Fostering Disciplinary Identification: The Impact of Project-Based Learning in First-Year Engineering

Dr. Daniel Selvakumar Raja, Greenville College

Daniel Raja is an Assistant Professor and Program Director of Engineering at Greenville University. He specializes in mechanical engineering, with a particular focus on solid mechanics and computational solid mechanics. His academic journey and professional career are marked by a dedication to advancing engineering education and research.

At Greenville University, Professor Raja is known for his engaging teaching style and his commitment to mentoring students. He actively involves his students in research projects, providing them with hands-on experience in the field of engineering. His work not only contributes to the academic community but also aims to solve real-world engineering problems.

Professor Raja's research interests include the development of new materials and the application of computational methods to understand and predict the behavior of solid materials under various conditions. He has published several papers in reputable journals and presented his findings at international conferences.

Outside of his academic responsibilities, Daniel Raja is passionate about community service and often participates in initiatives that promote STEM education among young students. His dedication to both his profession and his community makes him a respected and valued member of Greenville University.

Natalie Schleper, Saint Louis University

Natalie Schleper is an instructor in the Department of Chemistry at Saint Louis University. She holds both a B.S. and an M.S. in Chemistry from Southern Illinois University Edwardsville and researched student misconceptions and their effects on student understanding of chemistry. Natalie is dedicated to fostering a deep understanding of chemistry among her students. At SLU, Natalie is known for managing large class sizes averaging between 600-800 students per semester. She has taught various classes such as Fundamentals of Chemistry lecture, General Chemistry 1 & 2 lecture, recitations, and laboratory, Analytical Chemistry lecture and laboratory, Organic Chemistry laboratory, and Physical Chemistry Laboratory. Natalie's research contributions focus on innovative teaching methods to enhance student engagement and learning outcomes. Research interests include student misconceptions, instructional materials, and integration of technology to STEM courses. Outside of the university, Natalie has a passion for theater and architecture. Before finding her passion for chemistry education, she was a theater major and has an associate's degree in computer aided Drafting and Design.

Fostering Disciplinary Identification: The Impact of Project-Based Learning in First Year Engineering

Motivation and problem statement

This Complete Evidence-based Practice paper examines a unified introductory course designed to address the fragmented disciplinary understanding common among matriculating first-year engineering students. Recognizing that a lack of "disciplinary clarity" serves as a significant barrier to persistence and motivation , this study evaluates a curriculum that bridges the gap between student expectations and professional realities. By integrating multi disciplinary *Project-Based Learning* (PBL) with interventions rooted in *Self-Determination Theory* (SDT) , the course provides "low-stakes" experiential touchpoints across diverse fields. These modules range from structural tower and bridge construction to digital logic circuits and Arduino based robotics. The projects are coupled with foundational lectures on design and ethics to foster student self-efficacy, motivation, and agency. By investigating the implementation of scaffolded exploration tools described by Schleper and Raja [1], this study examines how structured decision-support frameworks empower students to navigate major selection with intentionality, thereby contributing to a comprehensive institutional strategy for student persistence.

Unified introductory course details

To address the lack of disciplinary clarity among incoming students, a unified introductory course designed to provide a comprehensive "panoramic view" of the engineering landscape was implemented. This 3-credit course meets three times per week for fifty minutes and is structured to balance theoretical foundations with experiential application. The details of the course are explained in brevity below but more details can be found in the paper [1]. The course is built upon a two-phase instructional model:

- Phase I: Foundational Orientation (Weeks 1 - 6): The first six weeks utilize a combination of "chalk talk" lectures, peer discussions, and in-class assignments. These sessions cover essential professional contexts, including the engineering design process, ethics, and the specific characteristics of various engineering disciplines.
- Phase II: Multi-Disciplinary PBL (Weeks 7 – 14): The remainder of the semester is dedicated to a series of sequential, discipline-themed projects. These projects are specifically designed to introduce students to the fundamental principles of electrical, mechanical, industrial and computer engineering.

Through this integrative approach, the course functions as a pedagogical bridge, transforming the assignments and projects into a tool for active disciplinary exploration and informed major selection.

