Work-In-Progress: Exploring the Impact of REU Program: Students' perceptions of research skills and graduate school motivation

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Abstract

This Work-in-Progress (WIP) paper explores how participation in a Research Experience for Undergraduates (REU) program at Texas A&M University shapes students' perceptions of their research experiences and considerations toward graduate education in Materials Science and Engineering (MSEN) and related disciplines. While REU programs are widely implemented and associated with gains in research skills and professional development, prior work has primarily emphasized outcome-level measures rather than how students interpret their experiences during the research process. The study explores undergraduate participants' perspectives following their participation in an MSEN-focused REU program involving experimental and computational research projects. A multi-method approach was used, incorporating qualitative analysis of open-ended reflections with descriptive analysis of post-program Likert-scale survey responses with each data source analyzed independently. Data was collected from seven participants using pre- (one open-ended reflection prompt) and post-program survey that included 22 Likert-scale items and open-ended reflection prompts. Findings indicate that participants described increased clarity regarding the nature of research, greater confidence in engaging with research tasks, and more informed perspectives on pursuing graduate-level education. Participants also reflected on their roles within research environments and the expectations associated with graduate study. Reflections also indicated that students perceived growth in their preparedness for graduate-level research and engagement with materials science research. In addition, participants reported increased perceived understanding of materials science and engineering concepts and a stronger sense of professional identity as emerging engineers. These findings are presented as exploratory and reflect participants' self-reported interpretations rather than objective or generalizable outcomes. This study contributes to ongoing discussions on undergraduate research by highlighting how students make meaning of their REU experiences, offering insights to inform future theory-driven and assessment-oriented investigations.

Introduction

Research Experiences for Undergraduates (REU) programs engage undergraduate students in authentic, mentored research and are designed to strengthen pathways to graduate education in engineering and related fields [1]. Since their establishment by the National Science Foundation [2], REU programs have aimed to broaden undergraduate students' participation in research through mentored, hands-on experiences from diverse institutions [1].

While studies demonstrate that REU participation is associated with gains in research skills, professional readiness, and interest in graduate education, they primarily emphasize outcome-level measures and program design features [3], [4], [5]. However, existing literature tends to examine outcomes such as research skills, professional readiness, and graduate school interest largely as end-point measures or as separate constructs. Fewer studies explicitly capture how students interpret and make sense of these outcomes as they develop during the research process, particularly through integrated accounts of their REU experiences.

Addressing this gap, this Work-in-Progress study investigates the following research question: How do undergraduate students describe their REU experiences in relation to perceived research skills, professional readiness, and perspectives on pursuing graduate education in materials science and related engineering disciplines?

Literature Review

Undergraduate research experiences, such as Research Experiences for Undergraduates (REU) programs, have been widely studied for their role in supporting students' development of research skills, professional competencies, and interest in graduate education. Prior studies report that participation in REU programs contributes to students' ability to engage in key research practices, including experimental design, data analysis, and scholarly communication [3], [6], [7]. Prior studies also highlight students' development of technical research skills. For example, Du [3] reported that students engaged in interdisciplinary REU projects developed core research competencies, including theoretical modeling, experimental design, data analysis, and scholarly communication, while also gaining confidence in conducting independent research.

Along with technical skill acquisition, REU participation has been shown to influence students' professional readiness [7], [8]. Also, comprehensive REU models in the literature emphasize not only disciplinary research training but also the development of students' professional skills, such as communication, teamwork, and planning [8]. These competencies are often developed through structured instructional mechanisms, including seminars, workshops, and collaborative projects [6].

Beyond skill development, REU programs have been shown to influence students' perspectives on pursuing graduate education and research-related careers. Several studies report that students who participate in REU programs demonstrate increased interest in graduate school and improved clarity regarding academic and professional pathways [4], [5], [9]. For example, some studies report increased student interest in pursuing graduate education and research careers following REU participation [4]. Empirical findings from multi-year REU sites indicate that a substantial proportion of participants reported increased interest in graduate school following their research experience. For instance, Hung et al. [5] found that participants in a micromanufacturing-focused REU program demonstrated strong intentions to pursue graduate education or research careers. Programs that cultivate community through peer collaboration, research dissemination events, and sustained mentor engagement have been shown to reinforce students' identification with research careers [4].

In the context of Materials Science and Engineering (MSEN), laboratory and research-based learning environments play a central role in supporting student learning. Prior work in MSEN education has examined how laboratory courses are designed to facilitate conceptual understanding and skill development through various instructional approaches, including in-person laboratories, computational laboratories, and project-based learning environments [10]. These learning environments are often grounded in theoretical frameworks such as the Processing–Structure–Properties–Performance (PSPP) framework and Experiential Learning Theory (ELT), which emphasize the integration of conceptual knowledge with hands-on experience [6], [10]. Furthermore, laboratory-based and project-based environments provide

students with opportunities to actively engage in the research process, supporting the development of both technical and professional competencies in engineering contexts [6], [10].

While prior research has established the benefits of REU participation and the effectiveness of structured learning environments in engineering education, these studies often focus on outcome-level measures or examine constructs such as skills, readiness, and career interest. Less attention has been given to how students interpret and make sense of these outcomes as they develop during participation in research programs. There is a need to examine how students describe their experiences within research environments and how they perceive the development of their skills, readiness, and future educational goals within a single REU context. Addressing this need, the present study explores how undergraduate students describe their REU experiences in relation to perceived research skills, professional readiness, and perspectives on pursuing graduate education in materials science and related engineering disciplines.

Research Design

This study used a multi-method research design to examine undergraduate students' perceptions of their research experiences within Texas A&M University's Multifunctional Materials REU program. The design incorporates both qualitative and quantitative approaches to capture participants' perspectives, with each method analyzed independently. This multi-method approach allows for a broader understanding of participants' experiences while maintaining analytical separation between data sources. The study is exploratory in nature and does not aim to establish causal relationships or statistically generalizable findings.

REU Program and Participants

The study was conducted at Texas A&M University as part of an NSF-funded REU program focused on Multifunctional Materials within the MSEN program. Data were collected from seven undergraduate participants enrolled in the REU program. The REU program provides undergraduate students with mentored, authentic research experiences, with an emphasis on recruiting students from institutions that do not offer a MSEN major. The program's Multifunctional Materials theme is reflected in the diversity of research projects available to participants, spanning advanced semiconductors, energy and space materials, shape-memory alloys, and MXenes.

Participants were eligible for the study upon admission to the REU program and provided informed consent. Recruitment occurred during mandatory orientation sessions at the beginning of the program and again during the concluding week. Participation was voluntary and had no impact on students' standing in the REU program. Following approval from the university's Institutional Review Board, consent was obtained electronically prior to data collection.

Measurement and Data Collection

Data were collected using pre- and post-experience surveys administered at the beginning and end of the REU program. In the pre-experience survey, participants responded to one open-

ended question describing their expectations for the REU program. In the post-experience survey, participants completed one open-ended reflection question focused on how the REU met their expectation. In addition, the post-experience survey included 22 Likert-scale questions rated on a seven-point scale (0 = strongly disagree to 6 = strongly agree) assessing participants' perceptions of their research experience (16 questions) and prospects for graduate study (6 questions). All surveys were administered electronically via a secure platform. Participants were informed that they could skip any question and withdraw at any time without penalty. Table 1 shows a sample set of questions that were included in the surveys.

Table 1: Sample questions and self-reported items included in the pre- and post-experience surveys

Question Type	Survey Type	Question
Open Ended Questions	Pre-Experience Survey	Please describe your expectations for this summer research program.
	Post-Experience Survey	Please describe how the REU program met your expectations.
Likert Scale Survey (Self-Reported)	Post-Experience Survey	I understand the nature of the job of a researcher
		I understand how to conduct a research project
		I am aware of career paths of the faculty in the program (how they got to where they are now).
		I am confident in my research skills generally.

Data Analysis

Qualitative data consisted primarily of open-ended responses from pre- and post-experience surveys. Analysis was conducted using an inductive thematic approach. All responses were first read in full to develop familiarity with the data. Open coding was conducted based on participants' written responses to the open-ended survey questions [11], with codes capturing salient ideas related to participants' expectations, research experiences, and perceived outcomes of the REU program. Codes were iteratively reviewed and refined to identify emergent themes that were not fully represented by the initial coding categories[11]. Quantitative survey items were used descriptively to contextualize qualitative findings rather than to support inferential statistical analysis. All analyses were conducted on anonymized data.

Results

Analysis of participants' pre-experience and post-experience survey responses yielded three analytic themes that describe how participants interpreted their REU experiences. These were

“Understanding the Nature of Research”, “Gaining Hands-On Research Experience” and “Exploring Graduate School Intentions”.

Theme 1: Understanding the Nature of Research

Prior to the REU program, participants commonly expressed curiosity about the nature of academic research and a desire to gain independent research experience. Several students emphasized that they wanted to work on their own projects rather than assisting on others’ work, with one participant stating, “I expect to gain more independent experience by working on my own project rather than helping out with someone else’s project.” For participants with limited or no prior research exposure, the REU was viewed as an opportunity to understand “what research is all about” and to gain insight into the research lifecycle.

Post-experience reflections indicated that these expectations were largely fulfilled through sustained ownership of individual research projects. Participants described engaging in research responsibilities that aligned with their expectations and provided a realistic understanding of academic research. One participant noted, “I was performing the research I expected with responsibilities that did not surprise me,” while another reflected, “I was basically a summer graduate student; my work was just as important as those pursuing graduate degrees.” These experiences contributed to a clearer understanding of research as an intensive, responsibility-driven process.

Theme 2: Gaining Hands-On Research Experience

Participants entered the REU with expectations centered on gaining hands-on experience with research practices and building confidence through active engagement. Several responses highlighted the desire to learn how to conduct research independently and apply technical knowledge in practice, including one participant who stated, “To learn more and get experience with what it is like to do research.”

Following the program, participants frequently described increased confidence in their ability to conduct independent research. Reflections emphasized applying technical expertise to real-world problems and contributing meaningfully within research groups. One participant shared, “I was able to apply my technical expertise to a real-world, innovative project,” while another noted that the experience “increased my self-efficacy as a researcher.” These reflections suggest that hands-on engagement and project ownership served as key mechanisms supporting the development of research self-efficacy.

Theme 3: Exploring Graduate School Intentions

Participants also entered the REU program with the intention to evaluate their interest in pursuing graduate education. Pre-experience responses reflected uncertainty about readiness and fit for advanced study, with one participant stating, “I really want to figure out if pursuing a PhD is meant for me and if I can handle research.”

Post-experience reflections indicated that participation in graduate-level research activities helped participants make more informed judgments about graduate school. Several students described gaining exposure to expectations typical of graduate research environments, including long work hours, technical responsibilities, and professional development activities. One participant noted that the program provided “a lot of professional development and introduction to graduate school,” while another described the experience as “throwing me in

the deep end to immerse myself in my work." However, some participants also expressed tension between research activities and program deliverables, noting that overlapping deadlines and reporting requirements contributed to perceived workload intensity.

Building on the qualitative findings, descriptive post-experience survey results are presented to summarize patterns in participants' perceived research and professional development outcomes across measured domains. Figure 1 and Figure 2 summarize the post-experience perceptions of the participants with respect to their research experience and graduate school readiness. Across all measured domains, mean survey scores exceeded the midpoint (>4) on a seven-point Likert scale, indicating generally positive perceptions of both research-related and professional development outcomes.

As shown in Figure 1, the highest mean scores were observed in awareness of engineering fields, engineering career prospects, and conducting a research project. Participants also reported relatively high agreement on items related to research planning (mean = 5.3 ± 0.4), written communication (mean = 5.3 ± 0.3), and oral presentation skills (mean = 5.4 ± 0.2), reflecting perceived growth in core research practices associated with independent research engagement. Collectively, these results suggest that participants perceived the REU as contributing to their developing research self-efficacy and readiness to function as independent researchers.

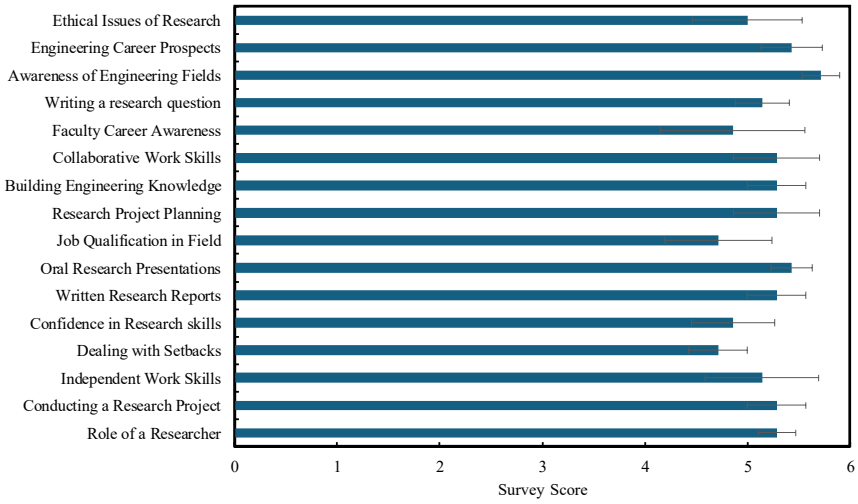

Figure 1: Mean post-experience survey scores reflecting participants' perceptions of their own research self-efficacy and professional development following completion of the REU program.

Figure 2 presents participants' perceptions of graduate school preparedness and aspirations. High mean scores related to attending graduate school, selecting a field of study, and succeeding in graduate school suggest increased confidence in navigating graduate-level academic expectations. In contrast, comparatively lower scores for identifying where to apply for graduate school indicate that, while participants felt prepared to pursue graduate education, uncertainty remained regarding specific institutional pathways. These findings suggest that the REU experience supported participants perceived readiness and motivation for graduate study while highlighting areas where additional guidance may be beneficial.

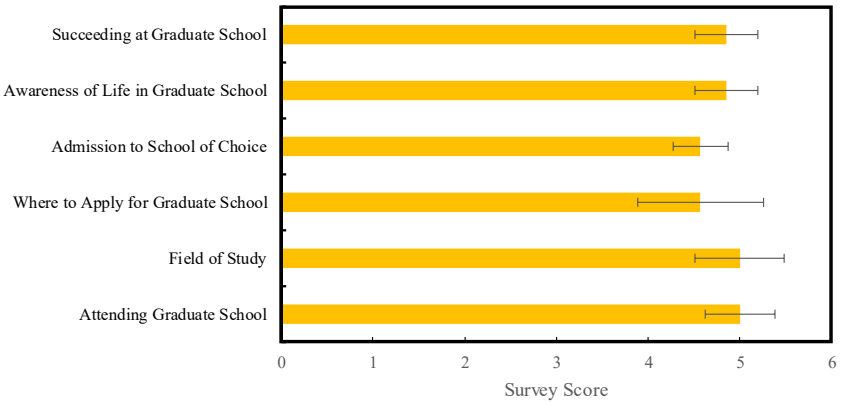

Figure 2: Mean post-experience survey scores reflecting participants' perceptions of graduate school readiness and motivation following completion of the REU program.

Discussion and Conclusion

This Work-in-Progress study examined how students described and interpreted their research experiences and perspectives on pursuing graduate-level education in MSEN following participation in a REU program. Findings indicate that participants described increased clarity in understanding the research process, greater confidence in engaging with research tasks, and more informed perspectives on pursuing graduate education. Quantitative post-survey responses indicated consistently high agreement across dimensions related to research skills, professional competencies, and graduate school readiness. While qualitative reflections provided contextual insight into participants' evolving perceptions of their research experiences, they are presented alongside the quantitative findings to offer a broader understanding of participants' perspectives [12]. Collectively, these findings suggest that participants perceived increased confidence [13] in conducting research and greater clarity regarding their future professional direction and readiness to consider graduate-level study following the REU experience [14]. Unlike prior studies that emphasize outcome-level gains, this study highlights how students interpret and make sense of their research experiences, providing insight into the processes through which these perceptions develop [13] .

The study focuses on a small cohort of REU participants (n = 7) to enable a close examination of students' perspectives and reflections, rather than to support broad generalization or inferential statistical claims. While open-ended responses were collected both before and after the REU experience, Likert-scale items were administered only at the post-experience time point. This limits the ability to directly assess change over time in self-reported confidence or preparedness. As a result, findings from the quantitative survey should be interpreted as reflecting participants' post-program perceptions rather than definitive evidence of growth attributable to the REU experience. Observed patterns therefore, represent self-reported perceptions [15] that are consistent with development, rather than objective or longitudinal measures of skill acquisition.

The findings also align with research in MSEN education that emphasizes the importance of structured, hands-on learning environments in supporting student development [10]. Participants' experiences reflect key characteristics of laboratory and project-based learning

environments, including active engagement, application of theoretical concepts, and iterative problem-solving.

This study has several limitations. The sample size is small (n = 7), and participants were drawn from a single REU program, limiting the generalizability of the findings. Additionally, quantitative data were collected only at the post-program stage, restricting the ability to examine changes over time. Therefore, the findings should be interpreted as exploratory and reflective of participants' self-reported experiences rather than objective measures of development. The findings have implications for both REU program design and future research. From a programmatic perspective, providing opportunities for project ownership, authentic research engagement, and structured mentorship may support not only skill development but also students' understanding of the research process and their professional trajectories. The study also highlights the importance of examining students' interpretations of their experiences alongside outcome-based measures.

Future work will incorporate theory-driven constructs, such as self-efficacy, expectancy-value, and professional identity, alongside longitudinal data collection to better understand how students' perceptions evolve over time. Overall, this Work-in-Progress study provides an exploratory perspective on how students make sense of their REU experiences within an MSEN context, offering a foundation for more comprehensive, theory-informed investigations.

This study was designed as an exploratory investigation of participants' perceptions and experiences within a specific REU context and to identify emergent patterns that could inform subsequent theory-driven inquiry. This study does not adopt an outcomes-based assessment framework and therefore does not define goals, metrics, or validated learning outcomes; instead, it presents exploratory evidence of participants' perceptions to inform subsequent theory-guided or assessment-oriented studies. In future iterations, we will use established theories (self-efficacy, expectancy-value, and professional identity) [16] to guide (a) the selection of survey/interview constructs, (b) the interpretation of participants' self-reported perceptions, and (c) the design of additional measures that examine change over time.

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