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Boosting Innovation Self-Efficacy: The Role of Learning Coaches and Project Mentors in Innovation-Based Learning

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As a Ph.D. candidate enrolled in the University of North Dakota's Biomedical Engineering Program, I am actively engaged in an enriching Innovative-Based Learning (IBL) experience. Within this dynamic academic setting, I have undertaken a leadership role in groundbreaking research focused on Parkinson's disease, collaborating seamlessly with a diverse cohort of both online and in-person graduate and undergraduate students.

One of my greatest sources of satisfaction lies in leveraging my knowledge and skills to mentor undergraduate students, guiding them in the refinement of their research and professional capabilities. I take immense pride in fostering an inclusive and collaborative environment where students can thrive, encouraging their academic growth and contributing to the broader community of biomedical engineering scholars.

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Abstract

This study explores the impact of learning coaches on innovation self-efficacy (ISE) in undergraduate and graduate biomedical engineering students within an innovation-based learning (IBL) program. Innovation self-efficacy, or the belief in one's ability to successfully engage in innovation-related tasks, was measured using a validated Innovation Efficacy scale. The study further explores the effect of graduate students acting as learning coaches and project mentors. This work examines whether the learning coaches' guidance and support contribute to increasing innovation self-efficacy. The IES scale was modified to include role-specific items for students to rate how the coach and mentor contributed to their innovation self-efficacy.

Innovation-Based Learning (IBL) is an educational approach designed to foster origination, particularly in science, technology, engineering, and mathematics (STEM) disciplines such as biomedical engineering. Unlike traditional project-based learning, IBL focuses on solving open problems, identifying new challenges, and developing impactful solutions through complex, open-ended projects that require applying core engineering concepts while promoting creativity and critical thinking. This framework encourages collaboration, iterative development, and real-world application, helping students create value beyond the classroom. Through constant feedback and peer support, IBL cultivates a growth mindset and develops leadership skills through continuous feedback and peer support.

Learning coaches take on three key roles: one-on-one coaches, project mentors, and token reviewers. In the one-on-one role, learning coaches meet individually with each student for 20-30 minutes weekly, providing support and advice while facilitating thought-provoking conversations that encourage critical thinking and independent problem-solving. Rather than giving students direct answers, learning coaches help students build confidence in decision-making and engineering solutions. As project mentors, they attend weekly project team meetings to ensure that teams address real-world gaps, offer innovative solutions, and create meaningful impact. Token reviewers provide thoughtful and constructive feedback on students' work. All three roles aim to enhance students' capabilities and autonomy in innovation through structured support and experiential learning. This study explores the suggested impact of one-on-one and project mentor learning coaches on student ISE. The surveys were conducted before participants started working with Learning Coaches and Project Mentors and then again after one semester of coaching and mentoring.

The analysis suggests a positive trend in students' innovation self-efficacy scores after one semester of working with Learning Coaches. Comparison of pre-and post-survey data indicates a consistent increase in innovation self-efficacy, with early results showing potential statistical significance. The program's experiential learning and mentoring components may enhance students' confidence in performing innovation-related tasks.

The findings show that adding mentoring to IBL programs can help students tackle real-world challenges and lead innovation initiatives, leading to long-term professional and academic growth. Future work may include using learning analytics and educational data mining to analyze the impact of learning coaches and project mentors more effectively.

Introduction

Innovation-Based Learning (IBL) is an educational approach designed to equip students with critical skills for addressing real-world challenges [1]. Unlike traditional project-based learning (PBL), which often emphasizes theoretical applications, IBL fosters creativity, collaboration, and critical thinking through open-ended projects that address complex, real-world problems [2]. IBL encourages students to identify gaps in knowledge, propose innovative solutions, and iteratively refine their ideas to create meaningful value beyond the classroom. Integrating core engineering concepts with experiential learning, IBL aims to cultivate an innovation-driven mindset and leadership capabilities [3][4].

The importance of IBL in STEM education is evident as industries increasingly demand professionals who can creatively solve problems and innovate in rapidly changing environments [5]. Programs leveraging IBL frameworks emphasize interdisciplinary thinking, collaborative teamwork, and iterative development processes, all of which prepare students to succeed in addressing multifaceted global challenges. Additionally, IBL fosters self-directed learning and resilience, encouraging students to persist through uncertainty and complexity, which are hallmarks of innovation [6].

A key challenge in STEM education is fostering innovation self-efficacy (ISE), which is students' belief in their ability to perform innovation-related tasks successfully. ISE is critical because students with higher self-efficacy are more likely to take initiative, engage in innovative practices, and confidently lead complex projects [7]. However, traditional educational frameworks often lack the mentorship and experiential components necessary to develop ISE effectively [8]. Students may struggle with decision-making, problem-solving, and implementing creative solutions in professional settings without focusing on ISE [9]. Addressing this gap is essential for producing technically skilled graduates capable of leading innovation in diverse industries [10].

This study investigates how learning coaches, which have been implemented in a biomedical engineering program at the University of North Dakota, can bridge the gap in fostering innovation self-efficacy (ISE) within an IBL framework. Learning coaches play different roles, serving as either one-on-one or project mentors, each with distinct responsibilities to enhance students' abilities to engage in innovation. One-on-one mentors meet individually with students for 30 minutes each week. These sessions provide personalized support, addressing a wide range of student needs, including coursework challenges, problem-solving strategies, and professional development questions. The individualized nature of this mentorship allows learning coaches to tailor their guidance to each student's specific goals and challenges, fostering confidence and autonomy in their academic and professional pursuits. Project mentors attend weekly team meetings to guide collaborative innovation projects. They mentor student teams as they navigate the complexities of open-ended, real-world problems. By offering feedback on the feasibility and impact of proposed solutions and ensuring alignment with innovation objectives, project mentors help teams develop creative and practical solutions.

Learning coaches undergo a rigorous selection and training process overseen by faculty. Graduate students are identified and selected based on their demonstration of a growth mindset, entrepreneurial mindset, professionalism, strong communication skills, engagement, and punctuality. To be considered, candidates must have successfully completed a prior IBL course, where their abilities are assessed through class participation, presentations, and coursework. Faculty specifically look for students with a background in mentoring, communication, and leadership or those who have exhibited strong skills in these areas during their IBL experience. Once selected, learning coaches participate in weekly faculty-led meetings focused on mentoring strategies and professional development.

Structured guidelines and expectations are established during weekly meetings with faculty to ensure consistency in the quality of mentorship provided to the students. These meetings serve as a platform to review mentoring practices, share challenges, and provide standardized strategies for addressing common student needs. These meetings include reflective discussions and peer feedback, allowing coaches to align their approaches.

Together, these roles aim to build students' confidence in critical thinking, problem-solving, and decision-making by providing structured yet flexible mentorship. This multifaceted approach supports students in both individual growth and team-based innovation, contributing significantly to the development of ISE. Specifically, this research investigates whether students' interactions with learning coaches and project mentors significantly affect their ISE and ability to lead innovation-based initiatives. By analyzing pre- and post-survey data, this study quantifies the impact of mentorship on ISE and examines whether the effect varies depending on prior experience with learning coaches. Additionally, it explores the unique contributions of learning coaches in fostering undergraduate students' innovative capacities, providing valuable insights into the differential impact of mentorship, and informing scalable practices for educational institutions.

Methodology

This study was conducted in a biomedical engineering program utilizing an IBL framework. The pre- and post-surveys were adapted from Gerber et al.'s [11] Innovation Efficacy Scale (IES), a validated tool for assessing ISE. The adapted survey can be found in Appendix A. This scale evaluates dimensions such as creative problem-solving, interdisciplinary thinking, and confidence in decision-making. Minor modifications were made to ensure the surveys aligned with the study's objectives and the IBL program's context. The surveys were administered through the MOOCIBL platform, a blockchain-enabled software to facilitate learning and track innovation processes [12]. Students completed the survey at the beginning and end of a single semester. The platform ensured secure data collection and ease of access for participants.

The data collected from the pre- and post-surveys were analyzed using Microsoft Excel. Paired one-tailed t-tests were conducted to assess changes in students' ISE scores throughout the program, with statistical significance evaluated at a 95% confidence interval. Subgroup analyses were also performed to compare the pre- and post-scores for participants with and without prior experience with a one-on-one learning coach. The University's Institutional Review Board (IRB) approved the current study (IRB protocol #IRB0005373).

Results

A total of 87 students participated in the pre-survey. 14 students did not complete the post-survey and were excluded in the final analysis, resulting in a final sample size of 73 students. Among the participants, 21 were graduate students, and 52 were undergraduates, with the undergraduate group further categorized into 25 freshmen, 18 sophomores, 5 juniors, and 4 seniors. Of the 73 participants, 30 were online students, while 53 were in-person students. Additionally, 28 students had prior experience with a learning coach, while 45 did not. Lastly, 25 students reported previously working with a project mentor, while 48 did not. Table 1 provides a detailed breakdown of the participants in this study. All of the surveys for this study were completed online.

The pre-survey scores had a kurtosis of -0.3519 and a skewness of -0.0083, indicating a normal distribution. Similarly, the post-survey scores were normally distributed, with a kurtosis of -0.5606 and a skewness of -0.2346, supporting the use of a t-test. A paired t-test revealed a statistically significant increase in ISE scores between the pre- and post-surveys ($p = 8.733 \times 10^{-5}$), suggesting that the IBL program, facilitated by learning coaches and project mentors, positively impacted students' innovation self-efficacy.

Subgroup analyses were conducted to explore the differential impact of the IBL program based on participants' prior experience with learning coaches. A paired one-tailed t-test for students who had prior one-on-one learning coach experience indicated a marginally significant improvement in ISE scores ($p = 0.0504$). A paired one-tailed t-test for students without prior one-on-one learning coach experience showed a statistically significant improvement in ISE scores ($p = 0.0012$).

Additional subgroup analyses were conducted to compare pre- and post-survey scores across academic levels and course formats. A paired t-test for graduate students revealed no significant difference in ISE score ($p =0.308$), while undergraduate students showed a statistically significant difference in pre- and post-survey scores ($p = 5.22 \times 10^{-5}$). In-person students demonstrated a significant increase in ISE scores between pre- and post-surveys ($p = 0.000662$), whereas online students did not ($p +0.0647$). Further breakdown by academic year revealed that Freshman ($p = 0.0153$) and Junior ($p = 0.0190$), showed statistically significant difference in scores, however, Sophomores ($p = 0.246$), and Seniors ($p = 0.187$) did not.

Category	Participants (n)
Graduate Students	21
Undergraduate Students	52
Freshmen	25
Sophomores	18
Juniors	5
Seniors	4
Online Participants	30
In-Person Participants	53
Did not have learning coach before	45
Had learning coach before	28
Did not have project mentor before	48
Had project mentor before	25

Table 1. Participant Breakdown

Discussion

This study explored the role of learning coaches in fostering Innovation Self-Efficacy (ISE) among students participating in an IBL program. A statistically significant increase in ISE scores between the pre- and post-surveys suggests that the program positively impacted students' confidence in performing innovation-related tasks. The involvement of learning coaches, who provided structured guidance individually and in team settings, appears to have contributed meaningfully to this improvement. However, the study does not isolate the specific factors responsible for this increase, leaving room for other program components, such as team-based projects and experiential learning activities, to play significant roles.

The subgroup analyses provide additional insights into the differential impact of the program. Students without prior experience with one-on-one learning coaches showed a statistically significant improvement in their ISE scores, while students with prior experience exhibited a smaller, borderline significant increase. This finding suggests that the novelty of working with a one-on-one learning coach may play an important role in amplifying mentorship benefits for students new to such support structures. Conversely, students with prior one-on-one learning coach experience may already have benefitted from earlier mentoring, leading to smaller incremental gains. These results underscore the potential value of tailoring mentorship interventions to students' previous experiences to maximize their impact. However, there is still a significant increase, suggesting that LCs can have lasting impacts on students spanning more than one year.

Additional subgroup analyses comparing pre- and post-survey scores based on academic level and course format provide further context. A significant increase in ISE scores was observed for undergraduate students, while graduate students did not show a statistically significant change. This difference may indicate that undergraduate students, who are still developing foundational innovation skills, benefit more from the structured guidance provided by the program. In contrast, graduate students may have already developed higher levels of ISE before participation, leading to smaller observable changes.

Similarly, in-person students exhibited a significant improvement in ISE scores, while online students showed a more moderate change that did not reach full statistical significance. This discrepancy may be explained by online students' perceived barriers to ISE. While online students have access to many of the same educational content and instructional support as in-person students, they may feel disadvantaged due to reduced opportunities for hands-on engagement, such as labs, 3D printing facilities, and other on-campus innovation spaces that provide critical experiential learning opportunities. The absence of a fully significant change in their scores suggests that these perceived barriers could influence their engagement with the IBL program and their ability to develop innovation self-efficacy. Addressing these concerns through increased remote access to hands-on resources, virtual lab experiences, or hybrid learning options may help bridge this gap. Despite the presence of LCs, online students may still struggle to translate theoretical knowledge into applied innovation, suggesting that additional targeted interventions, such as more structured remote prototyping experiences or peer-led innovation challenges, could further support their development.

The results by academic year also provide important insights. While freshmen and juniors exhibited significant increases in ISE, sophomores and seniors did not. The lack of a significant change among sophomores may be attributed to the challenges associated with sophomore-year coursework in engineering programs, which is often considered a particularly difficult and demanding phase of the curriculum [13]. The rigor of sophomore-year coursework may contribute to increased academic stress and cognitive load, potentially limiting students' ability to fully engage with innovation-related experiences or perceive growth in their self-efficacy. Similarly, seniors may share some of the same characteristics as graduate students, for whom no significant difference in pre- and post-survey scores was observed. Seniors may already have well-established perceptions of their innovation capabilities, meaning the program may not have significantly altered their self-efficacy. These findings suggest that students at different stages of their academic journey may require targeted interventions to maximize the impact of IBL experiences on their ISE development. For these groups, the role of Learning Coaches may need to be adapted, providing more personalized interventions for sophomores to help them manage cognitive load and reinforcing stretch-goal challenges for seniors to push beyond their existing innovation capabilities.

The results align with existing literature on the benefits of mentorship in educational settings [14]. While one-on-one learning coaches and project mentors are central to providing targeted support, their contribution to ISE development likely operates synergistically with the program's broader experiential learning elements.

These findings highlight the value of integrating learning coaches into IBL programs to enhance students' innovation capabilities. Structured mentoring helps students confidently navigate the complexities of open-ended, real-world projects. Educational institutions may consider adopting similar mentoring frameworks to support students in developing essential 21st-century skills such as creativity, collaboration, and resilience.

Additionally, this study underscores the importance of creating holistic learning environments where mentorship complements other elements of the educational experience. By aligning the roles of learning coaches and project mentors with program objectives, institutions can provide students with a more cohesive and impactful learning journey.

Limitations

This study has several limitations that should be acknowledged. First, the reliance on self-reported survey data introduces the potential for response bias. Participants may have over- or under-estimated their ISE due to subjective perceptions. Second, the sample size of 73 participants, while sufficient for preliminary analysis, limits the generalizability of the findings. Third, the study does not include a control group, making it challenging to attribute changes in ISE specifically to the involvement of learning coaches and project mentors. Fourth, while weekly faculty-led meetings are currently used to ensure consistent quality of mentorship, there is not yet a fully standardized or quantifiable method for measuring the quality of mentoring provided.

Additionally, the statistically significant difference in ISE scores observed in students with prior learning coach experience highlights the need to further explore how mentorship interventions might benefit different student groups.

Future Research

Future studies should assess mentorship efficacy by exploring specific strategies used by learning coaches and project mentors, such as the quality of feedback, frequency of interactions, and alignment with program objectives. To build on the existing practice of weekly meetings with faculty, future research could aim to develop standardized metrics or frameworks to evaluate mentoring practices more systematically. This could include designing rubrics to measure mentoring quality, creating tools to track outcomes tied to mentoring practices, and leveraging student surveys to assess perceptions of mentoring effectiveness. Examining techniques like scaffolding, active listening, and open-ended questioning could provide deeper insights into how mentors foster critical thinking and autonomy. Research should also evaluate the structure and timing of mentoring sessions to identify best practices for enhancing ISE.

A critical area for future investigation is the comparison of IBL coaching with other forms of mentorship. While the results suggest that IBL coaching plays a role in fostering ISE, it remains unclear whether the benefits are unique to this model or whether they could also be achieved through interactions with experienced mentors in a more traditional setting. Since many mentors may not be familiar with IBL, future studies should compare IBL-based mentorship to a random intervention, such as a traditional mentorship program where students work with a mentor in a conventional academic or professional setting. Implementing a controlled study with a non-IBL mentorship group as a control would help determine whether the structured, innovation-driven approach of IBL coaching yields distinct advantages over more general mentorship strategies. This comparison could provide valuable insights into whether IBL-specific techniques enhance innovation self-efficacy beyond what is achieved through general mentoring relationships that emphasize guidance, career development, or academic support.

Given the importance of scalability in expanding IBL mentorship models, ongoing efforts to secure NSF funding aim to address these challenges and develop frameworks for large-scale implementation. Future research funded through these initiatives could provide critical insights into optimizing mentorship strategies across institutions and disciplines.

By addressing these research directions, future studies can refine our understanding of effective mentorship models, optimize the scalability of IBL coaching, and explore the broader applicability of mentorship-based interventions in fostering innovation self-efficacy across diverse academic and professional settings.

Conclusion

This study highlights the potential of structured mentorship within engineering education. By integrating learning coaches and project mentors into a collaborative, problem-solving framework, educational programs can help students build the confidence necessary to engage in innovation-driven tasks. While the overall results suggest a positive impact on ISE, the study highlights key areas for further exploration. Differences in outcomes based on academic level and course format suggest that mentorship interventions may not have a uniform effect across all student populations. Understanding how to tailor mentorship strategies to different student needs, whether based on prior experience, access to resources, or academic standing, will be critical for refining IBL-based mentorship models.

Beyond ISE, this approach has broader implications for cultivating key skills such as adaptability, interdisciplinary thinking, and resilience in STEM education. These attributes are critical for navigating a rapidly evolving world where innovation is essential for progress. Structured mentorship within IBL programs bridges theoretical knowledge and practical application, preparing students to thrive as future innovators.

This study also highlights the value of innovation-focused mentorship frameworks that extend beyond technical guidance to foster personal and professional growth. As educational institutions seek to remain relevant and impactful, leveraging such frameworks could prepare students to address real-world challenges creatively and confidently. These findings advocate for a renewed focus on mentorship as a cornerstone of transformative learning experiences, inspiring future efforts to refine and expand such initiatives.

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Appendix A: Innovation Self Efficacy Survey [11]

Demographic Information

Question	Options
Are you an undergraduate or graduate student?	Undergraduate, Graduate
If you are an undergraduate student, what year are you?	Freshman, Sophomore, Junior, Senior, N/A
If you are a graduate student, which program are you currently in?	Masters program, PhD program, N/A
What instructional setting do you mainly use?	Online, In person

Previous Learning Coach Experience

Question	Options
Have you previously had a 1-on-1 Learning Coach before the Fall 2024 semester?	Yes, I had a 1-on-1 LC last semester; No, this is my first semester having a 1-on-1 LC
Have you previously had a Learning Coach Project Mentor?	Yes, I had a Project Mentor on my project last semester; No, this is my first semester with a Project Mentor

Confidence Rating Section In the following section, please rate your degree of confidence that you can do each activity listed below on a scale from 0 to 5. (0 being not at all confident and 5 being extremely confident.)

Activity	0	1	2	3	4	5
Understand the needs of people by listening to their stories						
Find connections between different fields of knowledge						
Seek out information from other disciplines to inform my own						
Identify opportunities for new products and/or processes						
Question practices that others think are satisfactory						
Come up with imaginative solutions						
Make risky choices to explore a new idea						
Consider the viewpoints of others/stakeholders						
Evaluate the success of a new idea						
Apply lessons from similar situations to a current problem of interest						
Envision how things can be better						
Do things in an original way						
Set clear goals for a project						
Troubleshoot problems						
Keep informed about new ideas (products, services, processes, etc.) in my field						
Communicate ideas clearly to others						
Provide compelling stories to share ideas						

Learn by observing how things in the world work						
Solve most problems if I invest the necessary effort						
Be resourceful when handling an unforeseen situation						
Suggest new ways to achieve goals or objectives						
Test new ideas and approaches to a problem						
Share what I have learned in an engaging and realistic way						
Make a decision based on available evidence and opinions						
Relate seemingly unrelated ideas to each other						
Think of new and creative ideas						
Model a new idea or solution						
Find new uses for existing methods or tools						
Explore and visualize how things work						

Rating Scale: 0 - Not at all confident
1 - Slightly confident
2 - Somewhat confident
3 - Moderately confident
4 - Very confident
5 - Extremely confident