Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
ASEE
Paper ID #47366

Enhancing Lab Learning and Graduate Aspirations with Multi-Level Mentorship and Vertically Integrated Projects in Research Groups: A Case Study

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Abstract
This case study presents an integrated mentorship model within a mechanical engineering research group to enhance engineering education and training through peer-led learning and collaborative laboratory projects. The faculty advisor oversees PhD candidates, who mentor masters students, who in turn guide undergraduates, creating a continuum of knowledge transfer, leadership development, and task accountability. Integrated lab projects connect all levels, fostering collaboration and communication while addressing real-world engineering challenges. This structure motivates undergraduates to pursue graduate studies by providing hands-on research experience and demystifying pathways to advanced degrees. Initial findings reveal improved student performance, satisfaction, and academic ambition, highlighting this model's scalability and potential impact on laboratory-based disciplines.

Introduction

Practical laboratory training is a cornerstone of engineering education, bridging the gap between theoretical knowledge and practical skills while preparing students for real-world challenges. Research groups can provide essential environments for fostering such learning, where students develop key competencies in discipline-specific knowledge, problem-solving, teamwork, and leadership [1], [2]. Burt [1] highlights the transformative potential of research groups in shaping graduate students' academic trajectories and professional identities, mainly through structured mentorship and collaborative practices.

Vertically integrated projects (VIPs) model a robust framework for engaging undergraduates in meaningful project activities, such as research. As Snyder [3], Fowee-Gasaway *et al.* [4], and Strachan *et al.* [5] describe, VIPs connect students across undergraduate levels, allowing undergraduates to participate in long-term interdisciplinary projects embedded in faculty research. This structure creates a seamless mentorship continuum where more experienced peers guide newcomers, fostering collaboration and academic growth [3-5]. Additionally, Sonnenberg-Klein and Coyle [6] demonstrate that sustained involvement in VIP teams not only enhances leadership skills but also exposes undergraduates to the demands and rewards of graduate-level research. Based on the demonstrated benefits in undergraduate development, this model provides a practical framework for managing these research groups.

The integration of undergraduates into research environments through structured mentorship and problem-solving frameworks is particularly effective in motivating them to pursue advanced studies. Greer *et al.* [7] emphasize the role of inquiry-driven lab projects in connecting academic theories with real-world applications, cultivating the critical thinking and metacognitive skills essential for graduate-level education and aligning with Carstensen and Bernhard's [2] findings on using design science research to refine engineering education methodologies. Mentorship models further enhance this trajectory by fostering a supportive ecosystem. Karkoub *et al.* [8] and Rieg *et al.* [9] demonstrate how peer-led research projects encourage undergraduates to see their contributions as part of a larger academic continuum, building confidence in their capabilities and aspirations. Additionally, Schneider *et al.* [10] show that mentorship in STEM education improves motivation and skill development, which are critical for building the undergraduate-to-graduate pathway.

Furthermore, the areas of social psychology, sociology, and management research have developed a body of work describing the most effective leaders as those who do not micromanage but instead build capacity, autonomy, and purpose in their teams. For instance, Amundsen and Martinsen [11] reported that effective leadership centers on empowering employees and removing barriers to their success. By fostering autonomy and supporting independent decision-making, empowering leadership enhances motivation, engagement, and performance. Relatedly, Zhang and Bartol [12] found that empowering approaches also stimulate employee creativity by boosting intrinsic motivation and psychological ownership. A meta-analysis by Llorente-Alonso *et al*. [13] of 94 studies observed that empowerment positively impacts job satisfaction, commitment, performance, organizational citizenship, and overall well-being and mental health, also reinforcing the value of obstacle removal and autonomy in leadership. Arnold *et al.* [14] found that transformational leaders who connect employees to meaningful work promote both higher performance and better psychological well-being. These perspectives provide further grounding for the operation of the mentorship structure within this research group case study.

This paper introduces an integrated mentorship structure within a research group context, leveraging the VIP framework to empower and motivate undergraduate students toward graduate studies, and to develop leadership and management skills in graduate students. By embedding undergraduates in vertically integrated teams, this approach demystifies the path to advanced degrees, providing a supportive and inspiring environment. Initial findings from a research group in a mechanical engineering department suggest that this model not only improves academic performance and leadership skills but also increases the likelihood of undergraduates continuing to graduate education.

Case Study: Mechanical Engineering Lab

The lab we will focus our case study on is located in the department of mechanical engineering at a flagship U.S. public state university, and focuses on the design and development of microscale and nanoscale devices and structures. The lab's research spans across materials development and characterization, multiscale micro/nano device development and packaging, and applied mechanics, drawing from a diverse range of disciplines such as chemistry, physics, and mathematics. This multidisciplinary approach allows the lab to explore both fundamental scientific insights and manufacturable innovations. Current areas of interest include bistable compliant mechanisms, multi-scale manufacturing and materials characterization, automation of laboratory processes, engineered surface properties, and geometric nonlinearity in mechanics.

