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Enhancing Learning through Undergraduate Research: Insights from a First-Generation Student (Experience)

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Allen John Rivas

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Enhancing Learning through Undergraduate Research: Insights from a First-Generation Student (Experience)

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Abstract:

Students arrive at the university from a wide range of personal and educational circumstances, each influenced by family, cultural, and community experiences. For some, higher education is a familiar path supported by relatives who provide guidance and established strategies for success. In contrast, first-generation students often lack such inherited knowledge, leading to difficulties in adapting to demanding coursework, navigating institutional systems, and developing academic confidence. For underrepresented students, these challenges are often magnified and can limit access to opportunities—such as undergraduate research—that are critical to academic growth and professional development.

This paper highlights the experience of Allen Rivas, a first-generation college student of Mexican heritage at the University of Nevada, Reno, who engaged in advanced experimental and analytical engineering research alongside Dr. Cameron Rusnak during their postdoctoral appointment. Through this work, the student connected abstract classroom concepts to tangible experimental results, which improved retention of material and deepened analytical reasoning skills. The research experience also strengthened problem-solving abilities by exposing them to real-world challenges beyond traditional coursework.

Beyond academics, the research experience fostered professional confidence, broadened career aspirations, and provided networking opportunities that positioned them for future success after graduation. This paper articulates the perspective of a first-generation student and demonstrates the broader value of undergraduate research as a tool for enhancing learning, empowerment, and equity in engineering education. The examined intentional undergraduate research experience extends the conversation about how such opportunities can reshape educational trajectories for first-generation and underrepresented students, offering insights that support more inclusive and effective practices across engineering education.

Keywords: Undergraduate research, First-generation students, Underrepresented students, Engineering education, Student empowerment, Educational Equity, Inclusive practices in STEM

Introduction

Students entering higher education bring with them a wide range of backgrounds and life experiences that shape their academic pathways. Among these groups, first-generation college students stand out, as they frequently begin their university studies without the benefit of parental experience in navigating higher education. Data from the National Center for Education Statistics [1] indicate that nearly one-third of undergraduates in the United States are first-generation

students. In contrast, those whose parents have attended college often possess a stronger awareness of academic expectations and campus life, contributing to greater confidence and smoother adjustment to university settings [2]. Understanding the factors that lead students to become first-generation and the challenges they encounter in adjusting to college life provides important context for exploring strategies that foster their success.

Many of these students become first-generation college students due to intertwined socioeconomic, cultural, and perceptual factors that limit access to higher education within families and communities. They are more likely to come from low-income households and under-resourced schools, which reduces exposure to college-preparatory coursework and guidance on navigating the application process [3, 4]. In many families where higher education is not the norm, success is often defined by immediate employment rather than long-term educational investment, leading some to view college as an uncertain or unnecessary pursuit [5]. The College Board reports a substantial decline in students' confidence that the financial costs of a college degree are justified by future returns, with larger declines observed among students from traditionally underserved backgrounds, including those with lower parental educational attainment [6]. Cultural influences may further discourage college attendance when higher education is perceived as incompatible with local community values or family responsibilities [3, 4, 7]. Collectively, these factors help explain why first-generation students continue to comprise a substantial portion of the undergraduate population despite ongoing efforts to expand access to higher education.

Once enrolled in higher education, first-generation college students often face a distinct set of challenges that extend beyond gaining access. Many report difficulty adapting to the academic rigor and self-directed learning expected at the university level, particularly when they arrive with fewer advanced courses or less exposure to college-level study habits [8, 9]. These academic barriers are frequently compounded by financial pressures, as first-generation students are more likely to balance coursework with employment or family responsibilities, leading to heightened stress and reduced engagement [10, 11]. Socially and emotionally, they often experience feelings of isolation or "imposter syndrome," stemming from uncertainty about belonging within academic environments predominantly shaped by continuing-generation peers [12, 13]. Limited access to mentoring networks and unfamiliarity with institutional resources may further restrict their participation in enriching experiences such as internships, undergraduate research, or professional development opportunities [8, 10]. Taken together, these factors contribute to disparities in persistence and degree completion, underscoring the need for intentional academic and social support systems that promote belonging, confidence, and self-efficacy among first-generation students [9, 14].

