a given semester, and the instructional team determines the rotation.

The instruction on programming presented in ENGR-111 extends the programming skills learned in ENGR 110. ENGR 110 teaches programming basics in Python, where ENGR-111 uses Arduino microcontrollers for the programming curriculum and cornerstone project. The programming lessons are scaffolded to prepare the students for the end-of-semester cornerstone. Students are exposed to a wide variety of software design concepts to prepare them for their academic and professional careers.

This work in progress paper looks at two semesters of ENGR-111 with the same Cornerstone project with differences in the programming portion of the project. Project 1A took place during the spring semester of 2022 and Project 1B takes place during the spring semester of 2026. The Cornerstone project designation Project 1 is the windmill power generation system. There have been modifications to the system that will be referred to as A or B.

Project 1A's programming involved receiving input from a proximity sensor connected to a circuit to allow calculations to be performed in the cornerstone code. The students were to calculate and display: RPM, Power Generation, Windmill Blade Efficiency, Motor Efficiency, and Overall Efficiency.

Project 1B's programming involved everything in 1A and added a motor detachment control. If the wind was too strong their code would control a servomotor to disconnect the DC motor from the windmill. The code would also control the servomotor to reconnect the DC motor when wind speed was below the disconnect threshold.

Project 1B changes were made due to students' self-reported programming interest from Project 2. Project 2 is a water filtration system for stormwater routing. In Project 2 the students controlled a valve and pump with the Arduino, and the students' programming interest was higher than Project 1A. The instructional team made changes to Project 1B to incorporate visible control to determine if students' programming interest would increase on Project 1. The spring 2026 students will take a survey to provide their perceptions of the programming instruction as well as self-report their confidence in programming. These results will be compared to the survey results from the last semester that Project 1A was used.

Introduction and Course Description

Incoming first-year students at the JB Speed School at the University of Louisville are required to enroll in a two-course sequence that is an introduction to engineering. The first course is ENGR-110 which covers basic skills that are fundamental to engineering and the engineering profession. Topics in this first course are: engineering graphics, an introduction to programming with Python, spreadsheets, teamwork, critical thinking, etc. ENGR-111 is the second course in the sequence of courses and has traditionally been taught in the JB Speed School's 15,000 ft^2 makerspace. ENGR-111 incorporates application of the fundamental engineering skills learned in ENGR-110 as well as adding instruction for circuitry, Arduino microcontrollers, three-dimensional graphics via SolidWorks, 3D-printing, and technical writing.

ENGR-111 includes a semester long project. This Cornerstone project is completed by each student team in the course, and the teams must demonstrate and present their Cornerstone project at the end of the semester. The course instruction builds their knowledge towards the Cornerstone project. The Cornerstone is to simulate a long-term team-based industry project [1]. The Cornerstone also involves team-based hands-on learning with the presence of multiple instructors and teaching assistants to assist the teams in their daily deliverables as well as their Cornerstone [2][3].

This work in progress paper will detail two semesters of ENGR-111 using the same overall Cornerstone. The windmill power generation is the first Cornerstone project (Project 1) used in ENGR-111. Project 1 was used in the spring semester of 2022 and the spring semester of 2026. There have been course modifications to this project based on student feedback, as well as lessons learned from Project 2, a metropolitan sewer district water filtration system. The spring semester of 2022 will be labeled Project 1A (Figure 1) going forward, and the spring semester of 2026 will be labeled Project 1B (Figure 2), since both semesters used the windmill power generation system however with changes. The main differences in Project 1A and Project 1B are related to programming.

Project 1A's primary programming was receiving input, calculation of values related to windmill system behavior, and displaying those values. Project 1A used a proximity sensor connected to a circuit that allows the Arduino to receive input. The input from the proximity sensor allows the students to calculate and display the following: RPM, Power Generation, Windmill Blade Efficiency, Motor Efficiency, and Overall System Efficiency.

Figure 1: Project 1A Sample Team

Figure 2: Project 1B Sample Team

Project 1B's programming includes everything mentioned in Project 1A (input from the proximity sensor, and calculating and displaying the values for: RPM, Power Generation, Windmill Blade Efficiency, Motor Efficiency, and Overall System Efficiency). However, Project 1B also added a motor detachment control. If the wind becomes too strong, the students' code needs to control a servomotor to disconnect the DC motor from the windmill system. Their code would also need to reconnect the DC motor when the windspeed becomes lower than the disconnect threshold.

The changes to Project 1B were informed by student related programming interest in Project 2. Project 2 forces students to control a valve and a pump with the Arduino and circuitry. The students' programming interest was higher than Project 1A, possibly due to this visible control output of their program. The instructional team made changes to create Project 1B and to include a visible control element. The first iteration of Project 1B to the large spring student cohort will be spring 2026. The instructional team believes the control element will increase the students self-reported confidence in programming. The spring 2026 results will be compared to the spring 2022 results.

Methodology

At the end of the Spring 2022 semester, a survey was administered to all students in the course. While this survey consists of questions for many different course topics, three questions were on the subject of programming:

Q1: Rate your current confidence level in programming with ARDUINO.
Q2: Rate your current confidence level programming with ANY language.
Q3: Rate how helpful your ENGR 110 programming instruction was at preparing you for your ENGR-111 programming experience.

Answers to each of these questions follow a 5-point Likert scale from: not at all, slightly, somewhat, very, and extremely.

Nearly 400 students took part in this survey as a whole, with 364 students answering Q1 and Q2, and 362 students answering Q3.

Results & Discussion

The results for Q1 are shown in Figure 3 below.