Since the lab's inception in 2017 the lab has provided research opportunities to 24 undergraduate students, 12 master's students and 3 PhD Students. The lab is equipped with materials testing and characterization tools, including a nanoindenter, tensile tester, and laser confocal scanning microscopy, which support research in device development, applied mechanics, and materials analysis. Students also use computational tools including CAD design software (Onshape and SolidWorks), simulation software (COMSOL, ANSYS, and the open-source FEniCS package), and programming languages such as Python and MATLAB for data processing, firmware, middleware, and GUI development. The findings presented below are based on survey responses from 16 participants who have been involved in the lab, reflecting their experiences and outcomes within the mentorship framework.

Methods:

The mentorship structure in this case study is a multi-level, vertically integrated framework designed to maximize knowledge transfer, leadership development, and student retention in engineering research environments. It consists of three hierarchical academic levels, Figure 1: PhD students, masters students, and undergraduate researchers, all under the supervision of a faculty advisor. This structure emphasizes both technical knowledge dissemination and the cultivation of professional skills such as communication, leadership, and project management.

Roles and Responsibilities

In this hierarchy, the advisor plays a pivotal role in guiding the overall direction of the group's research activities. They provide overarching guidance, set deliverables and deadlines for all members, find and secure funding and other resources, and oversee the group's overall progress. While the advisor determines the focus areas for each PhD student and ensures their work aligns with the group's research goals, the day-to-day supervision and workload distribution for each student fall under the responsibility of their immediate mentor within the group framework. The PhD students, under the direct supervision of the advisor, work independently on their research projects. Additionally, they provide mentorship to master's students, helping refine their research goals, develop technical skills, and troubleshoot challenges. Similarly, the master's students take on their research projects while mentoring undergraduate students. This mentorship includes guiding technical problem-solving, research methods, and professional development. In cases where an undergraduate student's research interests or skills align more closely with a specific PhD student, they may work directly under that PhD student's guidance. This framework fosters effective collaboration across all levels and ensures optimal alignment of skills and goals.

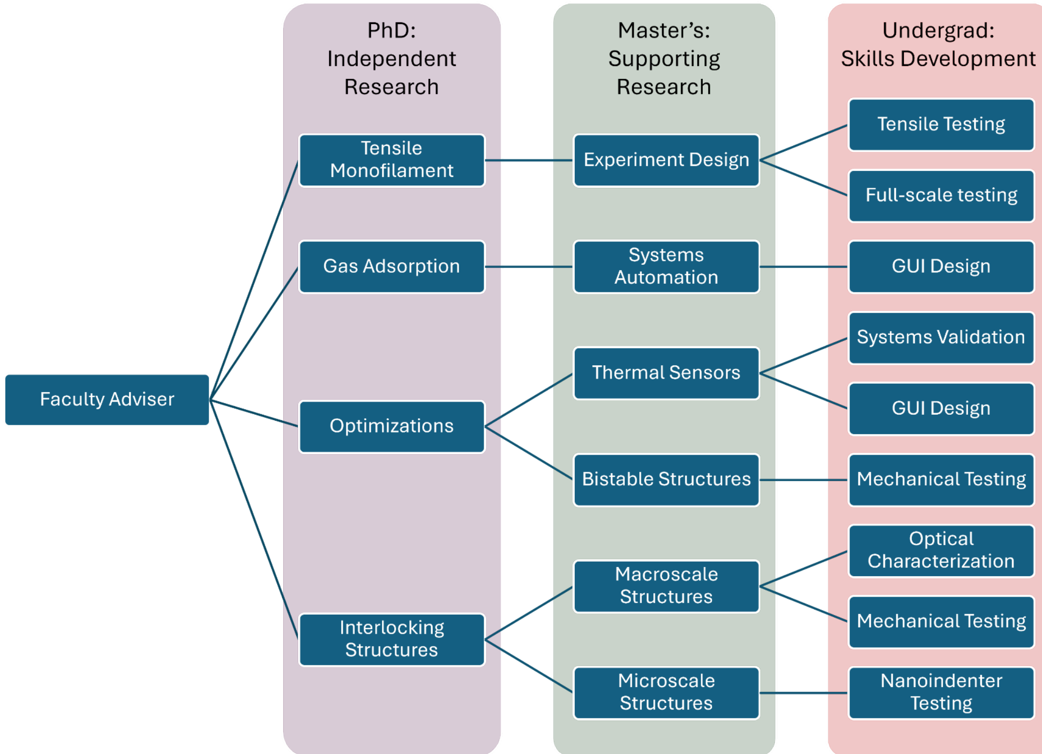

Figure 1: Hierarchical mentorship structure in a mechanical engineering research group working in areas related to multiscale engineering, applied mechanics, and applied materials. The faculty advisor guides PhD students in independent research, who mentor master's students on supporting tasks. Master's students mentor undergraduates focused on skills development, fostering collaboration and knowledge transfer across academic levels.

Collaboration and communication are essential to maintaining group cohesion. Regular communication includes weekly lab meetings (mandatory for graduate students, optional but recommended for undergraduate students), as-needed check-ins with the advisor during the semester, and end-of-semester individual development reviews between graduate students and the faculty mentor to discuss progress and address any potential challenges. In the end-of-semester reviews, before meeting with the faculty supervisor, graduate students are prompted (more information in Appendix) to review their accomplishments and plan the steps and actions to be performed before their next review. These draft individual development plans are finalized in one-on-one discussion with the faculty supervisor. These practices ensure alignment with the group's goals, provide timely feedback, and help all members stay on track with their deliverables. Furthermore, the practice of students planning their own goals, within a supervised environment, helps to support students' motivation and buy-in for the work plan, and also supports accountability and more realistic planning when the students fall short of the goals they set for themselves.