Recognizing these barriers, institutions across the country have developed targeted programs to better support first-generation student success. To address these challenges, colleges and universities have implemented targeted programs that promote academic preparedness, mentorship, and belonging. Early outreach initiatives and bridge programs aim to ease the transition to college by strengthening academic skills and introducing campus resources before the first semester begins [15, 16]. Mentorship programs—particularly those pairing first-generation students with faculty or continuing-generation peers—have been shown to enhance retention and academic confidence by providing social capital otherwise unavailable through family networks [17, 18]. Financial aid counseling and learning communities also play critical roles in reducing the financial and emotional stressors that disproportionately affect this population [16, 19]. More recently, participation in undergraduate research has emerged as a powerful mechanism for

supporting first-generation student success. Engaging in research fosters active learning, mentorship, and integration into the academic community, all of which contribute to greater self-efficacy and persistence [20, 21]. Research experiences allow students to connect classroom theory to tangible outcomes, develop a sense of belonging in academic spaces, and envision themselves as contributors to their discipline— key factors that increase retention and motivation among first-generation and underrepresented students [20–22].

This paper highlights the experience of Allen Rivas, a first-generation college student of Mexican heritage, and their time conducting advanced experimental and analytical engineering research at the University of Nevada, Reno alongside Dr. Cameron Rusnak during their postdoctoral appointment. Allen Rivas contributed to a comprehensive study on the performance of threaded cast iron pipe fittings used in fire suppression systems, engaging in all phases of the project, from experimental testing to data analysis and interpretation. Through their reflections and outcomes, this paper demonstrates how meaningful research experiences can empower first-generation students to connect theory with practice, build confidence, and recognize their capacity to contribute to the field. In doing so, it underscores the broader importance of providing students from all backgrounds with opportunities to engage in research and reach their full academic and professional potential.

Allen Rivas and How Conducting Research Enhanced Their Learning Experience

This paper is authored by Dr. Cameron Rusnak, who served as a postdoctoral researcher on the project, and Allen Rivas, the first-generation undergraduate student described in this case. The research itself was conducted under the supervision of Dr. Sherif Elfass, the project's principal investigator. The reflections and interpretations presented here were developed collaboratively by the two authors based on their shared experience during the project.

Who Allen Rivas is

Allen Rivas was born in the United States to parents who immigrated from Mexico and was raised in an environment that emphasized hard work, perseverance, and responsibility. Brought up in a family-run plumbing business, Allen Rivas achieved an apprentice level plumbers status in the state of Nevada & North Dakota at the age of 17, and subsequently a journeyman plumbers status at the age of 19 respectively. From an early age, they demonstrated curiosity about how things are built and how structures function, which eventually led them to pursue a degree in Civil Engineering at the University of Nevada, Reno. As a first-generation college student, they navigated the challenges of higher education largely on their own, learning to balance academic expectations with family and cultural responsibilities.

Through conversations with faculty mentors and exposure to coursework in statics and mechanics of materials, Allen Rivas began to see the connection between classroom concepts and real-world engineering applications. This growing interest ultimately led them to join a comprehensive research project examining the performance of threaded cast iron pipe fittings used in fire suppression systems. Their involvement in this project marked the beginning of a transformative experience that deepened their understanding of engineering principles while strengthening their confidence as a developing engineer.

The Research Project

The research project Allen Rivas joined was a comprehensive, multi-phase analysis of threaded cast iron pipe fittings used in fire suppression systems. They entered the project during Phase 1.5, which investigated the structural response of as-built pipe-fitting configurations with the introduction of water leakage. This phase also examined how different thread compounds affected the sealing performance at the fitting–pipe interface. In addition, a "Torque Study" was conducted to determine the torque required to fully engage the pipe threads during assembly, a critical parameter that had not been previously quantified. Allen Rivas contributed to all aspects of this phase, including experimental setup, specimen preparation, data collection, and post-processing, with particularly substantial involvement in executing and analyzing the torque study.

