PURM
Perspectives on Undergraduate Research & Mentoring

Mentorship and Professional Development: A Qualitative Study of a University and Industry Partnership in Creating a STEM Workforce Pipeline

Ever Barraza, Ph.D., California State Polytechnic University (ebarraza@cpp.edu)
Winny Dong, Ph.D., California State Polytechnic University
Arezoo Khodayari, Ph.D., California State University
Laurie Barge, Ph.D., California Institute of Technology
Jessica M. Weber, Ph.D., California Institute of Technology

Introduction

The expanding role of Hispanic-serving institutions in promoting career readiness among STEM students warrants a closer examination of how these institutions utilize industry partnerships to improve educational outcomes. In recent years, there has been an increasing emphasis on the responsibility of higher education institutions to provide support and actively engage students in career readiness programs. This focus is particularly vital for Hispanic-serving institutions (HSIs), which enroll at least 25% of Latinx students. HSIs and other minority-serving institutions are committed to enhancing the educational experiences of diverse students in STEM (Science, Technology, Engineering, and Mathematics). The increased attention to career readiness has led to significant interest in understanding how institutional support influences student persistence, academic success, and workforce readiness. Mentorship in various forms has emerged as a crucial element in promoting the academic and professional development of students, particularly within STEM fields, where underrepresented and minority students often face significant barriers and are underrepresented in STEM careers (Bachkirova et al., 2021; Bensimon et al., 2019; Blake-Beard et al., 2011; Crisp et al., 2017).

A faculty member from California State University, Los Angeles (CSULA), a Hispanic-serving institution, collaborated with two researchers at NASA's Jet Propulsion Laboratory (JPL) to create a unique model combining sustained mentorship and hands-on research opportunities. This partnership, hereinafter referred to as the CSULA-JPL partnership, aimed to cultivate a diverse and skilled STEM workforce by providing extended internships, often extending beyond a year, and offering CSULA students immersive research internship experiences at JPL. The program's primary objectives were to increase student retention in STEM disciplines and inspire the pursuit of advanced degrees and career readiness by promoting interdisciplinary learning through projects that intersect environmental engineering and astrobiology. This study examined a unique model of sustained mentorship coupled with research opportunities, aiming to illuminate its impact on promoting students' professional identity formation and career preparedness.

The CSULA-JPL Partnership is particularly notable for its emphasis on mentorship as a transformative tool for student development. Students work closely with mentors who guide research methodologies, scientific communication, leading independent projects, and navigating the broader scientific community. Research suggests that high-impact educational activities, such as research,

significantly enhance students' sense of belonging, STEM identity, and overall retention and graduation rates (Bowman & Holmes, 2018; Kuh et al., 2010; Kuh & O'Donnell, 2013). This partnership's mentorship and research internship model is highly individualized, adapting to students' unique learning preferences, work styles, and career aspirations. Through regular meetings, collaborative research projects, and structured support systems, mentors build students' confidence, foster independence, and facilitate career advancement (Allen & Eby, 2010; Museus et al., 2011).

Background

One faculty mentor was from CSULA, specializing in Environmental Engineering, and two supervisors from JPL, specializing in astrobiology and planetary science, formed their partnership to support student research on topics relevant to NASA missions. Their collaboration aimed to enhance the diversity of the NASA workforce and provide students with access to a wealth of NASA resources. The partnership offers a sustained, funded research opportunity for students throughout two to three years, complemented by comprehensive mentorship. The approach to project design is distinctive and integral to the program's success. Research mentors strive to make engineering engaging and science relevant by defining projects that bridge both disciplines and align with NASA missions. This strategy sparks interest in NASA-related work and tailors projects to match students' interests and experiences, ensuring a personalized and stimulating learning environment. The program is built on four foundational pillars that reinforce its structure and success.

Extended Support: The internship program goes beyond typical internship durations, providing ongoing financial support throughout the academic year and extending into students' master's programs as they work on their theses. This extended internship allows students to undertake comprehensive research projects that can lead to peer-reviewed publications, further enhancing their academic and professional opportunities. Additionally, the extended financial support allows students to fully dedicate themselves to their research and academic pursuits without the distraction of financial constraints. This is particularly crucial for students from economically disadvantaged backgrounds.

Exciting Interdisciplinary Research Projects: Student projects are deliberately designed to be relevant to both engineering and planetary science, with strong ties to NASA missions. This relevance has proven effective in igniting student interest in STEM fields. Students are motivated by the prospect of making a significant impact on their communities through engineering applications and are captivated by the scientific importance of NASA missions. For instance, one project investigates nitrate chemistry, which is critical to wastewater treatment and has implications for understanding the origins of life and the search for extraterrestrial life.

Diversity and Empowerment: The program is led by an all-women team, emphasizing a commitment to supporting and empowering diverse participation in STEM. This leadership structure promotes inclusivity and serves as a source of inspiration for students, fostering a supportive environment where diverse perspectives can thrive.