Conflict resolution occurs hierarchically within the group. Smaller challenges, such as workload distribution or communication issues, are initially addressed by the immediate mentor. For example, undergraduate students raise concerns with their master's student mentor, and master's students consult their PhD mentor. If an issue remains unresolved, it is elevated to the advisor, who acts as the final arbiter and mediator for significant challenges. This structure ensures that conflicts are resolved promptly while minimizing disruptions to workflow.

Integrated Lab Projects

Within the multilevel mentorship framework, vertically integrated lab projects provide the foundation for success. Undergraduate students focus on foundational tasks, such as data collection, basic prototyping, and experimentation, under the guidance of more experienced peers, mentors, and faculty. Master's students take on more specialized roles, working on deeper analysis, system integration, and applying more advanced methodologies. PhD students are responsible for the high-level research and innovation, contributing original ideas and strategies, advanced simulations, and complex problem-solving techniques. The involvement of students across different academic stages allows for a comprehensive approach to problem-solving, as the team works together to test, refine, and enhance their solutions iteratively. It also provides a comprehensive learning experience where students gain exposure to the entire lifecycle of an engineering project, from concept to implementation, while building experience in participating in teams and in managing the work that they and others perform. A surprising observation of this structure is that it has allowed the group to pursue project opportunities that are shared among the group members rather than allocated to just one graduate student.

Design Principles

The multilevel mentorship framework balances six principles that reenforce knowledge transfer and student engagement. Knowledge transfer is supported at each level by (1) collaborative learning and mentorship as undergraduate students are exposed to the hands-on application of practical and academic knowledge. Defining (2) clear roles based on students' academic levels ensures that each student works on tasks aligned with their expertise, helping them develop relevant skills while avoiding overwhelm or underutilization. Emphasizing the importance of (3) effective communication and thorough documentation at every project stage helps students improve technical writing, presentation skills, and the ability to articulate complex ideas. Student engagement supported by an (4) iterative approach of prototyping, testing, and refining keeps students actively engaged as they learn how to adapt designs based on real-time feedback, building resilience and adaptability throughout the project. Furthermore, aligning the project with (5) real-world challenges and collaborating with external stakeholders enhances the relevance of the project, ensuring students engage with practical, industry-relevant problems. Lastly, allowing students to adapt the project as new challenges arise encourages (6) flexibility, motivating students to pivot, refine their approach, or incorporate new technologies based on emerging insights or changing project parameters.

Implementation Strategies

To successfully implement an integrated lab project with undergraduate, masters, and PhD students working together, we first establish a structured project framework, Figure 2. Similar to most research groups, overarching projects usually derive from funded grants and other initiatives, although we also make use of other project funding (the University's undergraduate research opportunity funds, NASA Space Grant funds, graduate student fellowships) to support projects that may be more directly aligned with students' particular abilities and interests. Definition of student roles within a project requires clear project milestones, timelines, and deliverables, tempered through clarifying roles and specific tasks based on the students' academic levels, interests, and skill sets. The project should be broken into phases such as design, prototyping, testing, and evaluation, with specific tasks assigned to each level of student. Additionally, providing and confirming access to necessary resources and tools ensures that students have the equipment, software, and training they need to complete their tasks effectively. A collaborative platform should also be set up for shared record-keeping and progress tracking, reinforcing transparency and organization throughout the project. Accountability is maintained through weekly student presentations to others in the group regarding progress towards the project goals, and the semiannual individual development plan review discussed earlier.

Mentorship and supervision are key components of successful multi-level collaborations. PhD students should be assigned as mentors for master's and undergraduate students, offering guidance and insight based on their advanced expertise, and perspectives based on past experience overcoming routine obstacles. The faculty member must oversee the entire project, ensuring it adheres to academic rigor and industry standards, and engage with students to develop strategies to address significant challenges. To facilitate teamwork and foster knowledge transfer, cross-level collaboration is encouraged, with students from different academic stages contributing their unique strengths. Regular presentations and peer reviews should be incorporated into the project schedule, where students can share their progress, receive constructive feedback, and refine their ideas based on team discussions.

Integrating research and practical application is the next important aspect of the project. PhD students should lead the theoretical and research-intensive tasks, while master's and undergraduate students focus on hands-on prototyping, data collection, and testing. This combination of theoretical depth and practical implementation ensures that students gain understanding of fundamental concepts and real-world applications. The project should follow an agile, iterative approach where design and testing are continuously refined based on feedback from test results. Moreover, industry/external stakeholder engagement provides students with valuable real-world context, which demonstrates the relevance and impact of their work.

Finally, planning for scalability and future impact ensures the project's long-term relevance. Students should be encouraged to think beyond the immediate scope of the project, considering how their work could scale, apply to future research, or have broader societal impact. Assessing and documenting learning outcomes at every stage ensures that students not only develop technical skills but also gain professional growth in areas like communication, problem-solving, and leadership. By carefully tracking progress and reflecting on the project's impact, the team can ensure that both the project and the students benefit from a comprehensive and meaningful learning experience.

