Full Paper: Comprehensive Analysis and Assessment of An Introduction to Engineering and Computing Course

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Abstract: In fall 2023, for freshman undergraduate students majoring in Engineering and Computing studies, Gannon University's School of Engineering and Computing (SEC) implemented the Introduction to Engineering and Computing course. The new Introduction to Engineering and Computing course is a 1-credit course that provides students with an overview of engineering and computing as professions and disciplines. The course is designed to serve as a foundational exploration into the interconnected worlds of engineering principles and computational problem-solving. The course covers professional and ethical considerations, career development, and communication skills vital for success in these fields. Students are also introduced to the resources available in MakerSpace, including but not limited to 3D printing, laser cutting, and microcontroller applications. Through hands-on projects and instructional activities, students explore fundamental concepts in engineering while fostering critical thinking and problem-solving skills. This paper outlines the course, and the project structure details, and provides a summary of student feedback gathered from course evaluations and surveys conducted at least one semester after completion. Future work on how to modify the course structure is also discussed according to the student feedback.
Keywords: Engineering Education, First-year Seminar, Hands-on Project, Professional Development, Course Evaluation.

1. Introduction

Freshman engineering students often struggle with the transition from high school to college, facing increased academic rigor and self-directed study. Many enter with a vague understanding of the field. An introductory course can bridge this gap by gradually introducing engineering-specific academic expectations and workloads [1]. This introductory course is crucial for acclimating students to college studies, exposing them to engineering fundamentals, and fostering a sense of community. The benefits include smoother academic transitions, career orientation, skill development, retention, and motivation [2]. By offering a broad overview of engineering disciplines, the course helps students make informed decisions about their interests and career paths [3]. It emphasizes essential skills such as teamwork, problem-solving, and basic engineering design, crucial for later success [4]. However, designing such a course poses challenges, including balancing content, accommodating diverse preparedness levels, resource allocation, assessment strategies, and scalability [5]. Effective planning, resource allocation, and innovative teaching practices are essential to maximize the course's impact.

In the fall of 2023, Gannon University's School of Engineering and Computing (SEC) launched a new course titled "Introduction to Engineering and Computing" for freshman undergraduate students majoring in engineering and computing studies. The newly developed 1-credit course is divided into four sections, each with up to 25 students, and is led by instructors from various engineering disciplines, such as environmental, electrical, biomedical, and industrial engineering. While lectures are held jointly for all sections, project sessions and workshops occur in separate classrooms. The students are primarily from Computer Science (28.3%), Cybersecurity (23.9%), and Biomedical (12%) majors, among others. Projects utilize the Gannon University MakerSpace, which provides tools like 3D printing and laser cutting. The course is designed to provide students with a foundational understanding of the professions and disciplines of engineering and computing. The course offers an integrated exploration of engineering principles and computational problem-solving. It aims to address the essential question of what it means to work and think in the fields of engineering and computing. The curriculum adopts a "hands-on" project approach to help students engage with the practical aspects of these disciplines, supported by an introduction to the necessary technical concepts. Students will also become familiar with the professional vocabulary that every engineer and computing professional should know. Key topics covered include professional and ethical considerations, career development, and the communication skills crucial for success in these areas. Table 1 shows the course schedule.

Table 1. Course schedule of the newly developed introductory course.

Date	Topic	Assignments
27-Aug	Course Introduction	
3-Sep	Labor Day No class	
10-Sep	Project idea and planning	
17-Sep	Spirit of Engineering	Writing on Engineering Spirit
24-Sep	Careers in Engineering and Computing	
1-Oct	Technical Communication	
8-Oct	Workshop Arduino	
15-Oct	Project Design #1	Project Design #1: Presentation & Report
22-Oct	Workshop 3D printing	
29-Oct	Project Design #2	Project Design #2: Presentation & Report
5-Nov	Computer Applications	Excel Assignment
12-Nov	Ethics in Engineering and computing	Quiz on Blackboard
19-Nov	Professional Development	Resume
26-Nov	Project design & Build	
3-Dec	Project design & Build	
13-Dec	Final Presentations	Final Project Presentation and Report

The course emphasizes the importance of excelling in various communication skills tailored for engineering and computing majors. Additionally, students gain exposure to the resources available in the Center for Manufacturing and Technology (CMT), which includes 3D printing, laser cutting, and microcontroller applications, among others [6]. Through hands-on projects and instructional activities, the course encourages students to explore basic engineering concepts while developing critical thinking and problem-solving skills.