Building upon the insights gained in Phase 1.5, Phase 2 expanded the investigation into a full-scale, systematic evaluation of the rotational capacity and failure behavior of threaded pipe fittings. This phase involved 126 experiments conducted on two fitting types (elbows and tees) across nominal diameters ranging from 1 inch to 4 inches. The intent of Phase 2 was to quantify how these fittings rotate, deform, and ultimately fail, as well as to evaluate how functionality changes once leakage or complete structural failure occurs. A typical Phase 2 test configuration is shown in Figure 1.

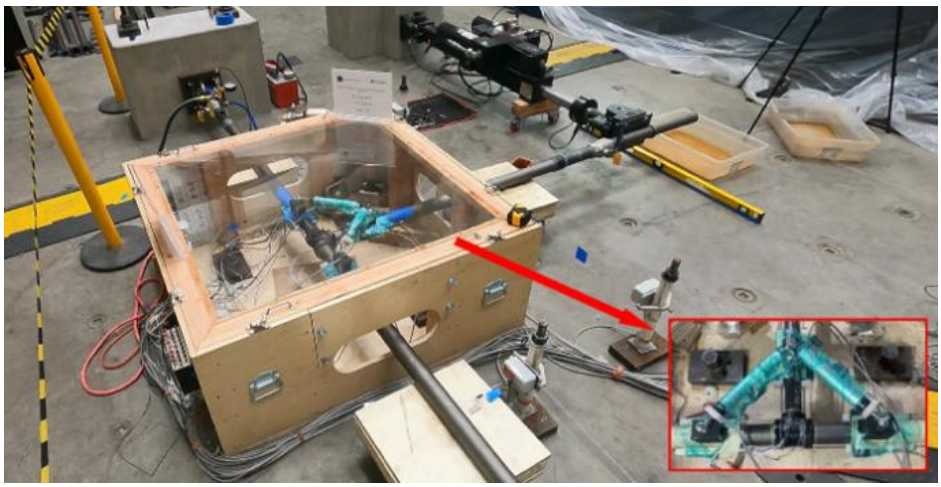

Figure 1. Typical Test Setup in Phase 2

Allen Rivas took on a significant and highly technical role throughout Phase 2. They led the construction and assembly of every test specimen, ensuring consistent fabrication procedures and proper installation. They also played a central role in instrumentation, installing displacement sensors and applying strain gauges (Figure 2), which required precision and attention to detail. During all testing, Allen Rivas worked alongside Dr. Cameron Rusnak to coordinate data acquisition, monitor specimen behavior, and ensure experiments were performed correctly and safely.

After testing, they contributed extensively to data analysis, including the development of a novel rotational-capacity evaluation procedure, code generation for automated data processing, the creation of numerous analytical plots, and interpretation of structural response data. Several components of this research have since been published in peer-reviewed venues [23–26], with additional manuscripts currently in preparation for review.

Figure 2. Allen Rivas Installing a Strain Gauge on a Specimen

Learning in the Classroom Enhancement

Allen Rivas's involvement in the research project had a significant impact on their performance and engagement within the classroom. Prior to joining the research team, much of the material in their engineering courses, particularly statics, mechanics of materials, and structural analysis, felt abstract and disconnected from tangible applications. Through hands-on experimentation with threaded fittings, data acquisition systems, strain measurements, and structural response interpretation, they began to see clear connections between coursework concepts and real engineering behavior.

This experience strengthened their understanding of fundamental mechanics topics commonly emphasized in Civil Engineering curricula. Concepts such as moment–rotation behavior, stress–strain relationships, boundary conditions, stiffness degradation, and failure modes became more intuitive after observing them directly in full-scale laboratory testing. Classroom discussions on topics like deformation compatibility, torque–tension relationships, load paths, and nonlinear material response no longer felt theoretical; instead, they could anchor them to the specimens they had built, the failures observed, and the data they had analyzed.

The research experience also improved their confidence in quantitative coursework. Tasks such as working with large datasets, validating sensor accuracy, interpreting strain signals, and assembling moment–rotation curves allowed them to approach classroom problems with greater independence and accuracy. They became more adept at identifying incorrect assumptions, thinking critically about sources of error, and evaluating the reasonableness of their solutions, skills that translated directly into improved performance on homework, exams, and in-class problem-solving activities.