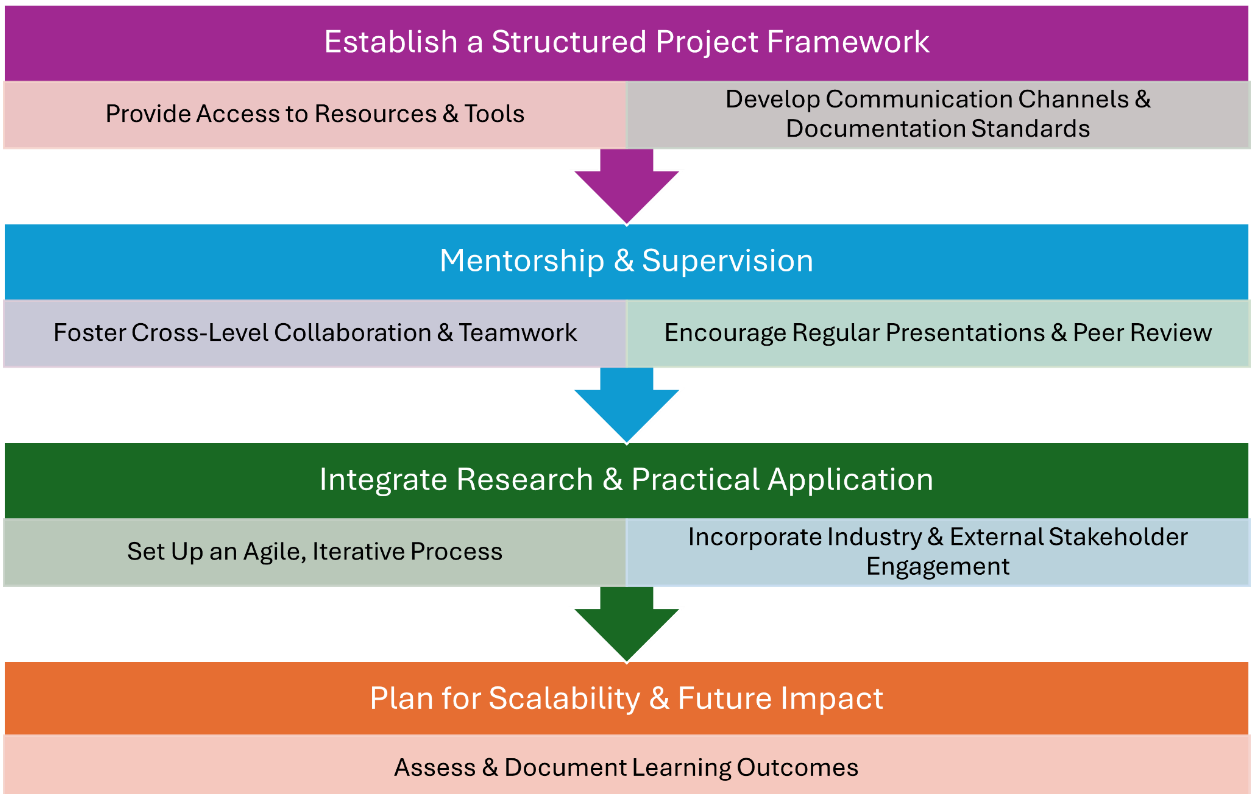

Figure 2: Framework for implementing multi-level mentorship and vertically integrated projects in research groups. The framework emphasizes establishing a structured project foundation, fostering mentorship and cross-level collaboration, integrating research with practical applications through iterative processes and industry engagement, and planning for scalability and future impact by assessing and documenting learning outcomes.

Educational Outcomes & Impact Assessment

The multilevel mentorship framework's success can be measured through a comprehensive evaluation of skill development, graduation aspirations, and student engagement. The project provides a dynamic learning environment where students at all levels are mentored, challenged, and engaged. By tracking key metrics associated with the six design principles, the framework's impact can be effectively assessed, ensuring it contributes meaningfully to the educational experience of students across academic levels.

The multilevel mentorship framework provides a robust structure for fostering skill development, aligning graduation aspirations, and ensuring student engagement. To evaluate the educational outcomes of the framework, several key metrics can be applied across these dimensions. The first key outcome is skill development, which is primarily measured through the depth and breadth of knowledge transfer at each academic level. Undergraduate students, through collaborative learning and mentorship, gain hands-on experience, applying both practical and academic knowledge in real-world scenarios. To assess this, metrics such as the number of technical tasks completed, the complexity of problems solved, and the development of specific skills (e.g., prototyping, data analysis, experimental design) can be tracked. Additionally, student self-assessments and faculty evaluations can provide qualitative insights into the development of practical and academic skills.

Academic and professional impact are supported by defining clear roles and responsibilities for students at different academic levels, ensuring each student works on tasks aligned with their expertise. This approach helps students focus on developing career-specific competencies and contributes to their progression toward graduation. Metrics for evaluating this outcome could include the successful completion of assignments aligned with their academic level, the number of students advancing to higher-level roles as the project progresses (e.g., from data collection to system integration), and the alignment of project contributions with career objectives and academic goals. Tracking graduation rates, post-graduation employment or further study placements, and student feedback on how the project helped shape their career goals are useful metrics for assessing the impact on graduation aspirations.

