Embedding Research and Innovation in Undergraduate Education: Lessons from the URaD Program

Dr. Haidar Harmanani, Lebanese American University

Haidar Harmanani received the B.S., M.S. and Ph.D. degrees in Computer Engineering from Case Western Reserve University, Cleveland, Ohio, in 1989, 1991 and 1994, respectively. He is currently a professor of computer science and the Dean of the School of Arts and Sciences at the Lebanese American University. His research interests span high-level synthesis, design automation, parallel computing, machine learning, and applied artificial intelligence. Throughout his career, he has led and contributed to multiple institutional initiatives in academic program development, accreditation, research infrastructure, and strategic planning. Dr. Harmanani has published extensively in the areas of design automation and optimization techniques for hardware–software systems, and he has supervised numerous graduate and undergraduate research projects in computing and data-driven systems.

Dr. Sandra Rizk, Lebanese American University

Sandra Rizk is Professor of Biology and Associate Dean of the School of Arts and Sciences at the Lebanese American University. She earned her PhD in 2000 from the Institute of Biomedical Life Sciences at the University of Glasgow, UK. She joined LAU in 2004 and has held several academic leadership roles, including Assistant Dean and Director of the Honors Program and the Freshman Arts and Sciences Programs. She is also the founding director of the LAU Honors Program, the first program of its kind in the MENA region. Her research spans intracellular trafficking and cancer chemoprevention, and she has supervised numerous graduate and undergraduate research projects in molecular and cellular biology, with a particular focus on cancer-related research.

Dr. George E Nasr, Lebanese American University

Dr. George E. Nasr has been Provost at the Lebanese American University (LAU) since 2018, following his tenure as Dean of the LAU School of Engineering. He holds a Ph.D. in Electrical Engineering from the University of Kentucky and has published extensively on energy modeling and engineering education. He is an active member of IEEE and ASEE and serves on various international educational committees.

Embedding Research and Innovation in Undergraduate Education: Lessons from the URaD Program

Abstract

Undergraduate research is widely recognized as a high-impact educational practice; however, many students, particularly at teaching-focused or Master's-level institutions, enter research experiences without adequate preparation in research design, methodology, ethics, and scholarly communication. This paper presents the Undergraduate Research and Discovery (URaD) Scholar Program, a selective, one-year initiative implemented at the School. URaD integrates scaffolded, transcript-recognized, zero-credit High-Impact Experience (HIE) courses with mentored, discipline-specific research projects. Students engage in engineering and engineering-adjacent work that emphasizes methodological rigor, analytical reasoning, and applied problem-solving. Grounded in experiential learning theory and transferable skill development frameworks aligned with engineering education outcomes, the program addresses research-readiness gaps while fostering interdisciplinary engagement. Mixed-methods evaluation data demonstrate strong early indicators of impact: 100% student satisfaction and recommendation rates, proposal presentation scores exceeding 8.5/10 across all criteria, and sustained engagement through mid-year evaluations. The paper concludes by discussing implications for engineering education and the scalability of the URaD model.

1 Introduction

Undergraduate research has been repeatedly identified as a high-impact educational practice that enhances student learning, retention, and persistence into graduate study and professional careers. In engineering education and related STEM fields, undergraduate research is closely linked to the development of problem-solving skills, ethical reasoning, teamwork, and communication competencies aligned with accreditation outcomes. However, access to meaningful undergraduate research remains uneven, and many students enter research environments without sufficient preparation in research literacy, methodology, or scholarly communication. At institutions classified as Master's Colleges and Universities, faculty often balance significant teaching loads with research expectations, limiting the scalability of traditional apprenticeship-style undergraduate research. These constraints are particularly evident in interdisciplinary schools that house engineering-adjacent disciplines such as engineering, computer science, natural science, and data-oriented social sciences. The Undergraduate Research and Discovery (URaD) Scholar Program was conceived to address this challenge: how can institutions systematically prepare undergraduates for research while maintaining rigor, equity, and disciplinary breadth?

2 Background and Related Work

Extensive literature documents the benefits of undergraduate research experiences (UREs), including gains in critical thinking, disciplinary identity, and persistence in STEM fields [1, 2]. Engineering education scholarship emphasizes UREs' role in fostering design thinking, systems reasoning, and professional skill development aligned with accreditation outcomes. However, recent work highlights structural challenges limiting equitable access, particularly gaps in faculty preparation. Foust [3] notes that many faculty mentor based on their own graduate experiences rather than evidence-based practices. Effective mentorship requires establishing clear expectations, balancing guidance with autonomy, and embedding reflection throughout research [3, 4], underscoring the need for formal programs at Master's-level institutions where teaching loads limit traditional apprenticeship models [5].

Institutional innovations demonstrate diverse approaches to democratizing research access within resource constraints. Adams and Cuarenta-Gallegos [6] implemented a student-driven, Arduino-based framework at a community college, achieving significant gains in research confidence through a nine-month timeline of literature review, experimentation, and symposium presentation. Hassler et al. [7] paired first-year S-STEM scholars with faculty mentors, with professional development workshops increasing faculty willingness to mentor from 3.2 to 4.3 on a 5-point scale. Course-Based Undergraduate Research Experiences (CUREs) offer another scalable model. Yan et al. [8] evaluated CURE implementation at an HBCU, finding increased STEM interest but identifying needs for enhanced collaborative skills, scientific communication, and career exploration components to address tensions between research immersion and career commitment.

3 Program Design and Implementation

3.1 Institutional Context

The University is a private institution classified as a Master's College and University with a strong liberal arts foundation. The School houses diverse disciplines that intersect with engineering education through applied research, data analysis, health sciences, and innovation-driven inquiry. URaD is a selective, one-year program open to junior-level undergraduates preparing to enroll in capstone or undergraduate research courses. Selection is based on faculty recommendation, a statement of research interest, and demonstrated academic readiness.

3.2 Participant Profile

The inaugural cohort in Summer 2025 included 25 applicants, of whom 22 juniors were accepted and 21 completed the program. While the cohort was intentionally interdisciplinary, engineering majors constituted the largest group of participants and engaged in mentored projects aligned with ABET outcomes, as reflected in strong proposal and mid-year evaluation scores in methodology and analytical reasoning.

3.3 Application and Selection

Students submit a faculty recommendation, 300-word research-interest statement, and current GPA. A cross-disciplinary faculty committee reviews for readiness and diversity of interests.

3.4 Curriculum Structure and Timing

The one-week intensive runs as a summer session, in the last week of June. Courses are taught by a rotating team of 8 faculty (engineering, computer science, natural sciences, writing center, library) to mirror the interdisciplinarity.

3.5 Curriculum Structure

The program delivers an intensive one-week sequence of transcript-recognized, zero-credit High-Impact Experience (HIE) courses that operationalize George Kuh's High-Impact Practices (HIPs) [9], particularly undergraduate research, followed by year-long mentored research. The curriculum includes:

HIE 310: Literature Search and Review (3 hours) focuses on developing search strategies, using bibliographic and citation management tools, and synthesizing information into coherent literature reviews.

HIE 320: Research Methods (4 hours) guides scholars through planning and designing research studies. The course begins with common theoretical frameworks before splitting into discipline-specific parallel sessions addressing methodological considerations.

HIE 330: Writing a Research Proposal (3 hours) covers identifying research problems, evaluating ethical considerations, selecting methodologies, and presenting expected outcomes.

HIE 340: Effective Communication (3 hours) enhances verbal and nonverbal communication skills, public speaking abilities, and presentation techniques for research dissemination.

HIE 350: Power of Artificial Intelligence in Research (3 hours) introduces AI tools for literature reviews, data organization, and academic writing, emphasizing ethical use and effective prompting strategies.

HIE 399: Innovation, Entrepreneurship, and Pitching (4 hours) covers the innovation process, elevator pitches, and startup fundamentals including business models and impact assessment.

Following the intensive curriculum, students work with faculty mentors to develop research proposals, present at proposal defense sessions, deliver mid-year progress reports, and conclude with final presentations at the University's Research Day.

Table 1: Proposal Presentation Evaluation Summary

Criterion	Average (out of 10)	Standard Deviation
Background and Rationale	9.15	1.25
Research Question and Objectives	9.01	1.18
Methodology	8.83	1.58
Clarity and Organization	8.89	1.44
Visual Aids	8.84	1.45
Delivery and Engagement	8.78	1.50
Response to Questions	8.49	1.57
Time Management	9.27	1.15

4 Results

4.1 Evaluation Methods

A mixed-methods evaluation framework assessed program outcomes through post-program student surveys (n=22), standardized proposal presentation rubrics evaluating eight criteria, and mid-year progress evaluation rubrics assessing four key dimensions. Descriptive statistics summarized quantitative data, while thematic analysis identified patterns in qualitative responses.

4.2 Student Satisfaction and Program Impact

Post-program evaluation revealed exceptionally high satisfaction, with 100% of respondents indicating they would recommend URaD to peers. Qualitative feedback emphasized faculty mentorship quality, interdisciplinary engagement, effective communication training, and practical introduction to ethical AI tools as transformative program elements. Students particularly valued the shift from passive lecture formats to interactive engagement. Representative comments included: ”URaD has been a transformative milestone in my academic journey,” ”It gave us permission to ask the kinds of questions that usually go unspoken,” and ”I loved the dense schedule used. It made me more motivated and focused.” Students appreciated learning ”knowledge that it takes years to accumulate over just a one week’s period.” Suggestions for improvement centered on three areas: extending program duration from one to two weeks to reduce intensity, increasing discipline-specific content, and providing more hands-on practice with citation management tools and proposal drafting.

4.3 Proposal Presentation Outcomes

Proposal presentations were evaluated using a standardized rubric across eight criteria. Average scores exceeded 8.5 out of 10, indicating strong proposal-stage readiness (Table 1).

Highest performance was observed in time management (9.27) and background and rationale (9.15). Moderate variability in methodology and response to questions reflects expected developmental differences at the proposal stage.

Table 2: Mid-Year Progress Evaluation Summary

Criterion	Average Score (out of 10)	Standard Deviation
Communication & Presentation Skills	8.54	0.76
Understanding Research Topic & Methodology	8.80	0.57
Results Progress & Troubleshooting	8.52	0.69
Reasoning (Analysis & Q/A)	8.61	0.62

4.4 Mid-Year Progress Outcomes

Mid-year evaluations demonstrated sustained engagement and effective transfer of preparatory learning into active research practice. Average scores ranged from 8.52 to 8.80 out of 10 across four criteria (Table 2).

Understanding of research topic and methodology emerged as the strongest area (8.80, SD=0.57), reflecting solid conceptual grounding. Communication and presentation skills showed greatest variability (0.76), suggesting differences in delivery styles and visual effectiveness. These results indicate URaD scholars are on positive trajectories toward research completion.

5 Discussion

5.1 Program Effectiveness and Key Success Factors

Findings demonstrate that structured, transcript-recognized preparation effectively addresses undergraduate research readiness gaps. The combination of intensive skill-building followed by mentored research successfully bridges the transition from classroom learning to independent inquiry. Several elements emerged as critical to success: interdisciplinary engagement fostering cross-pollination of ideas, intensive one-week format creating focused immersion, contemporary tool integration (particularly ethical AI applications), and faculty mentorship paired with structured curriculum.

5.2 Implications for Engineering Education

For engineering and closely related STEM students, URaD directly addresses three well-documented gaps: (1) limited formal training in research design prior to the capstone experience [1]; (2) underdeveloped scholarly communication and ethical reasoning skills, competencies reflected in ABET Student Outcomes 3 (effective communication) and 4 (professional and ethical responsibility); and (3) insufficient exposure to interdisciplinary collaboration. URaD can be positioned as a “pre-capstone accelerator” that enhances proposal quality (see Table 1) while reducing faculty mentoring demands during the senior year. The model is particularly well suited to Master’s-level institutions seeking to expand undergraduate participation in experimental, computational, and empirical research without substantially increasing faculty workload.

URaD also responds to critiques of narrow, exclusionary definitions of “rigor” in engineering education [10].The program broadens who counts as “ready” for research without sacrificing disciplinary standards by embedding structured preparation in ethics, communication, and interdisciplinary methods.

5.3 Scalability, Sustainability, and Refinements

The URaD model appears scalable across institutional contexts. Its modular HIE structure allows customization while maintaining core competencies, and the zero-credit, transcript-recognized format provides meaningful incentive without adding degree requirements. Replication costs remain accessible across a range of institutional budgets, as faculty load is light, roughly one week of intensive instruction plus six to eight mentoring hours per student, and modest stipends limit financial burden. Future cohorts can grow to 40–50 participants by introducing parallel discipline-specific tracks in the afternoons while preserving the interdisciplinary morning sessions that give the program its integrative character. Student feedback has also identified clear opportunities for refinement: extending the intensive curriculum to two weeks would reduce cognitive load, increasing hands-on practice would strengthen skill transfer, and formalizing discipline-specific content tracks would address tensions between breadth and depth. Longitudinal outcome tracking is planned, with particular attention to graduate school placement, peer-reviewed publications, and transitions into industry research roles.

6 Conclusion

The URaD Scholar Program represents an intentional, institutionally embedded approach to undergraduate research readiness that addresses documented gaps in student preparation while maintaining accessibility across disciplines. Early evidence supports its effectiveness in developing research competencies, fostering interdisciplinary collaboration, and preparing students for independent inquiry. The program's relevance extends beyond traditional research-intensive institutions, offering a model for Master's-level universities and teaching-focused colleges seeking to strengthen undergraduate research cultures. Future work will examine longitudinal outcomes, including research productivity, graduate school enrollment, and career trajectories. Refinements based on student feedback will be implemented in subsequent cohorts. The model's potential for adaptation across institutional contexts warrants further exploration and dissemination within the engineering education community.

References

[1] Elaine Seymour, Anne-B Hunter, Sally L. Laursen, and Tina DeAntoni. Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study. *Science Education*, 88 (4):493–534, 2004. doi: 10.1002/sce.10131.

[2] Susan H. Russell, Mary P. Hancock, and James McCullough. Benefits of undergraduate research experiences. *Science*, 316(5824):548–549, 2007. doi: 10.1126/science.1140384.

[3] Emine Foust. Effective mentoring practices for undergraduate research. In *2025 ASEE Annual Conference & Exposition*. American Society for Engineering Education, 2025. Paper ID #45618, Board #160.

[4] William B. Johnson, Laura L. Behling, Pamela Miller, and Maureen Vandermaas-Peeler. Undergraduate research mentoring: Obstacles and opportunities. *Mentoring & Tutoring: Partnership in Learning*, 23(5): 441–453, 2015. doi: 10.1080/13611267.2015.1126167.

[5] Vicki L. Baker, Laura Gail Lunsford, and Meghan J. Pifer. Systems alignment for comprehensive faculty development in liberal arts colleges. *To Improve the Academy*, 34(1-2):91–116, 2015. doi: 10.1002/tia2.20029.

[6] Elizabeth A. Adams and Gabriel Cuarenta-Gallegos. Community college undergraduate research using a student-driven and student-centered approach. In *2024 ASEE Annual Conference & Exposition*. American Society for Engineering Education, 2024. Paper ID #41416.

[7] Ryan Scott Hassler, Rungun Nathan, Marietta Scanlon, and Catherine L. Cohan. Cultivating curiosity: Faculty insights on mentoring s-stem undergraduate researchers. In *2025 ASEE Annual Conference & Exposition*. American Society for Engineering Education, 2025. Paper ID #48133, Board #349.

[8] Jing Yan, Lin Li, and Ivan T. Mosley. NSF HBCU-UP implementation program: Enhancing STEM education for underrepresented students through course-based undergraduate research at HBCUs. In *2025 ASEE Annual Conference & Exposition*. American Society for Engineering Education, 2025. Paper ID #45452.

[9] George D. Kuh. *High-impact educational practices: What they are, who has access to them, and why they matter*. Association of American Colleges and Universities, 2008.

[10] Donna Riley. Rigor/us: Building boundaries and disciplining diversity with standards of merit. *Engineering Studies*, 9(3):249–265, 2017. doi: 10.1080/19378629.2017.1408631.