Additionally, the iterative nature of the research process, setting up tests, troubleshooting instrumentation, refining procedures, analyzing results, and comparing them to theoretical expectations, helped them develop a deeper appreciation for the engineering design and feedback cycle often described in coursework but rarely experienced by undergraduates. This iterative mindset carried over into their academic work, where they began refining their written explanations, checking calculations more thoroughly, and adopting a more systematic approach to open-ended problems. These shifts in approach and mindset did not go unnoticed by faculty involved in their coursework and research supervision. As noted by an adjacent professor in

feedback provided to Allen Rivas, “I also wanted to share with you ... though you missed an A in my class, I saw other things in you that I do not see in a lot of students: inquisitiveness, demonstration of conceptual understanding, creative thinking and thinking about problems in a slightly different way. There is a lot more to it than mastering the textbook problems which is mainly what we can assess. In short, you have a lot of potential and I encourage you to stay the course.”.

Experience Outside of the Classroom Enhancement

Allen Rivas’s research experience also contributed meaningfully to their development outside the classroom, shaping their emerging professional identity and expanding their understanding of the engineering field. As a first-generation college student, they initially viewed engineering as an intimidating discipline reserved for those with greater experience or familiarity. Through hands-on research, they began to see that they could contribute to real engineering problems, prompting them to envision new possibilities for their future in the field.

Working in the laboratory exposed them to the collaborative and iterative nature of engineering practice. They developed skills in communicating results, asking technical questions, and discussing unexpected outcomes, competencies that are not always emphasized in traditional coursework. As they grew more comfortable interpreting data and explaining experimental findings, they engaged more confidently with faculty, researchers, and professionals associated with the project.

Their involvement in research also expanded their access to networking and internship opportunities. Regular interactions with faculty mentors, laboratory personnel, and external collaborators introduced them to a broader professional community and helped them understand industry expectations and potential career pathways. The technical responsibilities they carried during the research project strengthened their résumé and gave them concrete examples to discuss with potential employers, improving their competitiveness for internships and future opportunities.

The experience further broadened their understanding of the engineering field and helped refine their career aspirations. Engaging in full-scale testing, instrumentation, and analysis prompted them to consider pathways such as structural engineering, laboratory research, or even graduate studies, options they had not previously envisioned. Exposure to advanced analytical tools and real-world problem-solving scenarios provided a clearer sense of what engineering practice entails and encouraged them to pursue opportunities beyond the standard undergraduate curriculum.

Perhaps most importantly, participating in a multi-phase research effort fostered a stronger sense of belonging within the engineering community. Seeing their work contribute to formal documentation and peer-reviewed publications helped them begin to view themselves not simply as a student, but as a developing engineer capable of meaningful contributions. This shift in identity is especially impactful for first-generation students who often contend with self-doubt or uncertainty about their place in higher education. The research experience helped reinforce the belief that they could succeed, contribute, and build a meaningful career within the engineering profession, which at one point felt completely out of reach for the student.

Discussion

The experience of Allen Rivas aligns with and reinforces existing research demonstrating that undergraduate research can serve as a powerful mechanism for enhancing learning and promoting

persistence among first-generation college students. Prior studies have shown that first-generation students often enter higher education with limited exposure to advanced coursework, reduced access to academic networks, and lower confidence in navigating complex academic environments [3, 4, 8, 10]. The transformations observed in Allen Rivas, increased academic engagement, improved conceptual understanding, strengthened analytical skills, and greater confidence, mirror the kinds of gains identified in the literature for students who participate in high-impact educational practices such as undergraduate research [20–22].

A key finding underscored by this case is that hands-on research can help first-generation students bridge the gap between theoretical knowledge shown in class and applied engineering practice. For Allen Rivas, observing mechanical behavior in the laboratory and working directly with full-scale structural systems provided a level of conceptual clarity not easily achieved through lectures or homework alone. This direct link between theory and practice not only improved their understanding of fundamental mechanics concepts but also enhanced their ability to recognize the relevance and purpose of their coursework, an outcome that has been shown to positively influence motivation and retention, particularly among underrepresented and first-generation students.