Literature review & theoretical foundations

Prior academic literature consistently supports the notion that early exposure to discipline specific content and hands-on technical experiences positively influence students' academic and career trajectories [2–4]. However, first year engineering students often begin their studies with a developing but incomplete understanding of the various engineering discipline [5, 6]. This lack of clarity frequently results in academic uncertainty and diminished engagement. As these are primary drivers of institutional attrition, this presents a problem. While the benefits of hands-on learning are well documented, there remains a lack of empirical evidence specifically demonstrating how structured PBL in introductory courses impact a student's cognitive ability to discern and commit to a particular discipline. This research leverages and expands upon the theoretical foundations of multiple theories to address this gap by synthesizing four key theoretical frameworks.

1. Experiential learning theory (ELT) or project based learning (PBL): The foundational premise of this study is rooted in Experiential Learning Theory (ELT), which posits that knowledge is created through the transformation of experience [7]. In an "Introduction to Engineering" course, PBL provides the concrete experience necessary for students to engage in reflective observation and abstract conceptualization of professional roles [8–15]. This experiential approach is a critical component of career choice and development, as it allows students to transition from theoretical ambiguity to a more defined professional identity. By simulating or "trying on" different engineering roles, students engage in a process of self-discovery that facilitates more informed and deliberate academic choices.

2. Social cognitive career theory (SCCT): To understand the underlying cognitive and psychological processes of this identification of self, the study incorporates Social Cognitive Career Theory (SCCT) [16]. SCCT suggests that career-related interests and choices are heavily influenced by self-efficacy, a student's belief in their ability to succeed in specific tasks, and outcome expectations. SCCT is used to explain student motivation [17], career goals [18], and career decisions [18, 19]. In this course, the sequential series of discipline themed projects functions as a series of "mastery experiences". For instance, when students successfully navigate a mechanical design challenge, their increased self-efficacy in that domain drives enhanced interest and a stronger identification with mechanical engineering. Conversely, significant difficulty in a specific domain, such as coding, can lead to diminishing self-efficacy beliefs and a subsequent reconsideration of that as a career path.

3. Expectancy value theory (EVT): Complementing SCCT, Expectancy-Value Theory (EVT) provides a lens for analyzing why students gravitate toward certain disciplines over others based on the "subjective task value" they assign to the work [20]. In the context of first-year engineering, EVT provides a lens for analyzing the cognitive process behind disciplinary identification. According to the model, a student's choice to persist in a specific academic pathway is determined by two primary psychological constructs: their expectancy for success and the subjective task value they assign to that field. While other theories focus on the "how" of learning, EVT explains the "why" behind a student's motivation to move from a nascent understanding to a definitive commitment. High expectancy and task values have previously been used as a predictor of student choice, performance, and persistence in Engineering success [21–24]. This research suggests that by clarifying disciplinary

boundaries through PBL, educators can help students optimize their internal "value" calculations, leading to more informed, thoughtful academic choices.

Together, these theories suggest that discipline oriented projects serve as informal, embedded advising instruments that guide students toward professional fields robustly aligned with their individual values.

Methodology

The instructional interventions and data collection described in this study were conducted as part of an institutional program evaluation aimed at improving first-year engineering curricula. This project was submitted to the Greenville University Institutional Review Board (IRB), which determined the study to be exempt from formal oversight as it constitutes quality improvement of standard educational practices using de-identified data.

This study was conducted at a small, rural, private, faith based liberal-arts college focusing on undergraduate engineering education. The instructional design utilizes a dual-track exposure model. Students gain technical proficiency in mechanical, electrical, computer, robotics, and industrial engineering via direct project involvement. Concurrently, the theoretical landscape of the profession is expanded through lectures covering traditional and specialized disciplines, such as civil, chemical, aerospace, and petroleum engineering, to ensure a comprehensive understanding of the field.

Upon the conclusion of the six-week foundational lecture phase, students were issued two distinct assessment instruments designed to capture their baseline disciplinary understanding and self-efficacy.

The primary quantitative instrument utilized was a baseline pre-test questionnaire administered to measure students' perceived academic and professional preparedness. This instrument required participants to self-report their confidence levels regarding their intended engineering major, grounded in their current comprehension of professional roles and responsibilities. Furthermore, the questionnaire served to evaluate the perceived informational adequacy of the cohort, determining whether students felt they possessed sufficient data to make an intentional, evidence-based decision regarding their academic trajectory.