Comprehensive Mentorship: Given that most students in this program are first-generation college students, mentorship is vital in shaping their academic and professional journeys. It goes beyond project-related support to encompass career development and personal growth. Mentors actively engage with students to discuss their career aspirations and interests, helping them connect with relevant opportunities that align with their goals. Encouraging participation in professional conferences and student competitions enhances their networking skills and boosts their self-confidence. To cultivate an effective and inclusive

mentoring environment, mentors integrate mentoring training workshops into their grants and/or engage in informal discussions with one another and their colleagues about best practices in mentorship. This ongoing refinement of mentoring practices ensures they effectively support students from diverse backgrounds, address their unique needs, and promote a culture of inclusivity.

Research mentors at both institutions (i.e., CSULA and JPL) collaborate closely to guide students through their projects. They intentionally design these collaborations to foster interactions with peers, especially graduate students and postdocs in the lab. Meetings between mentors and students ensure consistent support, enabling progress checks, research assistance, and strategic direction. Research on mentorship and research experiences in STEM and non-STEM alike indicates that sustained, personalized mentorship can profoundly affect student outcomes, including enhanced confidence, skill development, and career aspirations (Bandura, 1977, 1986, 1997; Dong et al., 2021; Margolis & Mccabe, 2006). These experiences provide students with a realistic understanding of the demands of a scientific career, preparing them to tackle complex challenges with resilience and adaptability (Zimmerman, 2000). The program's focus on real-world research applications also helps students develop a professional identity and a clear pathway to advanced studies or careers in STEM.

Motivation for Study

This study explores the impact of mentorship provided through the CSULA-JPL Partnership on students' professional development, career readiness, and academic achievements. Through qualitative narrative approach data collected from participant interviews, the study identifies key themes related to the role of mentorship in overcoming challenges, fostering resilience, and preparing students for successful careers in STEM. The findings underscore the transformative potential of mentorship in shaping the educational and professional trajectories of underrepresented students in STEM disciplines**.** The following will present the theoretical framework guiding this effort and existing literature discourse on mentoring and professional development, followed by research findings, and the authors will provide a mentorship framework for future practitioners.

Mentorship in Higher Education Research Contexts

A growing body of literature highlights the central role of mentorship in undergraduate research experiences. Shanahan et al. (2015) identified ten key mentoring practices that enhance student learning and development. Among these, overlapping practices with this study include pre-planning, establishing clear expectations, providing technical skill development, fostering independence alongside emotional support, and promoting professional growth.

Further, highlighted that effective undergraduate research mentoring is relational, iterative, and responsive to students' developmental needs (Shanahan et al., 2018). More recent scholarships have explicitly framed mentoring as an equity practice. Leavitt et al. (2022) argue that mentoring within undergraduate research must be intentionally designed to disrupt inequities in access, validation, and professional socialization. Equity-minded mentoring attends not only to skill development, but also to students' identities, lived experiences, and structural barriers. Similarly, Greer and Lester (2025) emphasize that mentoring relationships in STEM must acknowledge power dynamics and institutional contexts while fostering inclusive, affirming environments that support students' holistic development.

Industry-based and university-industry research partnerships offer unique mentoring contexts by exposing students to professional scientific environments while maintaining academic support structures. When sustained over time, these partnerships can bridge academic learning with professional practice, enhance students' career readiness, and expand access to professional

networks that are often inaccessible to underrepresented students (Gault et al., 2010; Estrada et al., 2018).

Student Retention Framework

This study draws on Tinto's extensive research over decades (1975, 1987, 1993, 2012) on student retention and attrition, offering valuable insights for education scholars. His work provides strategies to enhance student retention and success, highlights the primary reasons students withdraw from college, and emphasizes the importance of social and academic integration. Furthermore, Tinto (1993) emphasizes that successful integration into academic and social systems is linked to students' commitment to their educational and career goals and to their sense of belonging to the institution, which increases their likelihood of persisting. Therefore, Tinto's theory emphasizes campus connections through academic and social structures that the university and industry partnership offer to students to prevent departure, such as positive and meaningful interactions with peers, faculty, and other professionals, and a sense of deep involvement and connection to the university, which can be enhanced through participation in curricular, co-curricular, and extracurricular experiences. It is important to note that the theory asserts that students leave for reasons including forced ones, such as grades, financial issues, or family reasons, and voluntary ones, such as isolation, lack of campus connections, lack of motivation, or not seeing the benefit of a college degree. It is also essential to identify the limitations of the theory; one critique from scholars is that the theory fails to address intersectional and multilayered elements that influence students in higher education, such as cultural and racial considerations (Tierney, 2000).

Self-efficacy and Professional Identity Development

To interpret the study's findings, we also draw on Bandura's (1986, 1997) self-efficacy theory, which posits that individuals' beliefs in their ability to perform tasks are fundamental determinants of motivation, persistence, and achievement. In higher education contexts, self-efficacy has been consistently linked to academic performance, resilience, and willingness to pursue challenging career paths (Zimmerman, 2000). Self-efficacy is essential in influencing students' motivation and learning, which can lead to greater academic achievement. To better understand the self-efficacy theory and how it relates to higher education, Bandura (1997) points to four tenets that include *mastery experience* whereby students are given practical experiences and being successful in those practices, then lead to greater confidence and positive academic experiences can help belief in their capacity to succeed in future activities; furthermore, students who observe others such as role modeling can lead to a believe that they can see themselves completing similar tasks through a *vicarious experience*; within the college environment, when students receive verbal encouragement and affirmations, this plays a critical role in helping overcome self-doubt which Bandura (1997) called *social persuasion*; finally, students emotional well-being, stress, and physical health is vital in impacting self-efficacy which is a focus on *physiological and emotional states*. According to Zimmerman (2000), self-efficacy was an indicator of academic performance. Students with high self-efficacy were more likely to take risks, set more challenging goals, and persist when things did not go their way. Similarly, Bandura (1993) found that students with high self-efficacy were more motivated to engage in learning activities, persist, and remain resilient when encountering challenges in their academic journeys. Educators on and off campus play a critical role in shaping students' self-beliefs about their ability to succeed in pursuing career choices. For example, students with high self-efficacy in math are more likely to pursue a STEM-related career (Margolis & McCabe, 2006).

Academic Internships and Student Success

To emphasize the importance of the research, the study draws on prior studies, including a survey of 215 employers. Gault et al. (2010) found that internships related to students' disciplines integrate academic knowledge with real-world experience, bridging the gap between theoretical learning and practical application. This integration enhances critical thinking, problem-solving, and professional

competencies that employers highly value. Furthermore, a study employing quantitative analysis of surveys on academic performance, internship experiences, and job placements found that participation in internships contributes to higher achievement and persistence rates among students (Knouse et al., 1999). The positive impact of internships largely stems from the context and professional connections they provide, which motivate students to stay engaged and complete their degrees. During research internships, it is essential for students to concentrate on cultivating their scientific identity. One study emphasized that research experiences and mentorship can empower students to navigate the professional landscape, build transferable skills, and enhance their self-efficacy, STEM professional identity, and aspirations for a career in STEM fields (Estrada et al., 2018).

Integrating mentorship within STEM education has been extensively documented as a critical factor in enhancing student success (Bandura, 1997; Blake-Beard et al., 2011). However, the unique contributions of sustained, hands-on mentorship through industry partnerships remain underexplored. Building on Tinto's (1993) and Bandura's (1986) foundational works, this study examines how structured mentorship within a specific university-industry context supports underrepresented students' engagement and retention in STEM fields. By leveraging these theoretical insights, the study aims to uncover a deeper understanding of the mentorship dynamics and their impact on student outcomes.

Program Context and Multimodal Internship Mentoring Structure

The CSULA–JPL Partnership is a sustained university–industry research internship program intentionally designed to support underrepresented undergraduate students through long-term engagement, funded research opportunities, and multimodal mentorship. Unlike short-term or summer-only internships, this program supports students for one to three years, often extending into graduate study, allowing for deeper research engagement, skill development, and professional identity formation.

Students are recruited primarily from STEM majors at California State University, Los Angeles, a Hispanic-Serving Institution. Eligible students typically enter the program during their junior or senior undergraduate years, though participation may extend into master's-level study. Selection is competitive and based on academic preparation, expressed interest in research, faculty recommendations, and alignment between student interests and ongoing research projects. A central goal of the program is to reduce structural barriers to research participation by providing sustained financial support, thereby enabling students—many of whom are first-generation and from low-income backgrounds—to engage fully in research without the burden of outside employment.

The program's mentoring structure is intentionally *multimodal,* integrating academic, industry, and near-peer support. Students are jointly mentored by a faculty advisor at CSULA and a research supervisor at NASA's Jet Propulsion Laboratory (JPL). Faculty mentors provide academic guidance, degree planning support, and continuity across students' academic trajectories. In contrast, industry mentors guide day-to-day research activities, professional scientific practices, and integration into a high-stakes research environment. In addition, students interact regularly with graduate students, postdoctoral scholars, and peers within research laboratories, providing informal near-peer mentoring and socialization into scientific communities.

Mentoring practices within the program emphasize individualized guidance, regular one-on-one and group meetings, scaffolded research independence, and iterative feedback on scientific writing, presentations, and data analysis. Mentors also intentionally support students' professional development by encouraging conference participation, co-authoring publications when appropriate, and reflecting on career and graduate school pathways. Collectively, these elements form the

Multimodal Internship Mentoring Framework that structured students' experiences and shaped the outcomes examined in this study.

Importantly, this framework reflects the program's intentional design rather than a model derived from qualitative findings. The qualitative analysis presented in this manuscript examines how students experienced and interpreted this mentoring structure and which elements they identified as most influential in their development.

Research Design

This study employs a narrative inquiry design to explore the impact of the CSULA-JPL partnership on students' professional development and career readiness. As a qualitative methodology that focuses on the stories and personal experiences of participants and mentors, this study seeks to provide rich, in-depth insights into their professional and academic journeys and the meanings they attached to those experiences as they prepared for the workforce. Narrative inquiry is a qualitative research method that collects, interprets, and presents participants' stories to understand their experiences within a specific context. It emphasizes the importance of personal narratives in making sense of and recognizing how individuals construct their professional identities through storytelling. This approach allows researchers to explore the unique perspectives and meanings that individuals attribute to their experiences, offering valuable insights into the complexities of human experience and identity formation (Clandinin & Connelly, 2004; Creswell & Creswell, 2018; Saldaña, 2021).

Data Collection

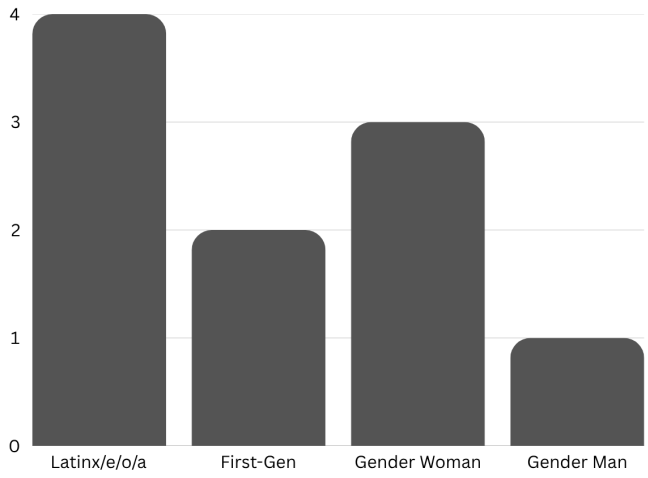
The California State Polytechnic University, Pomona's Institutional Review Board (IRB-24-127) approved this project. Data were collected through semi-structured interviews with student alums conducted via Zoom. Interviews ranged from approximately 60 to 90 minutes, were audio-recorded with participant consent, and professionally transcribed. Interview questions focused on students' experiences within the internship, perceptions of mentorship, challenges encountered, skill development, and post-graduation aspirations and outcomes.

Mentor data were collected through open-ended written reflections on mentoring goals, program structure, and approaches to supporting underrepresented students. Member checking was conducted by sharing thematic summaries with participants to confirm accuracy and resonance with their experiences. Additionally, they discussed the support structures available to them, how the internship prepared them for their future careers, and the skills they acquired during their time there. The open-ended nature of the interviews allowed participants to express their thoughts and experiences in their own words, capturing the depth and complexity of their perspectives. This method provided rich qualitative data that enabled a comprehensive exploration of the internship experience (Creswell & Creswell, 2018). Narrative inquiry allows for a deep exploration of the participants' lived experiences. It provides insights into the factors contributing to their professional and academic success through a constructivist epistemology, meaning that participants' experiences construct knowledge (Patton, 2015).

Participants and Sampling

The study engaged four alumni from California State University, Los Angeles (CSULA), who had completed their research experience under CSULA and NASA's Jet Propulsion Laboratory (JPL) partnership program. In addition, it included one CSULA faculty advisor and two JPL internship supervisors. A purposive sampling strategy was employed to select participants, focusing specifically on individuals who had completed the internship program since its inception. This targeted approach enabled the collection of comprehensive and diverse insights directly relevant to the research objectives (Patton, 2015). By focusing on this well-defined cohort, we aimed to capture rich, nuanced data that reflect the breadth and depth of the internship experience.

Figure 1. *Participant Demographics of Student Alums of the Research Collaboration*



Note: *Self-Reported and Identified Demographics by Participants During the Interview*

The study captures alumni experiences and integrates the perspectives of faculty and JPL supervisors who served as mentors. By incorporating mentors' narratives, this study seeks to contextualize the mentoring process and provide a framework for best practices in mentoring students in high-stakes research environments. This dual perspective allows a holistic understanding of the mentorship dynamic, highlighting the mentors' structural support mechanisms and the interns' growth trajectories. Through this comprehensive approach, the study aims to construct a new paradigm for equity and inclusive mentoring practices that future practitioners can leverage to enhance diverse student populations' professional development and academic success (Bachkirova et al., 2021).

By weaving together the experiences and insights from mentors and mentees, this study offers a multifaceted view of mentorship's impact within a prestigious research internship program. The integration of these narratives contributes to a richer, more informed discourse on effective mentorship practices and their potential to foster professional growth and resilience among underrepresented students in STEM fields.

Validity and Trustworthiness

To maintain the integrity and validity of the findings, the mentors did not participate in the student interviews or in the data review and analysis. The design intentionally separates roles to minimize potential biases or undue influence that mentors might unintentionally exert. The study employed a combination of narrative interviews, mentor open-ended surveys, and member checking to triangulate findings, thereby enhancing the study's credibility and providing a nuanced understanding of the mentorship program's impact (Creswell & Clark, 2017; Patton, 2015). A peer debriefing session was conducted throughout the data analysis process, fostering a collaborative approach that provided additional scrutiny and validation. This method allowed the research team to critically examine their interpretations and address potential biases, ensuring a comprehensive and reliable analysis of the mentorship dynamics within the program.

Data Analysis and Findings

Researchers analyzed the data using a two-pronged approach: first, we applied initial coding to identify emergent themes related to the impact of mentorship. Then, we employed axial coding to explore the relationships between these themes and the outcomes reported by students (Saldaña, 2021). This structured analysis highlights how mentorship practices contribute to students' professional development and resilience in STEM fields (Saldaña, 2021). The analysis of mentorship and professional development within the CSULA-JPL Partnership reveals insights into how structured mentorship and hands-on research experiences contribute to creating a sustainable STEM workforce pipeline. Based on the accounts of four participants whose names were kept confidential using pseudonyms, this section explores the impact of mentorship on the academic and professional journeys of underrepresented students in STEM. The analysis is grounded in the theoretical frameworks of student departure and self-efficacy. These provide a lens to examine how institutional support and personalized mentorship foster a sense of belonging, motivation, and career readiness.

Through a detailed examination of participant experiences, this section identifies key themes, such as the role of mentorship in academic and professional growth, the influence of internship experiences on career goals, the challenges faced and overcome, and the development of transferable skills. These themes are supported by qualitative data from participant interviews, offering a comprehensive understanding of the program's effectiveness in cultivating a diverse and skilled STEM workforce. The research team identified and refined the themes in this study by using a combination of in vivo coding, extracting words and phrases, and axial coding methods. In the second stage of qualitative analysis, the team organized and related the codes into categories and themes (Saldaña, 2021).

Impact of Mentorship on Academic and Professional Growth

Mentorship emerged as a critical factor in the interns' academic persistence and professional growth, significantly influencing their decisions to pursue advanced degrees and shaping their career trajectories. The interns frequently highlighted their mentors' inspiring role, encouraging them to consider paths such as pursuing a Ph.D. The mentors' openness to ideas and the creative and supportive environments they fostered were crucial in the interns' decision-making processes. As Ricardo states:

> *I would describe them as positive. I think they were both really great mentors. We met on a weekly basis to discuss updates and the direction of the research. So, they were pretty much hands-on, and they were also very supportive of the different research avenues I wanted to explore. For example, if I wanted to test a certain reaction, they would say, 'Oh, that's really interesting. I think we can tie this in well.' They were open to my suggestions and offered really good input and advice. I think that made a huge difference in terms of me continuing to pursue a PhD because they were so great at mentoring.*

This reflection illustrates how mentorship provided technical knowledge and essential professional skills, helping interns like Ricardo develop critical thinking, problem-solving abilities, and confidence to handle complex challenges in their future careers. Similarly, Claudia emphasized the direct transfer of skills through hands-on experiences and mentorship, which were essential to her professional development:

> *The experience was really good. It helped me develop skills right from the beginning of the experiment. I read a lot of papers and gained valuable experience in scientific work. I had meetings with my mentors, who were like my bosses, and with my lab team. We all worked together to create a safe and productive working environment.*

Juanita also reflected on the impact of mentorship in preparing her for the workforce, particularly in developing effective communication skills:

> *I felt like I had a lot of support from a lot of the people in the lab; if you need any help reading papers, they would say, 'Just let us know.' We also had group meetings and presentations of different people's research. But I think the mentors were really supportive, and other interns were just really helpful throughout because they knew or were aware that this was all new for me. As the months passed and eventually years, I really gained a lot of insight into the lab procedures.*

These narratives collectively highlight the transformative potential of mentorship in shaping the interns' professional identities, equipping them with a diverse skill set, and enhancing their readiness for the workforce. Their mentors' guidance and support were crucial in helping them develop the technical expertise and soft skills necessary to excel in their careers.

Overcoming Challenges and Building Resilience

Mentorship within the CSULA-JPL Partnership was vital in helping interns overcome challenges and build resilience, essential for success in STEM careers. The mentorship provided the interns with a support system that helped them navigate the complexities of a demanding research environment and adapt to new academic and professional landscapes. Several participants described the initial difficulty of transitioning to JPL's rigorous and specialized environment, highlighting feelings of uncertainty, imposter syndrome, and unfamiliarity with the field's specific demands. Juanita shared her experience of overcoming these challenges with the help of her mentors, noting:

> *At first, I felt nervous…there were so many people at JPL who were very well-versed in these topics. I felt out of my element, but with everyone's support, especially my mentors, my confidence grew over time. They reminded me that it's normal to feel overwhelmed and that learning takes time. This was comforting and motivating, and it helped me through the initial phase of adjustment.*

Juanita's reflection emphasizes the significance of mentorship in addressing the emotional and psychological barriers that students face when entering high-pressure environments. The mentors played a crucial role in helping her understand that it's normal to have such feelings and that perseverance and growth take time and effort. Their support was essential in developing Juanita's resilience, allowing her to remain motivated and committed despite her initial unease. Elena also highlighted how mentorship helped her confront and manage the challenges associated with public speaking and networking, skills that she initially found intimidating:

> *I thought I was a very shy person…I always found public speaking terrifying. But my mentors at JPL and CSULA pushed me to present at meetings and conferences. They gave me tips, feedback, and lots of encouragement, which helped me gain confidence over time. Now, I am much more comfortable speaking in front of others, which is a skill I never thought I would have.*

This example demonstrates how mentors contribute not only to the development of technical skills, but also to the nurturing of personal growth and resilience. Elena's mentors were instrumental in guiding her beyond her comfort zone, offering both practical advice and emotional encouragement that empowered her to gain confidence and enhance her public speaking skills. The mentorship

experience thus equipped her with vital communication skills, enhancing her preparedness for future professional opportunities where effective communication is key.

When Ricardo encountered challenges during his internship, particularly in managing imposter syndrome and juggling multiple responsibilities, he attributed his ability to reframe these challenges as growth opportunities to the guidance of his mentors.:

> *I did feel welcome. I think everybody was super kind and welcoming, but I did still have the imposter syndrome. I even had to ask my friends, telling them, 'Hey, I don't know if I should take this. I was offered the position, but I don't know. I don't think this might be a good fit, because I don't know that.'*

These internship experiences serve as powerful examples of the influential role of mentorship and near-peer mentoring in fostering substantial personal and professional growth. They demonstrate how initial uncertainties and self-doubt can be transformed into confidence and competence, equipping students to excel in high-pressure environments and navigate the complexities of their future careers.

Mentorship as a Catalyst for Professional Identity Formation

The mentorship experienced by interns at the CSULA-JPL Partnership was pivotal in shaping their professional identities, particularly in fields where they had limited prior exposure. This mentorship not only provided technical guidance but also fostered a sense of belonging and identity within the STEM community. Participants described how mentors played a crucial role in helping them transition from students to confident professionals who could envision themselves contributing significantly to their fields.

Ricardo, who transitioned from environmental engineering to a more interdisciplinary field, shared how his mentors supported him in bridging gaps between his prior knowledge and the new research areas at JPL. He stated:

> *I had a lot of support from my mentors when I was learning to apply my environmental engineering background to the new astrobiology context at JPL. They didn't just tell me what to do; they engaged me in discussions about how my prior knowledge could fit into this new space. This made me feel like my input was valuable, which was empowering and essential for my growth as a researcher.*

Similarly, Juanita reflected on how the mentorship experience broadened her understanding of what a career in research could entail. She highlighted the importance of mentors and near peers in helping her navigate the scientific aspects and professional norms and expectations within a research environment. Juanita shared:

> *In the beginning, I was definitely out of my element and building my confidence. My mentors reassured me that it takes time, which is why we have year-long internships. I felt nervous at first, especially because there were many knowledgeable people in the lab. However, I received a lot of support from the other interns who had gone through similar experiences.*

Elena, who had a longer term at JPL, emphasized how mentorship helped her overcome personal challenges and develop a stronger professional identity. She noted:

> *I always thought I was too shy to be in a research environment where you have to present and defend your work. But my mentors pushed me to present at conferences and engage*

with the scientific community. This wasn't just about learning new skills; it was about becoming comfortable in my own skin as a professional and as a scientist. They made me believe I belonged in these spaces.

These narratives underscore the critical role of mentorship in various forms from academic, internship supervisors, and near-peer interns in professional identity formation. By providing a safe and supportive environment, mentors helped interns like Ricardo, Juanita, and Elena navigate the complexities of their fields, overcome self-doubt, and develop the confidence needed to pursue advanced careers in STEM. This theme highlights the need for mentorship programs to go beyond technical training and focus on the holistic development of interns, ensuring they are equipped to view themselves as capable and contributing members of their professional communities. Integrating this approach into mentorship models can significantly enhance the impact of such programs, fostering a new generation of confident, capable, and resilient professionals.

Faculty and Supervisor's Mentorship Intentionality for Academic and Professional Growth

Supervisory mentors played an instrumental role in the academic and professional development of interns, especially in real-world research-intensive contexts. Their influence extends beyond the mere transfer of knowledge and skills, fostering a culture of inquiry and a commitment to excellence. Within the CSULA-JPL Partnership, supervisory mentors engaged deeply with students, guiding them through complex research internship projects and providing the necessary support to develop autonomy and professional confidence. One mentor described:

The most important goal is that the students have a productive and positive internship. Often, this involves exposing them to scientific writing and presenting in the form of conference abstracts, peer-reviewed papers, and presentations at group meetings or conferences. For outcomes, I want the students to have a realistic view of what a science project is and how it can be presented.

By immersing students in the entire research process—from experimental design to data analysis and publication—supervisors ensured that interns gained a thorough understanding of the scientific method, preparing them for future academic and professional pursuits. Additionally, the supervisors were deeply committed to creating an inclusive and supportive environment, reflective of the diverse Los Angeles community. One mentor shared their motivation for working with underrepresented students:

As someone who has navigated the challenges of being a minority and a first-generation college student, I connect with these students and recognize the transformative impact that these research opportunities can have on their futures. Many of our students at CSULA balance multiple jobs to support their families, which doesn't leave them any time for research engagement, and often, they are not aware of opportunities for funded research experience. My primary goal is to create accessible, exciting, and relevant research projects that foster sustained interest without the burden of financial distractions. To achieve this, we tailor students' research experiences to connect them with the exciting world of space missions. We have intentionally designed a structured support system, including financial support, joint advising with a mentor at NASA JPL and leveraging the JPL internship program and its resources. By doing so, we try to maximize our resources, cultivate students' talents better, boost their confidence, and promote interdisciplinary learning. This would also enhance diversity within the student population at NASA JPL.

The valuable insights mentors provide emphasize the significant impact of well-structured programs that support marginalized students through intentional mentorship, practical experiences, and

opportunities to develop their abilities. This equity-minded and student-centered approach helps students manage their research projects effectively and fosters critical thinking and adaptability, preparing them to overcome future professional challenges. In the upcoming discussion, an exploration of the broader implications will be presented based on these findings and consider how mentorship programs like these can be expanded to strengthen a more diverse and skilled STEM workforce.

Discussion

The findings from this study highlight the significant role of sustained multimodal mentorship from academic, professional, and peer support in promoting educational and career development among underrepresented students in STEM fields. The thematic analysis revealed that mentorship was pivotal in shaping participants' career paths and academic persistence. To ensure the findings are robust, participant quotes have been critically evaluated to support the narrative. The CSULA-JPL Partnership demonstrates how an industry- and education-based mentorship program, integrated with immersive research experiences, can help overcome barriers to success, foster student self-efficacy and soft-skill development, and increase career motivation. This discussion will explore the implications of these findings in the context of the existing literature, highlight key contributions to STEM education, and provide recommendations for future programs.

Mentorship as a Tool for Overcoming Institutional Barriers

The study reveals that mentorship was pivotal in helping students navigate challenges, including feelings of imposter syndrome, adapting to complex research environments, and developing essential professional skills. These findings align with prior research indicating that mentorship can significantly impact students' self-efficacy and persistence in STEM fields as found in other studies (see Estrada et al., 2018). For instance, Ricardo's experience of overcoming imposter syndrome with the support of his mentors mirrors findings by Zeldin and Pajares (2000), who demonstrated that role models and mentors play a critical role in bolstering self-confidence and mitigating self-doubt among underrepresented women groups in STEM.

Furthermore, the personalized nature of mentorship, as highlighted by participants such as Juanita, illustrates the importance of tailoring mentorship to individual student needs. This approach is consistent with the work of (see Museus et al., 2011), who emphasized that culturally relevant mentorship that recognizes and addresses the unique experiences of minority students can significantly enhance their sense of belonging and academic success. The CSULA-JPL Partnership's focus on adaptive mentorship strategies demonstrates how understanding individual backgrounds, learning preferences, and career goals can create a more inclusive and effective mentoring environment.

Building Resilience and Professional Skills

This study also underscores the critical role of mentorship in fostering resilience and professional skills, which are essential for success in STEM careers. Participants reported a significant growth in public speaking, scientific writing, and collaboration, all facilitated through sustained mentorship. This finding is supported by Bandura's (1997) theory of self-efficacy, which posits that individuals' belief in their ability to succeed in specific tasks is enhanced through mastery experiences, social modeling, and supportive environments (Bandura, 1997). As provided in this program, mentorship aligns with these principles by offering consistent guidance, feedback, and opportunities for students to develop and practice new skills in a supportive setting.

The emphasis on hands-on experience and ownership of projects further illustrates how the program promoted autonomy and self-confidence among the students. As Margolis and McCabe (2006) also found, opportunities for active engagement in authentic research tasks, coupled with constructive mentorship, can significantly boost students' motivation to pursue STEM careers. The CSULA-JPL Partnership's mentorship structure balanced guidance with independence and enabled students to develop critical thinking and problem-solving skills essential for navigating the complexities of professional environments.

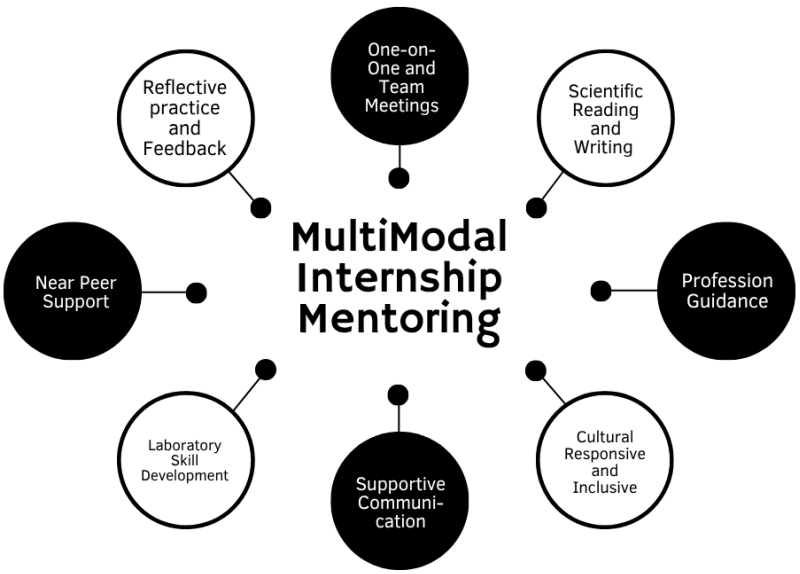
Practical Implications for Enhancing Diversity in STEM

The study's findings have important implications for increasing diversity in STEM fields. The partnership's explicit focus on providing research opportunities for students lacking access to such experiences reflects best practices for promoting equity in higher education (Estrada et al., 2018). The program's sustained financial support and inclusive mentoring practices align with recommendations from the National Academies of Sciences et al. (2019), which advocated for structured mentorship and financial incentives to enhance the participation and retention of underrepresented groups in STEM.

Additionally, as several participants described, the partnership's commitment to fostering a sense of belonging among students is critical for supporting minority students' persistence in STEM fields. Research by Strayhorn (2015, 2018) has shown that a strong sense of belonging is associated with higher academic motivation and success among minority students. The partnership's approach, which emphasizes creating an inclusive lab environment reflective of the diverse Los Angeles population, illustrates how institutions can foster environments where all students feel valued and capable of success.

Framework for Future Practitioners and Mentors

Figure 2. *Multimodal Internship Mentoring Approach.*



The *Multimodal Internship Mentoring* figure above illustrates the key components of an effective mentoring model for research internships. It highlights eight interconnected elements that contribute to a comprehensive and adaptive mentoring approach tailored to the unique needs of students in high-stakes research environments. This model integrates multiple forms of support, guidance, and feedback to foster professional growth, skill development, and academic success among interns.

One-on-One and Team Meetings: Regular, personalized interactions between mentors and mentees, as well as group discussions, create an open platform for sharing research progress, addressing challenges, and providing tailored guidance. This element is critical in building trust and ensuring that each intern's developmental needs are met.

Scientific Reading and Writing: This component emphasizes the importance of developing strong communication skills. It enhances interns' abilities to critically analyze scientific literature, write research papers, and effectively communicate their findings to diverse audiences. This skill set is essential for academic success and career advancement in STEM fields.

Profession Guidance: Mentors provide strategic advice on career pathways, graduate school applications, and professional opportunities, helping interns navigate their future trajectories. This guidance is particularly valuable for first-generation and underrepresented students who may need access to these resources.

Culturally Responsive and Inclusive: Creating a culturally responsive and inclusive environment involves recognizing and valuing interns' diverse backgrounds, identities, and experiences. A culturally responsive mentoring framework ensures that interns feel seen, supported, and valued, which is essential for cultivating motivation.

Supportive Communication: A core mentoring skill, active listening involves mentors engaging deeply with interns' concerns, questions, and reflections, fostering a psychologically safe environment. This practice helps address personal and academic challenges hindering interns' progress.

Laboratory Skill Development: Hands-on training in laboratory techniques and research methodologies ensures interns acquire the technical skills necessary for their projects. This component bridges the gap between theoretical knowledge and practical application, enhancing interns' confidence and competence in research settings.

Near Peer Support: Interaction with more experienced peers recently completing similar internships provides interns with relatable role models and informal guidance. This peer support network can demystify the research process and foster a sense of community.

Reflective Practice and Feedback: This component emphasizes the importance of continuous, iterative feedback between mentors and mentees. Regular reflection and adjustment based on feedback allow for dynamic adaptation of mentoring practices, ensuring they remain responsive to interns' evolving needs and challenges.

Conclusions

Based on this study's findings, several recommendations emerge to enhance mentorship programs that support historically marginalized students in STEM. First, mentorship programs should prioritize sustained, personalized mentorship responsive to individual students' diverse backgrounds, experiences, and needs. This approach requires mentors to undergo training that enhances

their understanding of diversity, equity, and inclusion, equipping them to provide targeted and effective support, as indicated by research on best practices in mentorship (Eby et al., 2008). The findings from this study contribute significantly to existing mentorship frameworks by illustrating how multimodal mentorship can be effectively implemented in research-intensive settings. This approach aligns with and expands upon the work of Zimmerman (2000) and Bandura (1997), who emphasize the importance of self-efficacy and agency in educational settings. By integrating these theories with practical, real-world research internships, the study offers a new framework for understanding how mentorship can directly influence student outcomes and professional development in STEM fields.

Lastly, integrating financial support with mentorship is essential for enabling students from economically disadvantaged backgrounds to engage in research opportunities fully. The CSULA-JPL Partnership model, which provides financial support throughout the academic year and beyond, serves as a model that other programs should consider replicating to promote diversity and inclusion in STEM fields, as many minoritized students may also be low-income. The financial element is critical for their full participation.

Limitations and Future Work

The study's limitation was that it involved a small cohort and only focused on the partnership between CSULA and JPL. Future research should investigate the long-term effects of sustained mentorship on the career trajectories of underrepresented students in STEM through various academic internships. Other studies can target multiple institutions and industry partners for a more comprehensive understanding. Longitudinal studies could offer insight into how early mentorship experiences influence retention, career advancement, and success in STEM disciplines. The CSULA-JPL Partnership demonstrates how mentorship and sustained research opportunities can significantly contribute to the academic and professional development of underrepresented students in STEM. Mentorship programs are crucial in advancing diversity and equity within the STEM workforce by fostering resilience, building essential skills, and creating inclusive environments. Future initiatives should continue to refine and expand these practices to ensure all students have access to the support and opportunities they need to excel in STEM careers.

Declarations

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Availability of Data

Due to the sensitive nature of the data collected for this study, which includes detailed qualitative interviews with individuals who may be identifiable, the data are not publicly available. Protecting the confidentiality and anonymity of the participants is a top priority, and sharing raw data could compromise this. However, summaries of the findings or specific aspects of the data that do not reveal participant identities may be made available upon reasonable request.

Competing Interest

We have no conflicts of interest or competing interests to declare.

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