The results also demonstrate the value of research involvement in promoting belonging and identity formation within engineering. First-generation students frequently navigate feelings of uncertainty about their place in higher education due to a lack of inherited academic capital and limited representation in STEM fields [12, 13]. Through sustained participation in a multi-phase research project, Allen Rivas began to see themself as a capable contributor to engineering inquir**ies** rather than a passive participant in their education. This shift is significant because a strong sense of identity and belonging has been linked to improved academic persistence, greater engagement, and increased likelihood of degree completion for first-generation and underrepresented students [9, 14].

Additionally, the research experience broadened Allen Rivas's access to professional networks and expanded their understanding of career pathways within engineering. The literature on first-generation college students notes that limited exposure to professional environments can constrain students' ability to make informed decisions about internships, research opportunities, and future academic pursuits [16, 17]. In this case, regular interaction with faculty, researchers, and external collaborators introduced Allen Rivas to perspectives and guidance they may not have otherwise encountered. These interactions helped them develop clearer career goals and provided them with the confidence and support necessary to pursue opportunities beyond the standard curriculum.

Taken together, these findings highlight the potential for undergraduate research to serve as a targeted, high-impact practice that addresses many of the structural barriers first-generation students face in engineering education. While broader institutional programs, such as bridge initiatives, mentorship networks, and learning communities, play an essential role in supporting first-generation students, this case demonstrates that research experiences can offer a uniquely transformative combination of academic, professional, and personal development. By integrating students into meaningful, real-world projects and fostering mentorship relationships grounded in authentic engineering practice, undergraduate research can help first-generation students develop the skills, confidence, and sense of belonging necessary to thrive in engineering programs.

It is important to clarify that the research experience described in this case was not part of a formally designated first-generation support initiative. While undergraduate research at the institution is designed to advance technical learning and scholarly engagement, outcomes such as

identity development and belonging are not always explicitly articulated institutional objectives. In this instance, these benefits emerged through sustained engagement, meaningful technical responsibility, and close collaboration within the research environment. This case therefore suggests that while such outcomes may not be formally codified in programmatic goals, undergraduate research can function as a powerful mechanism for supporting first-generation students when engagement and mentorship are intentional.

It is also important to acknowledge that this paper presents a single case study and does not claim universal applicability. While the experience described aligns with broader literature on undergraduate research and first-generation student development, outcomes may vary depending on institutional context, mentorship structures, and individual student characteristics. This case should therefore be viewed as illustrative rather than definitive. Future work examining multiple students across varied research environments would provide a more comprehensive understanding of how undergraduate research participation can systematically support first-generation student learning, identity formation, and persistence in engineering.

Conclusion

The experience of Allen Rivas demonstrates the powerful role that undergraduate research can play in supporting the success of first-generation engineering students. By engaging in meaningful, hands-on inquiry, they deepened their understanding of core engineering concepts, strengthened their analytical and problem-solving abilities, and developed greater confidence in their academic and professional capabilities. The research environment provided opportunities to connect theory with real-world applications, practice technical communication, and navigate the iterative process of engineering investigation, experiences that are often inaccessible through traditional coursework alone.

Beyond academic gains, participation in research helped Allen Rivas expand their professional network, clarify their career goals, and cultivate a stronger sense of belonging within the engineering community. These outcomes are especially significant for first-generation students, who frequently face barriers related to limited academic socialization, reduced access to mentoring, and uncertainty about their place in higher education. Their experience illustrates how authentic research engagement can counter these challenges by fostering identity development, providing mentorship, and equipping students with tools to navigate both academic and professional environments.

This case highlights the broader need for engineering programs to create intentional opportunities for first-generation and underrepresented students to participate in undergraduate research. While institutional initiatives such as bridge programs, mentoring networks, and learning communities play essential roles in student success, this study suggests that research involvement offers a uniquely transformative mode of support. By integrating students into substantive research projects and cultivating meaningful faculty–student relationships, engineering programs can promote deeper learning, increase persistence, and expand pathways to academic and professional advancement. Ultimately, providing equitable access to undergraduate research is a critical step toward creating more inclusive and empowering engineering education environments.

Conflict of Interest

The authors declare that no commercial or financial relationships exist that could be perceived as potential conflicts of interest concerning this work. The study was carried out independently, free from any external financial or commercial influence.

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