The second instrument consisted of formative end-of-day reflections submitted by students to document their evolving comprehension of engineering disciplines and the requisite competencies for professional success. During the designated laboratory or class periods, students engaged in facilitated peer-to-peer dialogues to examine their disciplinary interests and uncertainties, specifically contrasting their matriculation-level impressions with their post-intervention motivations. These discussions were further scaffolded by requiring students to explore a metacognitive gap analysis, wherein they systematically aligned their personal values and innate strengths with the functional requirements of the engineering branches they felt most inclined to pursue.

In the final weeks of the semester, the cohort participated in a structured group synthesis session. This facilitated discussion prompted students to construct a collective definition of professional engineering identity and to evaluate their personal confidence levels regarding their chosen disciplines. Specifically, students were tasked with mapping the technical roles, project types, and requisite skill sets identified during the PBL modules to their intended branches of engineering. To conclude the data collection process, a post-test research questionnaire was administered. This instrument mirrored the pre-test survey, allowing for a longitudinal comparison of student confidence and the perceived adequacy of their information-gathering process following the project interventions.

To evaluate the efficacy of the scaffolded exploration tools, a survey was administered focusing on four primary constructs. While the instrument is part of an ongoing longitudinal study and is not provided verbatim, the items were categorized as follows:

1. Branch Identification & Confidence: Items assessed the student's ability to select a specific engineering major and their level of certainty in that choice.
2. Awareness of Engineering Disciplines: Items measured the student's perceived understanding regarding different engineering fields.
3. Influence of Projects & Activities: Items prompted students to rank the impact of specific pedagogical components, such as PBL modules and lectures.
4. Career Orientation & Motivation: Items evaluated the student's drive to pursue a career within their identified field and their understanding of professional trajectories.

Results

Analysis of Qualitative Data

A thematic analysis was conducted on the formative end-of-day reflections submitted during week six, immediately following the conclusion of the disciplinary lecture series but prior to the commencement of the PBL modules. This analysis revealed several prominent themes regarding students' baseline professional awareness:

- Licensure and Professional Certification: Students demonstrated a high level of engagement with the professional pathway to licensure, specifically discussing the transition from the Fundamentals of Engineering (FE) exam to Engineer-in-Training (EIT) status and the requisite four-year experience period for Professional Engineer (PE) certification. Some students however expressed a sense of anxiety regarding the difficulty of the professional engineer exam.
- Disciplinary Mapping and Skill Sets: Reflections highlighted students' ability to categorize various engineering branches, identifying technical overlaps and distinctions between similar and dissimilar disciplines.
- Professional Affiliation and Economic Factors: Discussions frequently addressed the role of professional organizations, including the costs and benefits of membership. Additionally, students evaluated external market factors such as regional job outlooks, salary projections, and geographic concentrations of specific industries.
- Preliminary Disciplinary Intent: In the majority of cases, students were able to identify their intended or most probable branch of engineering.

- Societal and Ethical Purpose: Some students articulated the altruistic nature/goals of engineering such as “community stability” or “improving quality of life.”

It is important to note that while students articulated their intended paths, the underlying motivations and the depth of their commitment to these choices were not formally recorded at this stage, serving as a baseline for the subsequent longitudinal study of the project-based interventions.

The end-of-semester reflection assignment comprised two distinct components. The first prompt required students to synthesize their personal definition of engineering based on their cumulative experiences in the course. A thematic analysis of the qualitative responses revealed that students’ perceptions of the profession evolved into a multi-dimensional framework, categorized by the following themes:

- Social and Altruistic Impact: Students viewed engineers as vital contributors who improve community well-being and prioritize the safety and health of the public as a paramount responsibility.
- Technical and Creative Agency: The profession was defined by the ability to act as “creators” who convert abstract ideas into tangible realities through systematic problem-solving.
- Ethical and Professional Standards: A strong emphasis was placed on the necessity of honesty, integrity, and being held to a higher standard of conduct. Students identified that specialized knowledge must be paired with rigorous work ethics.
- Economic and Operational Awareness: Reflections highlighted the importance of developing affordable, cost-effective solutions and the high earning potential associated with the field.
- Project Management Proficiency: Students explicitly recognized the value of productivity and organizational tools, such as RACI matrices and Gantt charts, noting their broad applicability across all engineering disciplines.