This paper introduces the supportive resources for students, the entire course structure, main lectures and activities, hands-on projects, and a summary of student feedback collected from a student survey which was conducted at least one semester after the course completion. It also discusses future adjustments to the course structure based on the feedback received from students.

Student feedback on this newly developed course has highlighted several areas for improvement. Key concerns include the need for fairer assessment in group projects through peer evaluations to ensure equitable workload distribution. Students also noted the course's disorganization and suggested a more structured approach with clear instructions, detailed schedules, and regular checkpoints. Additionally, they called for a stronger focus on core engineering principles instead of business-related content. Other suggestions included increasing class frequency, better integration with other courses, and more proactive instructional support, particularly in using resources like 3D printers.

2. Course Activities

The course is structured into four sections, each capped at 25 students and led by instructors specializing in different engineering fields, including environmental, electrical, biomedical, and industrial engineering. Lectures are combined for all sections, while project-based sessions and workshops utilize separate classrooms per section. The student body primarily consists of Computer Science (28.3%) and Cybersecurity (23.9%) majors, who together make up about half of the enrollees as shown in Figure 1 (each section and overall). Projects leverage resources from the Gannon University MakerSpace, offering tools like 3D printing and laser cutting.

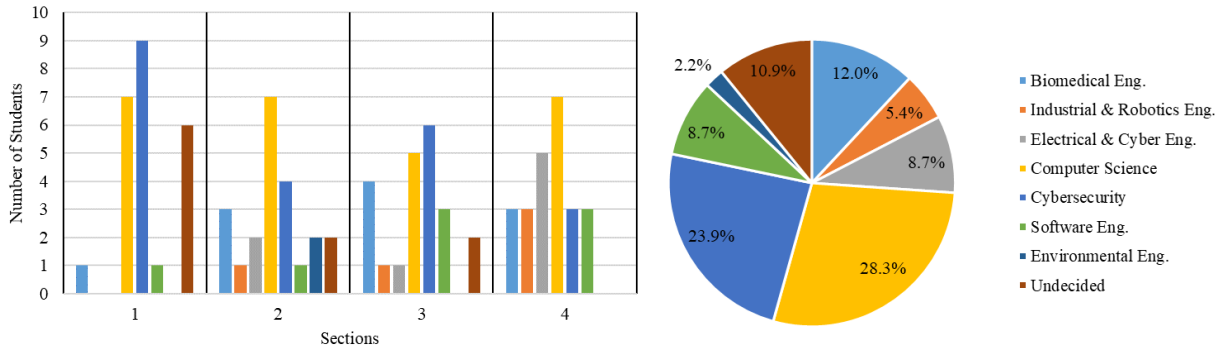


Figure 1. Student major distribution in the Fall 2023 ENG102 course.

2.1 Lectures

The lecture series in the engineering introduction course includes five key topics designed to orient students effectively. The "Engineering Major Exploration" lecture offers insights from faculty across disciplines like Biomedical, Computer Science, and Software Engineering, helping students choose their major by highlighting necessary skills and career paths. The "Spirit of Engineering" lecture delves into the history of engineering, distinguishing it from science and discussing its global impact and career development strategies. The "Professional Development" lecture, led by a student advisor, guides students in preparing professional resumes and navigating internship interviews, with follow-up support from the Career Exploration and Development Center at Gannon University. A "Communication" lecture focuses on crafting technical reports, providing a standard format for students. Finally, the "Engineering Ethics" lecture covers fundamental ethical concepts, the role of ethics in engineering, and includes a quiz to assess students' understanding.

2.2 Workshops

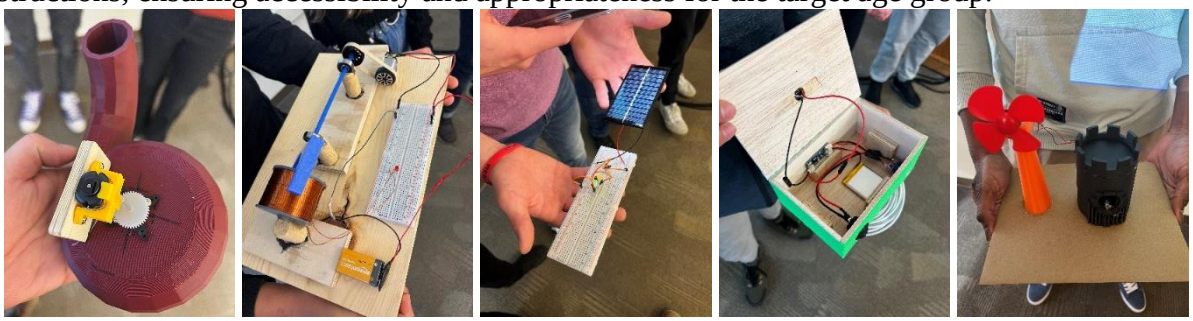
The ENG 102 course includes three practical workshops: 3D Printing, Microcontroller, and Computer Application, each designed to equip students with the essential technological skills