Student engagement is a critical component of the framework and can be assessed through both quantitative and qualitative metrics. The iterative nature of projects, with constant prototyping, testing, and refinement, keeps students actively engaged in their learning journeys. This can be measured through the frequency and quality of feedback sessions, the number of revisions or design changes made throughout the project, and the level of student initiative in problem-solving tasks. Engagement is also fostered by aligning projects with real-world challenges and collaborating with external research groups, institutions (government laboratories and researchers at other universities), and other stakeholders (e.g. local industry). Evaluating engagement can include metrics such as the number of external interactions (e.g., industry webinars, guest lectures, site visits), student involvement in these engagements, and their ability to apply industry-relevant feedback into the project. Furthermore, the flexibility and autonomy built into the framework encourages students to pivot and adapt as new challenges arise.

Evaluation Framework

Evaluation of the multilevel mentorship framework in this case study is based on survey responses from a sample size of twelve current and four past members (*i.e.* 16 individuals total) of the lab spanning student engagement since 2018. The survey, provided in the Appendix, is designed to investigate the effectiveness of the model in promoting skill development, academic growth, and student engagement. The survey is structured to assess various dimensions of the lab experience, focusing on both individual student development and the effectiveness of the mentorship framework. It is divided into several sections, with questions tailored to different aspects of the lab environment, including educational background, research experience, mentorship effectiveness, and student engagement. The survey begins by inviting participants to describe their primary research and specific technical skills developed. Additionally, the survey includes questions related to the clarity of role definitions, the alignment of projects with real-world engineering problems, and the frequency of interactions with peers from various academic levels, faculty, and industry professionals.

Further, the survey assesses the broader impact of participation in the lab, exploring students' confidence in pursuing independent research, further education, and collaborative work in interdisciplinary teams. Participants are also asked to rate the effectiveness of the mentorship framework, which is structured hierarchically with faculty providing guidance and senior students mentoring newer lab members. Questions related to the structure of mentorship, including the quality of peer interaction and mentorship support, aim to gather insights on how well students feel supported in their academic and professional growth. Finally, the survey concludes with open-ended questions, allowing students to provide qualitative feedback on their experiences, challenges encountered, and suggestions for improvements. This structure enables a comprehensive evaluation of both the lab's operational effectiveness and its impact on students' educational and professional development. It is important to acknowledge that such small sample sizes limit the opportunity for truly anonymous responses and introduce an inherent positive bias.

Preliminary Findings

We report preliminary findings in four areas that present the clearest metrics to assess mentorship framework based on the survey results:

1. Frequency of interaction with peers of various academic levels and industry professionals.
2. Student interest in pursuing further education before and after participating in the framework.
3. Student perception of role clarity and task assignment.
4. Student perception of the impact participation in the framework has had on their educational confidence.

Interaction Frequency:

Students were asked to report the frequency of their interactions with peers from other academic levels as well as industry professionals while participating in the mentorship framework. Responses, Figure 3, indicate at least weekly interaction with students and professors of various levels and rarer, but still common interaction with industry professionals.

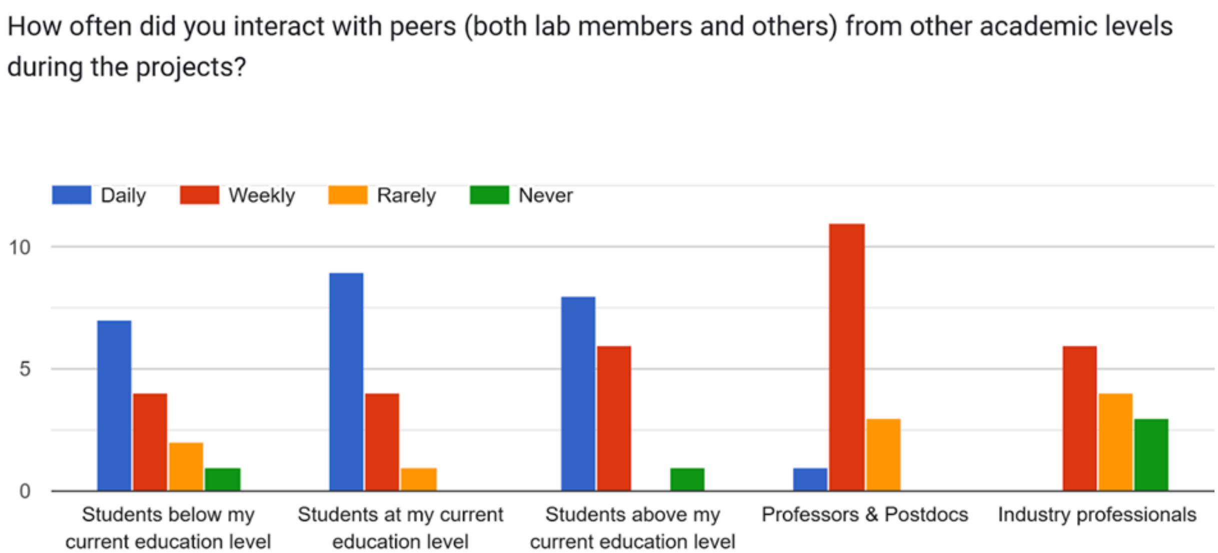

Figure 3: Student responses to a question regarding the frequency of interaction with other students at different education levels and with industry professionals.