The second component of the end-of-semester reflection was designed to assess the students’ self-efficacy regarding disciplinary literacy, institutional navigation, and career alignment. The prompt specifically queried their confidence in distinguishing between primary branches such as Mechanical, Electrical, Civil, and Computer Engineering and their ability to articulate the roles and technical projects associated with at least two of these fields. Additionally, the instrument measured their awareness of core professional competencies including problem-solving, teamwork, and communication, as well as their understanding of the institutional academic sequence and advising resources.

Students were also asked to perform a comparative analysis of the semester’s experiential modules truss bridge (civil, mechanical, and industrial), circuits (electrical and electronics), and robotics (mechatronics, computer programming, and electronics) to determine if they could envision these tasks as future professional responsibilities. The thematic analysis of these responses revealed the following insights:

- Pedagogical Synergy: Students reported that the foundational lectures provided the theoretical framework for professional roles and responsibilities, while the PBL modules served as critical reinforcement of that acquired knowledge.
- Disciplinary Filtering: The intervention enabled students to move beyond general curiosity to specific preferences; participants noted they could now clearly differentiate between disciplines they favored and those they wished to avoid.
- Breadth of Understanding: While confidence was high regarding the primary engineering branches, a notable subset of students expressed continued uncertainty concerning specialized or "niche" disciplines.
- The Influence of Prior Experience: A significant theme emerged regarding student engagement; interest and enjoyment were most pronounced in projects that aligned with pre-existing hobbies or skills, such as secondary school coding, woodworking, or mechanical tinkering.
- Affective Engagement: Students frequently associated "fun" and higher engagement levels with modules where they could leverage their prior background, suggesting that early success in familiar technical tasks positively influences their perception of the discipline.

Ultimately, this comprehensive feedback suggests that by the end of the semester, students moved beyond a purely technical view of the field to include the ethical, social, and managerial complexities of the profession.

Analysis of Quantitative Data

Due to the small cohort size ($N = 18$), which precluded the assumption of normality required for parametric testing, a Wilcoxon Signed-Rank Test was employed to analyze longitudinal changes. The reported sample size (n) for each test varies because the Wilcoxon method excludes "zero-difference" pairs (cases where student responses remained identical across both surveys) and requires complete paired data for each participant. In the resulting data visualizations, individual student responses are plotted along the X-axis, with their corresponding scores measured on a 5-point Likert scale on the Y-axis. This representation ensures a clear visualization of the magnitude and direction of individual shifts in professional awareness and self-efficacy.

Statistical analysis of the longitudinal data revealed no significant change in student confidence concerning their chosen engineering discipline ($W = 22, W_{crit} = 2, n = 7, p > 0.05$) as can be seen in Figure 1. Similarly, there was no significant shift in students' reported motivation to pursue a career within their identified field ($W = 22, W_{crit} = 10, n = 10, p > 0.05$) as can be seen in Figure 2. These results suggest that students' professional intentions and self-efficacy remained stable from the conclusion of the lecture phase through the completion of the project-based modules.