needed for engineering projects. Figure 2 shows the Prusa 3D printers and Arduino board and materials that students used in workshops. The 3D Printing Workshop at Gannon University's MakerSpace exposes students to advanced additive manufacturing, offering hands-on experience with over 40 state-of-the-art 3D printers. Students learn to create objects from digital designs using layer-by-layer fabrication. The Microcontroller Workshop introduces Arduino UNO boards, sensors, and actuators, focusing on programming and sensor data integration, enabling students to build and program simple circuits. Finally, the Computer Application Workshop trains students in using Microsoft Excel for data analysis and visualization, teaching techniques like data sorting, filtering, and graphical presentation to enhance their professional reporting skills.

Figure 2. Resources and materials for workshops (3D printers and Arduino materials).

2.3 Projects

The course project focuses on developing a STEM kit activity for middle school students themed around 'Going Green'. Groups, comprised of up to five students, will navigate through a two-stage process involving design and development, spread across four sessions. Each project must be cost-effective, with a cap of $20 for parts, require about 45 minutes for assembly, and include detailed instructions, ensuring accessibility and appropriateness for the target age group.



(a) (b) (c) (d) (e)

Figure 3. Sample student projects: (a) Hydro-Electric Power Generator; (b) Magnetic Pendulum; (c) Solar Powered LED; (d) Solar Energy Charging Station; (e) Wind Turbine.

In the initial design sessions, teams will define project goals, design requirements, and prepare detailed plans and materials lists. The development phase involves building the project, with a final evaluation based on mini reports during the design phase and a comprehensive final report and presentation. The projects, contributing to 60% of the course grade, aim to foster an understanding of engineering design, teamwork, and the application of engineering solutions to environmental sustainability.

Sample projects include solar-powered cars to explore renewable energy in transportation, wind-powered cell phone chargers that teach energy conversion, solar-powered vertical gardens for urban agriculture insights, green hydraulic arms to understand mechanical engineering principles, small-scale windmills for electricity generation, and solar water heaters that delve into thermal energy storage. Some sample student projects are shown in Figure 3.