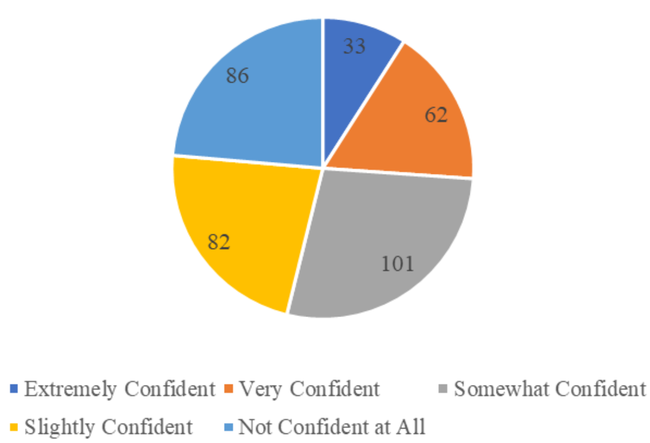

Figure 3: Student responses regarding confidence in Arduino programming.

These responses show that many students have some confidence in Arduino programming after completing this course, but not many students have high confidence. Only 26% of students are very or extremely confident with Arduino programming at the end of the course, whereas nearly 46% of students are either slightly confident or not confident at all. While this data is not showing significant issues with student learning (well over half of responses indicate at least some confidence), there are certainly improvements to be made.

The student responses to Q2 are shown in Figure 4 below.

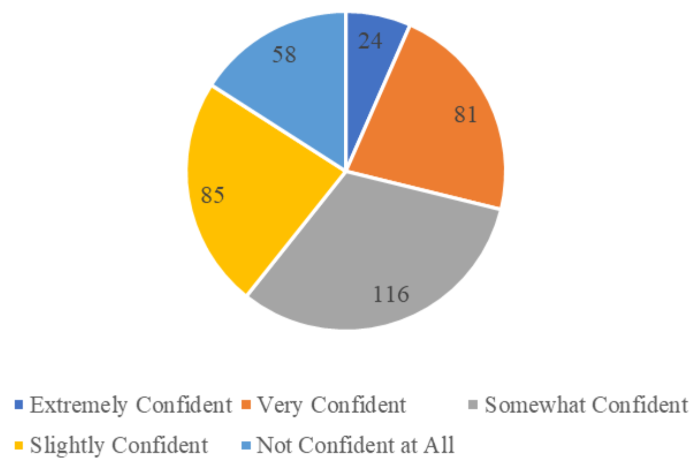

Figure 4: Student responses regarding confidence in programming (any language).

These responses are similar to the results for Q1, but more centered. About 32% of students responded with some confidence in programming any language, which is just a bit more than that selection for Q1. Overall, the confidence levels of students for programming any language is roughly the same as for Arduino specifically.

The results for Q3 are shown in Figure 5 below.

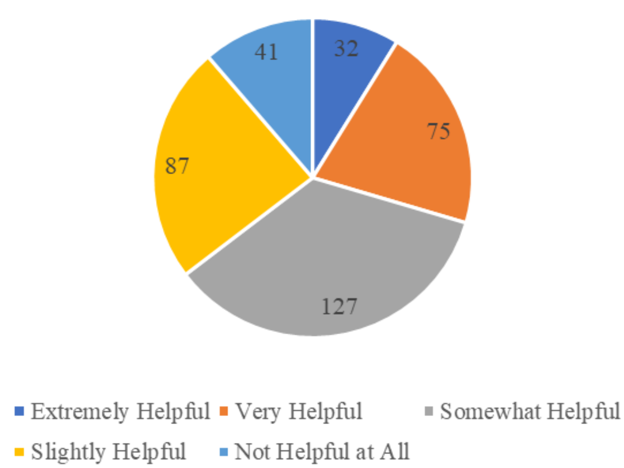

Figure 5: Student responses regarding helpfulness of programming preparation.

These results indicate that the majority of students find their programming preparation before entering ENGR-111 to be helpful, but not very/extremely so. The "somewhat" category is certainly the most common response at 35%, with slightly more students responding below that threshold (not helpful or slightly) than above it (very or extremely).

The first two questions seem to indicate that students are generally "medium" regarding their programming confidence. The "somewhat" response is the most common in each one. This generally would imply that the course fulfills its purpose. That is, this is an introductory course, not a wholly programming course. While programming is a learning objective in both ENGR 110 and ENGR-111, neither course focuses on programming to such an extent that they ignore other important content (both spend about a 3^{rd} of course time including programming in instruction).

With this in mind, while this course does not intend to produce any programming experts, it should help students feel more confident in their programming skills. The results from Spring 2022 indicate that while students are not generally unconfident, there is room for improvement.

The curriculum changes made to Project 1B are expected to assist with student confidence. This largely stems from the visual aspects of code execution. In Project 1A, all programming objectives are inherently numerical. The code contains mostly calculations that lead to numbers on a small LCD that update as the system operates. Project 1B adds a visual, controllable aspect to the programming experience that helps students better understand the way their code behaves, which course instructors expect to help students feel more confident with programming.

Question 3 is intended to be something of a check on the programming instruction for the course. Course instructors expect this to have somewhat mixed results, as the programming instruction in the two courses are intentionally different. They each teach different languages and teach about programming in different contexts. While improved responses to this question would be nice, the goal of this study is simply to ensure that it does not get worse.

Conclusions & Future Work

This study inspects student programming confidence for a hands-on engineering course, where the final project for students has experienced modifications. Data from the course survey conducted before these modifications show that student confidence is good but not great on average. Course instructors expect that the visual additions to the student programming experience will increase this confidence in Spring 2026.

Future studies will incorporate the Spring 2026 data and compare it to the Spring 2022 data to look for improvements in student confidence. Additionally, more surveys are being developed to better investigate the relationship between visual control objectives and programming.

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