Interest in Further Education:

Students were asked to report their interest in pursuing further education before and after participating in the mentorship framework. Comparison of the results shows an increase from 33% of students that were already interested in further education, to over 73% after some time in the framework, as shown in Figure 4. This result is reported as an after-the-fact result, rather than comparison of data before and after participation, but suggests potential effectiveness of the mentoring framework.

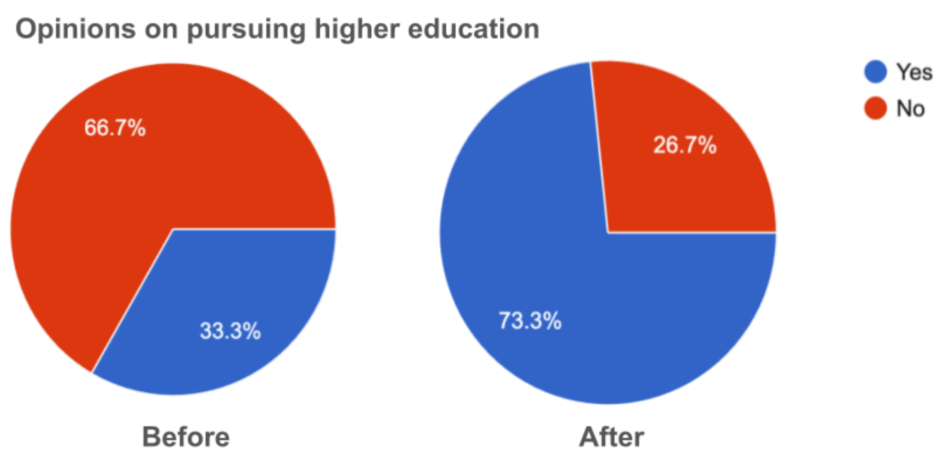

Figure 4: Comparison of students' interest in pursuing graduate studies before and after participating in the lab described in the case study. The first pie chart shows students' initial interest in higher education (graduate school for undergraduates and PhDs for master's students), while the second chart reflects their interest after engaging in lab activities, illustrating the lab's impact on academic aspirations.

Role Clarity:

Students were asked directly how clearly they perceived their assigned roles and responsibilities within the framework, Figure 5. Responses to this question were overwhelmingly positive. However, when given the opportunity to suggest improvements to the framework, several students asked for additional structure, which indicates room for improvement in this area.

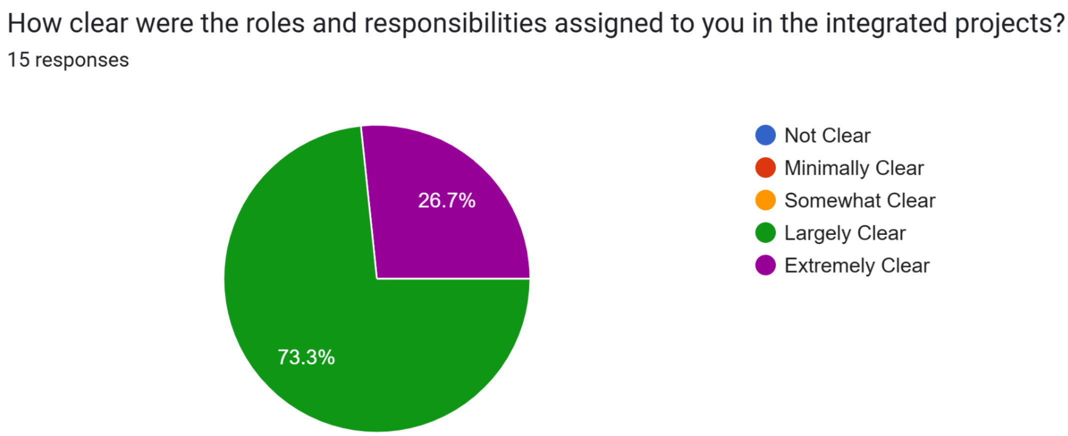

Figure 5: Student responses describing the clarity with which they perceived their roles and responsibilities within the mentorship framework. A total of 73.3% of students report that their roles are largely clear and 26.7% of students report that their roles are extremely clear.

Educational Confidence:

Students were asked to rate the impact of the mentorship program in four areas of educational confidence, Figure 6. Strong positive impact was reported for students' confidence to participate in group research and interdisciplinary teams which indicates a positive trend in interpersonal skills development. More moderate positive impact is reported for increases in confidence to pursue individual research and further education. No negative impacts in these areas are reported.