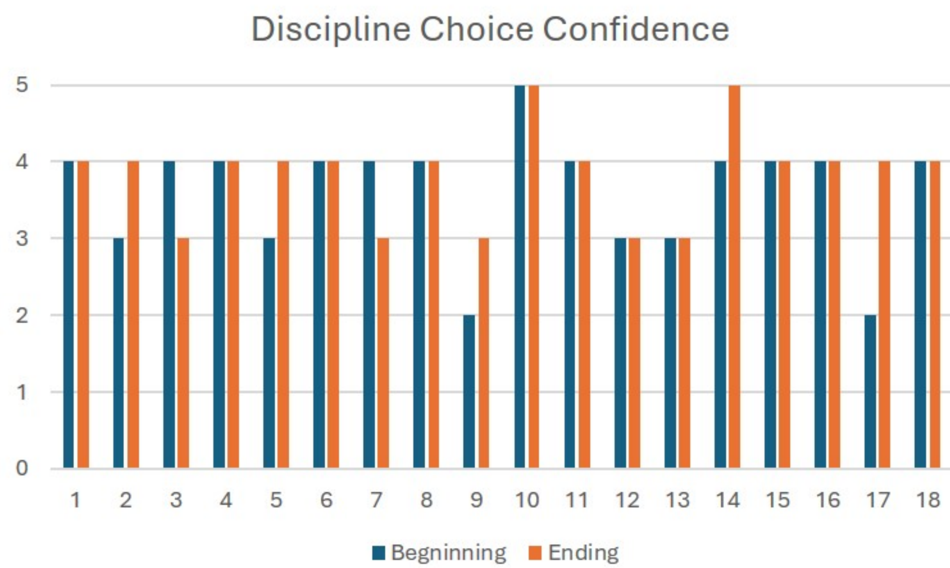

Figure 1: Shifting Confidence Levels Regarding Major Selection; $n = 7$ represents the subset of participants demonstrating a numerical change in score

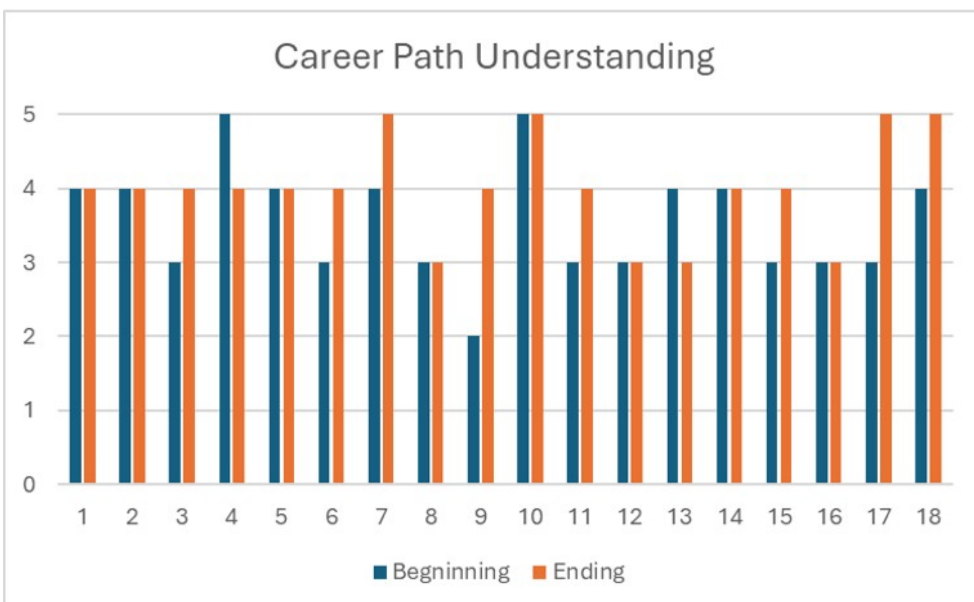

Figure 2: Shifts in Student Motivation to Pursue Careers within Identified Engineering Fields; $n = 10$ denotes the subset of participants demonstrating a numerical change in motivation scores

These data suggest that a majority of students possessed a high baseline of disciplinary confidence prior to the implementation of the PBL modules, specifically at the conclusion of the lecture phase. The qualitative data derived from both pre- and post-intervention surveys corroborate these statistical findings; while many participants reaffirmed their initial disciplinary selections and reported that they were "more sure now" than at the onset of the semester, a distinct subset remained in an exploratory phase, expressing a continued desire to investigate alternative fields. Notably, even among students who transitioned between engineering disciplines during the semester, confidence levels remained remarkably stable. This suggests that while specific career trajectories may have shifted, the students' underlying self-efficacy regarding their ability to make informed academic decisions was not diminished by the change in major.

Conversely, a significant increase was observed in student familiarity with professional roles and responsibilities ($W = 13, W_{crit} = 25, n = 15, p \leq 0.05$) as can be seen in Figure 3, alongside a notable expansion in their understanding of available career paths ($W = 9, W_{crit} = 10, n = 11, p \leq 0.10$) as can be seen in Figure 4. These results suggest that the integrated curriculum successfully broadened the cohort's professional literacy. While a portion of the participants attributed this cognitive growth to the foundational lecture series, the majority identified the hands-on, project-based learning (PBL) modules as the primary pedagogical driver for their increased comprehension as shown in Figure 5.

Figure 3: Shifting Levels of Familiarity Regarding Engineering Roles and Responsibilities; $n = 15$ denotes the subset of participants demonstrating a numerical change in scores

Figure 4: Shifts in Student Awareness of Available Engineering Career Trajectories; $n = 11$ **denotes the subset of participants demonstrating a numerical change in comprehension scores**

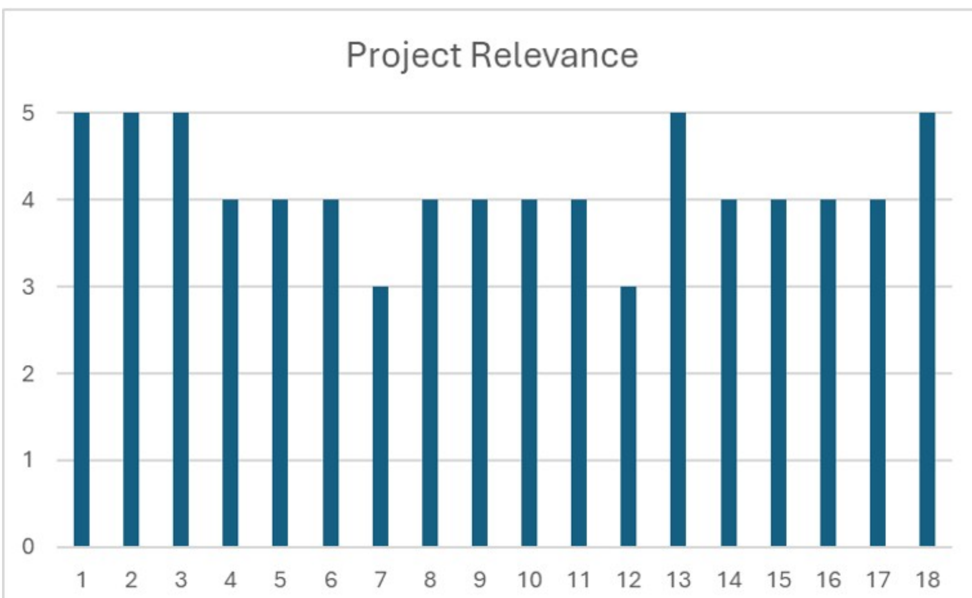

Figure 5: Student Perception of Pedagogical Drivers for Cognitive Growth; $n = 18$ **denotes the total number of participants responding via a 5-point Likert scale**

Interestingly, although most students reported that these interventions did not alter their final disciplinary preference, the projects served a critical role for those who did transition between majors. For this subset of students, the experiential components provided a necessary "deterring effect," facilitating a process of deductive reasoning that allowed them to systematically rule out specific disciplines that did not align with their interests or perceived strengths.

Conclusion

This study evaluated the impact of a first-year engineering curriculum that integrated a comprehensive disciplinary lecture series with hands-on project-based learning (PBL) modules. Quantitative analysis via the Wilcoxon Signed-Rank Test indicated that student confidence in their major selection and motivation to pursue engineering remained stable throughout the semester. This stability is attributed to a high baseline established during the initial lecture phase, where students were first introduced to professional licensure pathways, including the FE and PE exams, and disciplinary roles.

Qualitative findings from end-of-semester reflections demonstrated a significant evolution in student professional identity. Participants moved beyond a purely technical understanding of engineering to adopt a multi-dimensional definition that includes ethical standards, social responsibility, and managerial proficiency. The PBL modules ranging from structural bridge design to mechatronics served as critical pedagogical drivers, allowing students to reinforce theoretical knowledge and perform a "disciplinary filtering" process. For many, these experiences provided a necessary "deterring effect," helping them rule out specific branches that did not align with their interests or prior experiences in coding and mechanics.

Ultimately, the unified introductory course successfully equipped students with the professional literacy needed to navigate their academic trajectories. By fostering an environment where students can systematically align their personal values with the functional requirements of the profession, this program ensures that first-year engineers make intentional, evidence-based decisions regarding their future careers.

Future Work

Building upon the findings of this study, several avenues for future research have been identified to further enhance the efficacy of the first-year engineering curriculum:

- Longitudinal Tracking of Disciplinary Persistence: Future research will track this cohort through their sophomore and junior years to determine if the "intentional decision-making" and "disciplinary filtering" observed in the first year correlate with higher retention rates and academic success within their chosen majors.
- Expansion of Sample Size and Diversity: To move beyond the limitations of the current small sample size ($n < 30$), the study will be expanded to include multiple sections across different semesters. This will provide the statistical power necessary to perform parametric analyses and explore how demographic factors influence the "deterring effect" of hands-on projects.
- Investigating the Role of Prior Experience: Since a significant theme emerged regarding the positive impact of prior technical experience (e.g., coding or woodworking) on student engagement, future work will explore how to scaffold PBL modules to ensure students without such backgrounds achieve similar levels of self-efficacy and "affective engagement".

- Refinement of Quantitative Instruments: To address the observed “ceiling effect” in baseline confidence, the pre-test and post-test instruments will be refined to include more nuanced Likert-scale questions that better differentiate between general confidence and specific technical self-efficacy.
- Thematic Gap Analysis: Future research will task students with performing a formal gap analysis, requiring them to articulate how their personal values and innate strengths align with the functional requirements of specific engineering branches. This will provide a more granular look at the “disciplinary filtering” process observed in this cohort.
- Implementation of a Structured Reflective Framework: While the current study utilized formative end-of-day submissions, future iterations of the course will incorporate a formal longitudinal reflective essay. This intervention will require students to systematically document their evolving motivations by contrasting their matriculation-level perceptions of the field with their post-intervention realities.
- We acknowledge that the specific selection of hands-on activities (e.g., robotics vs. structural construction) may introduce ’activity bias,’ potentially steering student interest based on the perceived excitement of a module rather than the discipline itself. Future studies will assess activity neutrality.

References

[1] D. Raja and N. Schleper, “Wip: Evaluating the impact of multi-disciplinary projects on students’ engineering discipline choices,” no. 10.18260/1-2–57406. Montreal, Quebec, Canada: ASEE Annual conference & Exposition, June 2025.

[2] Y. Zhou and S. Shirazi, “Factors influencing young people’s stem career aspirations and career choices: A systematic literature review,” *International Journal of Science and Mathematics Education*, vol. 23, no. 7, pp. 2859–2918, 10 2025.

[3] A. C. Maltese and R. H. Tai, “Eyeballs in the fridge: Sources of early interest in science,” *International Journal of Science Education*, 2010.

[4] D. Lopatto, “Undergraduate research experiences support science career decisions and active learning,” *CBE life sciences education*, vol. 6, pp. 297–306, 02 2007.

[5] A. M. Singer, J. Mathews, and M. E. Jarvie-Eggart, “Understanding first-year engineering student definitions of systems engineering,” no. 10.18260/1-2–35781. East Lansing, Michigan, USA: ASEE First-Year Engineering Experience, July 2020.

[6] J. Zirnheld and A. Halstead, “Teaching new engineering students about the disciplines: A disciplinary or multi-disciplinary approach?” no. 10.18260/1-2-1153-50380. Washington D.C., USA: Spring ASEE Middle Atlantic Section Conference, April 2008.

[7] D. Kolb, *Experiential Learning: Experience As The Source Of Learning And Development*, 01 1984, vol. 1.

[8] P. M. N. Mariappan Jawaharlal and A. C. Shih, "A hands-on, first-year mechanical engineering course," in *2016 ASEE Annual Conference & Exposition*, no. 10.18260/p.26331. New Orleans, Louisiana: ASEE Conferences, June 2016, https://peer.asee.org/26331.