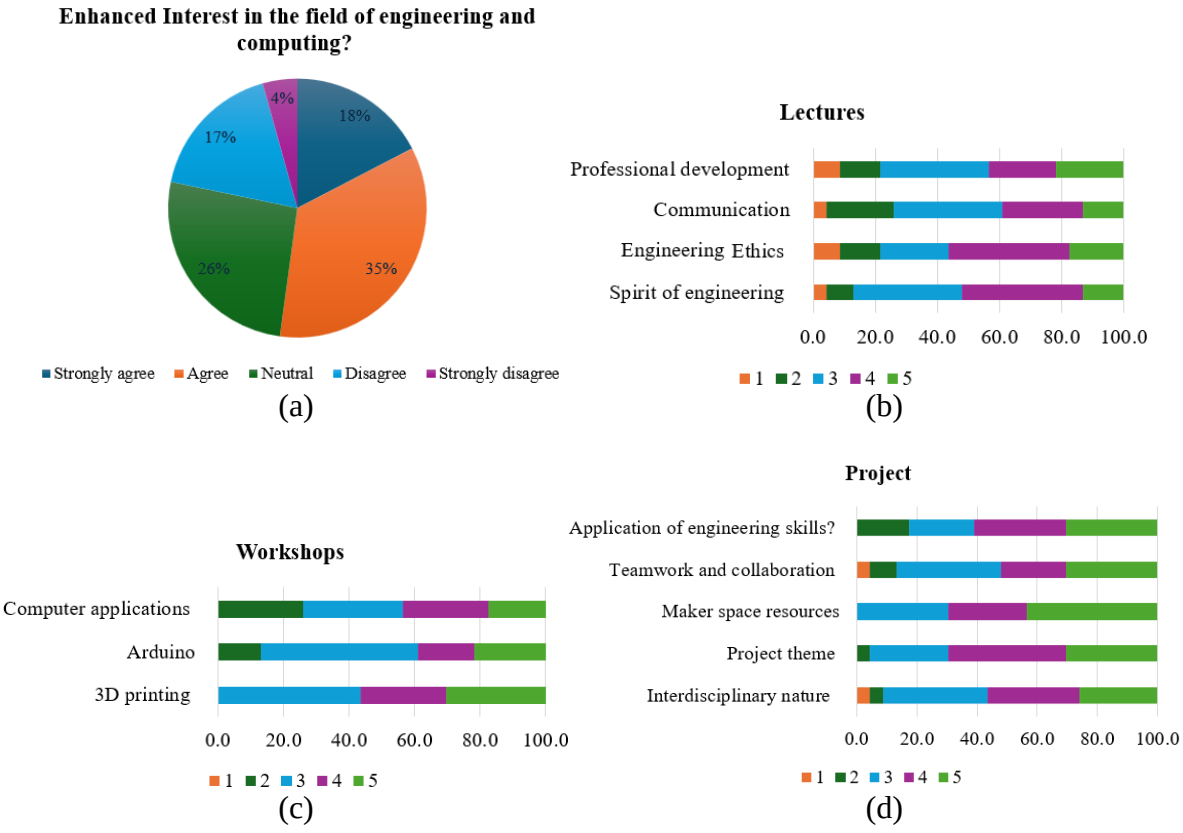


Figure 4. Students' feedback in the survey: (a) shows students' reponses to enhanced interest in the field of engineering and computing. Subfigures (b), (c), and (d) show students' reponses to rate the effectiveness from 1 (least effective) to 5 (most effective).

3. Student Survey and Feedback

In spring 2024, over 160 students who had completed the ENG 102 Introduction to Engineering and Computing course during the fall semesters of 2022 and 2023 were invited to participate in an anonymous survey conducted via Microsoft Forms. This survey aimed to collect comprehensive feedback on the course, focusing on three main areas: Overall course experience, effectiveness of course components, and general comments. Students were asked to rate their general experience, the impact of the course on their interest in engineering and computing, and the effectiveness of various course elements like lectures on core engineering concepts, ethics, and professional development; workshops; and project-based learning experiences in fostering teamwork and practical engineering skills. Additional questions solicited suggestions for course and project improvements.

Student feedback on the ENG 102 course at Gannon University has identified key areas for improvement to better align with educational goals. A primary concern is the need for fair assessment in group projects, where uneven workloads can impact grades. Implementing peer evaluation forms could help accurately grade individual contributions, alleviating concerns of disproportionate work distribution. Additionally, students have highlighted the course's disorganization, suggesting that a more structured approach with clear instructions, detailed schedules, and regular project checkpoints could enhance the learning experience. Furthermore, there is a call for a stronger focus on core engineering principles, rather than the perceived current emphasis on business-related content, to provide a more solid foundation in engineering practices. Other improvements could include more frequent classes, better integration with other courses, and more proactive instructional support, especially in the use of resources like 3D printers during project phases.

4. Faculty Reflections and Plans for Future Improvements

Addressing core concerns like fair assessment, structured guidance, and emphasis on engineering fundamentals can significantly enhance the ENG 102 course. Feedback suggests incorporating more frequent classes and better resource availability to align the course with engineering demands. Responding to this, faculty will focus on popular components like the Arduino and 3D printing workshops, shifting towards more project-based learning by reducing lecture hours. Other proposed improvements include introducing peer evaluations to balance team contributions, adjusting the computer application workshop to cater to diverse student backgrounds by including a range of computing tools, and ensuring a more even distribution of student majors across sessions. Additionally, merging the introductory class with the engineering disciplinary exploration could streamline the curriculum.

References

[1] Felder, Richard M. "Learning and teaching styles in engineering education." (2002).

[2] Lichtenstein, Gary, Alexander C. McCormick, Sheri D. Sheppard, and Jini Puma. "Comparing the undergraduate experience of engineers to all other majors: Significant differences are programmatic." Journal of Engineering Education 99, no. 4 (2010): 305-317.

[3] National Academy of Engineering, U. S. The engineer of 2020: Visions of engineering in the new century. Washington, DC: National Academies Press, 2004.

[4] Tinto, Vincent. Leaving college: Rethinking the causes and cures of student attrition. University of Chicago press, 2012.

[5] Sheppard, Sheri, Kelly Macatangay, Anne Colby, William M. Sullivan, and Lee S. Shulman. Educating engineers: Designing for the future of the field. Vol. 9. San Francisco, CA: Jossey-Bass, 2009.

[6] Center for Manufacturing and Technology, Gannon University. https://cmt.gannon.edu