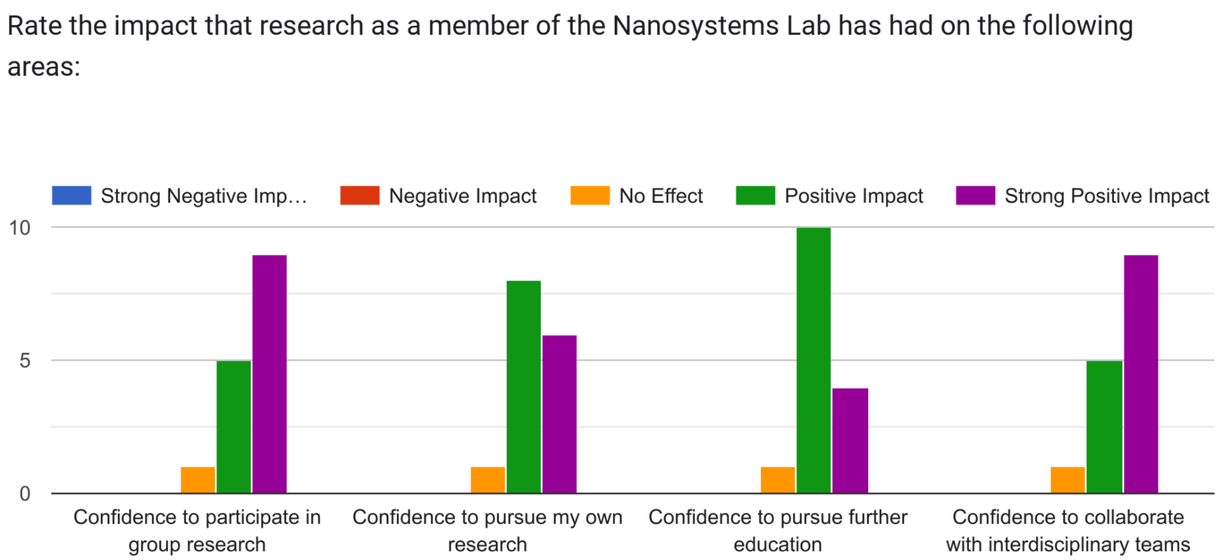

Figure 6: Student responses on the impact of the mentorship framework on academic confidence in four areas: group research, individual research, further education, and interdisciplinary collaboration. Fourteen of fifteen respondents reported a positive to strong positive impact in all categories.

Discussion of Findings

Respondents reported that the mentorship framework significantly enhanced their ability to understand theoretical concepts through practical application, particularly through the collaborative learning opportunities provided by students at different academic levels. Technical skills development, such as proficiency in prototyping, data collection, and experimental design, was frequently highlighted as a key outcome of their participation in the lab. Additionally, students noted a marked improvement in their ability to conduct independent research, with undergraduates and master's students specifically acknowledging the clear roles and responsibilities assigned within the integrated projects. These roles, aligned with real-world engineering problems, provided students with hands-on experience that was directly relevant to industry applications.

In terms of student engagement and career aspirations, the mentorship framework was found to foster strong peer interactions across academic levels, which facilitated the transfer of knowledge and experience. Survey respondents expressed high levels of confidence in pursuing further education, with many undergraduates reporting an increased interest in graduate school as a result of their involvement in the lab. Masters students also noted that the mentorship provided by PhD students and faculty played a pivotal role in guiding their academic and professional development. Students reported that the lab's structure, with the faculty adviser providing overarching guidance and experienced students mentoring newer members, positively influenced retention, graduation success, and encouraged many to consider pursuing further graduate studies. Furthermore, feedback indicated that participation in structured research and mentorship helped students engage more deeply with their coursework, enhancing retention and application of course material. The survey also revealed areas for improvement, with students suggesting increased opportunities for direct industry engagement and clearer communication regarding project expectations. Overall, the mentorship framework's impact on both academic and professional growth was seen as a critical factor in shaping the students' educational trajectories and career plans.

Conclusion

The responses highlight a key opportunity for improvement: while the mentorship framework is largely effective, many students are asking for greater clarity in role definitions and structured guidance. This feedback underscores a natural hurdle of the framework, which deliberately challenges students to step outside the traditional academic structure and develop flexibility, self-motivation, and independence by planning their own goals, under the supervision of mentors. However, this flexibility can sometimes leave students uncertain about their responsibilities and direction. To address these concerns, the framework could benefit from additional structure, such as more formal opportunities for students to present their research to the group, explicitly assigned mentorship roles to specific student pairs, and clearer task delegation at the start of each semester. These adjustments would ensure that mentorship responsibilities are distributed evenly, reducing reliance on a single individual and fostering a sustainable system that can continue seamlessly as current senior members graduate.

The multilevel mentorship framework presented in this case study demonstrates a robust approach to fostering student growth, skill development, and academic engagement through vertically integrated projects. By structuring projects across varying academic levels, the framework promotes effective knowledge transfer, encourages hands-on learning, and provides tailored mentorship to match each student's capabilities. Outcomes of the multilevel mentorship model include more than 2X increase in students' interest in continuing education and a positive impact on educational confidence in general. This model not only enhances technical proficiency and problem-solving abilities but also cultivates a deeper interest in pursuing advanced education, particularly for undergraduates considering graduate studies. Through its combination of collaborative learning, interdisciplinary engagement, and real-world problem alignment, the framework has proven to be an effective strategy for both academic and professional development, ensuring that students are well-equipped for future challenges in research and industry.