[9] P. M. N. Nolan Tsuchiya and M. Jawaharlal, "A student assessment of the value of a redesigned first year mechanical engineering orientation course," in *2017 Pacific Southwest Section Meeting*, no. 10.18260/1-2–29200. Tempe, Arizona: ASEE Conferences, April 2017, https://peer.asee.org/29200.

[10] L. Francis *et al.*, "Engaging first-year students with a hands-on course using student-driven projects," in *2019 ASEE Annual Conference & Exposition*, no. 10.18260/1-2–32718. Tampa, Florida: ASEE Conferences, June 2019, https://peer.asee.org/32718.

[11] J. D. Thompson *et al.*, "Designing a new holistic engineering program," in *2021 CoNECD*, no. 10.18260/1-2–36057. Virtual - 1pm to 5pm Eastern Time Each Day: ASEE Conferences, January 2021, https://peer.asee.org/36057.

[12] B. B. Terranova *et al.*, "Work in progress: Curriculum revision and classroom environment restructuring to support blended project-based learning in first-year general engineering laboratory courses," in *2017 ASEE Annual Conference & Exposition*, no. 10.18260/1-2–29147. Columbus, Ohio: ASEE Conferences, June 2017, https://peer.asee.org/29147.

[13] C. Loes, "The effect of collaborative learning on academic motivation," *Teaching and Learning Inquiry*, vol. 10, 01 2022.

[14] M. Shin, "Effects of project-based learning on students' motivation and self-efficacy," *English Teaching*, vol. 73, pp. 95–114, 2018.

[15] M. Laal and S. M. Ghodsi, "Benefits of collaborative learning," *Procedia - Social and Behavioral Sciences*, vol. 31, pp. 486–490, 2012, world Conference on Learning, Teaching & Administration - 2011. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1877042811030205

[16] R. W. Lent and S. D. Brown, "Integrating person and situation perspectives on work satisfaction: A social-cognitive view," *Journal of Vocational Behavior*, vol. 69, no. 2, pp. 236–247, 2006. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0001879106000169

[17] C. Carrico and C. Tendhar, "The use of the social cognitive career theory to predict engineering students' motivation in the produced program," 06 2012, pp. 25.1354.1–25.1354.13.

[18] T. Gupta, I. H. Yeter, and M. J. Khoo, "Linking undergraduate engineering students' outcome expectations, interests, career goals, self-efficacy, social support, and barriers in singapore: A social cognitive career theory study," no. 10.18260/1-2–43486. Baltimore, Maryland, USA: ASEE Annual conference & Exposition, June 2023.

[19] V. Dover, L. Fleming, D. Williams, and V. Quinones, "An examination of the use of social cognitive career theory to explore factors influencing the post baccalaureate decisions of

high achieving engineering students," no. 10.18260/1-2–4067. Pittsburgh, Pennsylvania, USA: ASEE Annual conference & Exposition, June 2008.

[20] N. A.-V. Hoose, *Educational Psychology*. Pressbooks, 2020, ch. Motivation.

[21] C. Bego, P. Thomas, X. Wang, and A. Dourado, "Investigating engineering persistence through expectancy value theory and machine learning techniques," no. 18260/1-2–41559. Minneapolis, MN, USA: ASEE Annual conference & Exposition, June 2022.

[22] P. B. Thomas, C. R. Bego, and A. D. P. Dourado, "Predicting student retention via expectancy value theory using data gathered before the semester begins," no. 10.18260/1-2–43930. Baltimore , Maryland, USA: ASEE Annual conference & Exposition, June 2023.

[23] Y.-k. Lee, E. Freer, K. A. Robinson, T. Perez, A. K. Lira, D. Briedis, S. P. Walton, and L. Linnenbrink-Garcia, "The multiplicative function of expectancy and value in predicting engineering students' choice, persistence, and performance," *Journal of Engineering Education*, vol. 111, no. •, pp. 531–553, Januray 2021.

[24] H. Matusovich, R. Streveler, H. Loshbaugh, R. Miller, and B. Olds, "Will i succeed in engineering? using expectancy value theory in a longitudinal investigation of students' beliefs," no. 10.18260/1-2–3593. Pittsburgh, Pennsylvania, USA: ASEE Annual conference & Exposition, June 2008.