The ASEE Engineering Leadership Development Division (LEAD) has adopted four strategic initiatives: **inform, design, explore, and assess**. [15] To these ends, this case study has been provided to **inform** the broader community of an effective framework for student empowerment and leadership training within the context of a research group, and has provided an example **assessment** of student leadership development within this framework.

Acknowledgment
The authors would like to thank all current and former members of the research group for their invaluable contributions and insights, which were instrumental in this study. Your dedication to collaboration, mentorship, and innovation has greatly advanced the lab's mission and impact. Thanks also to the ASEE reviewers and to others (Prof. Tyler Ray, UH-Mānoa; Nanosystems group members) who provided feedback on this manuscript.

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Appendix:
Part 1. Lab Student Outcomes Survey
Demographic Information: *Student Background*

1. What level of education are/were you as a lab member?
    - Undergraduate, Master's, PhD, Post Graduate Research
2. How long were you a member of the Lab?
3. Please give a short description of your primary research as a member of the Lab.
4. How would you describe your project(s)?

Technical Knowledge and Skill Development: *We wish to evaluate the effectiveness of the VIP mentorship framework for developing student technical skills.*

5. How effective has the mentorship framework been in helping you understand theoretical concepts through practical application?
    - (Not Effective, Minimally Effective, Somewhat Effective, Largely Effective, Extremely Effective)
6. What specific technical skills have you developed as part of this framework?
7. How much has your ability to conduct independent research improved since joining the framework?

    (No Improvement, Minimal Improvement, Some Improvement, Large Improvement, Extreme Improvement)
8. What technical tools/methodologies have you used? (Check all that apply)
    - One or more materials characterization tools, manufacturing tools/techniques, software for data processing, software for simulation, experimental design methodologies

Project Coordination and Engagement: *We wish to evaluate the effectiveness of the VIP mentorship framework for developing student soft skills.*

9. How clear were the roles and responsibilities assigned to you in the integrated projects?
    - (Not Clear, Minimally Clear, Somewhat Clear, Largely Clear, Extremely Clear)
10. Were the integrated projects aligned with real-world engineering problems? (Yes, very much; Somewhat; No)
11. Give a short description of the real-world application (or lack thereof) of your project.
12. How often did you interact with peers (both lab members and others) from other academic levels during the projects?
    - (Daily, Weekly, Rarely, Never – across different education levels and roles such as professors, postdocs, industry professionals)
13. Please describe any challenges you faced in coordinating with other team members from different academic levels.

Academic and Professional Impact:

14. Prior to joining the Lab, were you previously interested in further graduate studies?
15. For undergrads: Did working in the lab increase your interest in graduate school? For master's students: Did it increase your interest in a PhD?
16. How much has your confidence in pursuing additional education improved?
    - (Not Improved, Minimally Improved, Somewhat Improved, Very Improved, Extremely Improved)
17. Rate the impact that research as a member of the Lab has had on the following areas:
    - (Confidence to participate in group research, pursue own research, pursue further education, collaborate with interdisciplinary teams – Rated from Strong Negative Impact to Strong Positive Impact)
18. How likely are you to recommend the group to other students?
    - (Not Likely, Minimally Likely, Somewhat Likely, Very Likely, Extremely Likely)
19. Please describe how being a member of the Lab has affected you academically and/or professionally.

Perceived Outcomes:

20. Has participating in structured research and mentorship in the Lab enhanced your engagement with (and retention of) course material?
21. Which aspects of the mentorship framework have contributed to your growth as a student?
    - (Check all that apply: Faculty oversight, mentorship from PhD/master's students, collaborative projects, real-world problem focus, contributing to research above current level, providing mentorship to others)
22. What specific outcomes or achievements have resulted from your participation in this program?

Framework Feedback:

23. Rate the effectiveness of the mentorship framework in the following areas:
    - (Student retention, successful graduations, encouraging further studies, knowledge transfer/skills development – Rated from Not Effective to Extremely Effective)
24. What specific aspects of the program were most inspiring or fulfilling for you?
25. What improvements or changes would you suggest for the mentorship framework?
26. How did the structure of this framework influence your academic and professional growth?
    - (Please describe any specific ways it provided clarity or support in guiding your development)

Additional Information:

27. Is there anything else that you would like the survey authors to know?

Appendix:

Part 2. Semiannual Progress Review Worksheet

This worksheet is reviewed twice a year by the faculty mentor and each graduate student. The graduate student prepares initial responses, and then these responses and the student's proposed plans are reviewed with the faculty mentor.

Semiannual Progress Review and Individual Development Plan (IDP)

- May/June and December
- *Purpose: Review past 6 months' individual student progress and plan important goals for next 6 months*

Progress Review

Review vs. general expectation for graduate students:

- Progress towards graduate degree (List overall milestones completed, *e.g.* credits, qualifying exam, etc.):
- Progress on research project, including planning and following plan (List research highlights, progress, and accomplishments):
- At least 1 publication per year if supported as RA (List start date and number of publications):
- Good grades in courses (List courses and grades):

Review versus previous 6-month goals:

Significant challenges or obstacles, if any:

Planning

Scheduling and planned time off:
Financial and course plans:
Goals for next 6 months:

Research:

Writing:

Degree progress:

Development of other areas (teaching, mentoring, leadership, oral communication, career development, community):

Additional supportive actions, if necessary: