PURM
Perspectives on Undergraduate Research & Mentoring

# OPPORTUNITAS: A dialogues reflection on lessons learned by minority alumni from undergraduate research

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## Introduction

Retention through undergraduate degree completion remains a significant concern within science, technology, engineering and mathematics (STEM) fields. It has been reported that fewer than 40% of students in STEM completed their degree (Olson and Riordan, 2012), and this percentage is even lower among underrepresented minorities (URMs) that include African American, Hispanic and Native American students. In one report, 33% of White students and 42% of Asian American students completed their STEM degree after five years, in comparison to only 22.1% of Latino students and 18.4% of black students (Hurtado et al, 2010). Many URM students face unique challenges that contribute to lower retention rates compared to their non-URM counterparts, including 1) lack of representation or lack of role models and mentors with the same racial or ethnic background, 2) an inadequate support system, 3) lack of access or opportunities (Ajayi et al 2021). Understanding the mechanisms that promote retention and persistence among these students is critical and one promising intervention is undergraduate research (UR), which can provide meaningful access to mentorship, hands-on learning, and a sense of belonging in STEM.

As defined by the Council of Undergraduate Research (CUR), UR refers to the supervised exploration or creative inquiry undertake by undergraduate students with the aim of contributing to scholarly or artistic knowledge. It is considered a high-impact educational practice and has been widely implemented in colleges and universities to actively engage students and improve retention, persistence and overall success (Kuh, 2008). Among these impactful practices that include learning communities, writing-intensive courses, e-portfolios and internship programs, UR has been found to have the most positive influence on attracting and retaining students in the STEM fields (Kuh 2008). Although UR can be resource-intensive, demanding considerable time commitments from both faculty and students and financial investments from the institution or university, its benefits are well documented, particularly for URM students (Adedokun et al., 2014; Graham et al., 2013).

Participation in UR has been associated with enhancing the overall college experience, as well as contributing to the recruitment, retention, and graduation of students particularly URM students in

STEM fields (Adedokun et al 2014; Graham et al., 2013; Kuh 2018; Russell et al., 2007). Although UR has impacted students in different disciplines, STEM students generally have more opportunities to engage in UR in comparison to non-STEM students (Russell , 2008). Undergraduate research experiences have been recognized as an integral component of efforts to guide students towards scientific career paths (Graham et al., 2013, Russell et al., 2007). For URM students, UR can provide academic engagement, access to mentorship, and professional networks that may otherwise be unavailable, thus serving as a critical lever for persistence and success in STEM.

At a private non-sectarian university based in New York City, the authors have been collectively engaged in UR as both a learning practice and a mentoring framework. The research group at the center of this Dialogue focuses on analytical chemistry and applies techniques such as chromatography, spectroscopy and electrochemistry to address questions across multiple domains, including biochemistry, (studying how proteins and enzymes interact with other compounds), computational chemistry (comparing theoretical calculations to experimental findings), environmental chemistry (exploring emerging pollutants), food science and nutrition (analyzing chemicals found in human milk), materials science (investigating sol-gel and nanomaterials) and natural products (exploring nutraceutical products like tea and bee products). For many of us, particularly those from underrepresented backgrounds, this research group served as our first sustained entry point into authentic scientific practice beyond the classroom.

Participation in this research group enabled students to gain hands-on experience with experimental design, data interpretation, and scientific communication while navigating the social and academic dimensions of STEM training. Importantly, the group functioned not only as a site of technical training, but also as a mentoring community in which students developed confidence, professional identity, and a sense of belonging in STEM. These elements have been identified in prior work as essential to persistence, especially for students from historically marginalized backgrounds (Byars-Winston et al., 2015; Estrada et al., 2018).

This article is written as a Dialogue and is co-authored by alumni of an undergraduate analytical chemistry research group and their faculty mentor. Rather than presenting survey data or evaluating outcomes through a traditional empirical framework, the manuscript offers collective and individual reflections on the processes, challenges, and lessons that emerged through shared engagement in undergraduate research. Alumni contributors reflect on how research experiences such as conducting experiments, presenting at conferences and contributing to publications shaped their academic trajectories, professional development, and approaches to overcoming barriers commonly faced by URM students, including imposter syndrome, lack of representation, limited access to resources, and competing external responsibilities.

Situating alumni voices alongside the mentor's perspective allows this Dialogue to examine undergraduate research as both an educational practice and a relational process. To provide context for the reflections that follow, it is important to first orient readers to the individuals whose voices anchor this Dialogue and the shared research environment in which these experiences unfolded. The next section therefore outlines the positionality of the alumni and faculty mentor and describes the undergraduate research context that frames their reflections, before turning to alumni-authored narratives of their research experiences.

## Context and Positionality of the Dialogue

This Dialogue brings together the perspectives of undergraduate research alumni and their faculty mentor, all of whom were members of the same analytical chemistry research group at a private, non-sectarian university in New York City. Centering positionality is essential for understanding the reflections presented here, as they are shaped by shared research experiences, mentoring

relationships, and institutional context, as well as by the diverse pathways alumni pursued following graduation.

The alumni authors identify as African American and Hispanic/Latino and represent a range of post-graduation trajectories, including graduate education, healthcare professions, forensic science, and industry. Although their current professional roles differ, all alumni contributors participated in faculty-mentored undergraduate research during their time as undergraduates, engaging in laboratory-based analytical chemistry projects that emphasized hands-on inquiry, scientific communication, and collaborative problem-solving.

The reflections presented in this Dialogue were developed collaboratively through iterative drafting, shared discussion, and collective review. Alumni authors drew on experiences spanning different stages of their undergraduate careers, including research participation both before and during the COVID-19 pandemic. Alumni authors reflect as former undergraduate researchers looking back on experiences that influenced their scientific identities, confidence, and career trajectories. The faculty mentor contributes reflections grounded in sustained engagement with undergraduate research and inclusive mentoring practices across multiple cohorts of students. Together, these perspectives frame undergraduate research not as an outcome-driven intervention, but as a relational and developmental process whose impact extends beyond graduation.

An overview of the alumni authors' disciplinary training, post-graduation pathways, and research engagement is provided in Table 1 to orient readers to the voices represented in this Dialogue. The reflections that follow foreground alumni perspectives, allowing lived experience to anchor broader discussions of mentorship, persistence, and opportunity in undergraduate research.

Table 1. *Overview of alumni authors contributing to the Dialogue*

| Alumni | Major | Year(s) active* | Present occupation |
|---|---|---|---|
| Elijah Jones | Biology | 2016-2017 | Physician assistant |
| Fernando Sanchez | Biology | 2019-2021 | Life scientist/project officer |
| Lawrence Phillips | Forensic science | 2019-2022 | Graduate student |
| David Gonzales | Chemistry | 2020-2021 | Chemist |
| Jahaira Zapata | Forensic science | 2016-2018 | Forensic scientist |
| Victoria Carranza | Biochemistry | 2018-2020 | Biochemist |
| Amanda Falade | Forensic Science | 2012 | Forensic scientist |
| Santana Martinez-Symzcak | Biology | 2016 | Formulation specialist |

* Time working with the research group

**Alumni Reflections**

Our reflections on undergraduate research emerged from shared conversations and individual recollections shaped by our current professional and academic positions. While our trajectories since graduation span healthcare, forensic science, graduate education, industry, and research-intensive roles, we identified common experiences that defined our engagement in undergraduate research and continue to influence how we navigate STEM spaces today.

For many of us, undergraduate research represented our first sustained exposure to scientific inquiry beyond structured laboratory coursework. Prior to joining the research group, engagement with STEM was often limited to scripted experiments or theoretical instruction. Research participation allowed us to work hands-on with analytical techniques such as chromatography, spectroscopy, and mass spectrometry, transforming abstract classroom concepts into applied practice. This shift from

procedural learning to authentic inquiry has been widely recognized as a hallmark of effective undergraduate research experiences (Seymour et al., 2004; Lopatto, 2006). Several alumni reflected that access to advanced instrumentation, often unavailable in traditional teaching laboratories, expanded their understanding of the breadth of STEM careers and strengthened their confidence in pursuing them.

Mentorship emerged as a central theme across our reflections. Close, sustained interaction with a faculty mentor fostered an environment in which asking questions, troubleshooting failed experiments, and refining ideas were integral to the learning process. Alumni described gaining confidence through individualized guidance and iterative feedback, particularly when learning to make independent experimental decisions. These experiences align with prior findings that high-quality mentoring relationships play a critical role in the persistence and success of underrepresented students in STEM by supporting both skill development and science identity formation (Byars-Winston et al., 2015; Estrada et al., 2018).

Professional growth extended beyond technical competence. Presenting research at conferences was frequently identified as a transformative experience. Although many of us initially approached presentations with anxiety, repeated opportunities to explain our work to diverse audiences fostered confidence, ownership, and communication skills. Alumni recognized that these early presentation experiences directly translated into later success in interviews, graduate school applications, and professional settings. Prior research has similarly shown that undergraduate research enhances students' abilities to communicate scientific ideas clearly and confidently, contributing to long-term professional development (Bauer & Bennett, 2003; Osborn & Karukstis, 2009).

Collaboration within the research group further shaped our development. Working alongside peers from different majors and academic stages fostered teamwork, mutual accountability, and shared problem-solving. Several alumni described learning as much from peers as from formal instruction, reflecting the social and collaborative dimensions of learning emphasized in undergraduate research literature (Thiry et al., 2012; Shanahan et al., 2015). For many of us, this was the first experience of being treated as contributing members of a scientific team rather than passive learners, reinforcing a sense of belonging within STEM.

At the same time, our reflections acknowledge that undergraduate research was not uniformly exciting. Tasks such as waiting for instrument runs, engaging deeply with primary literature, and writing reports were often perceived as tedious. With hindsight, however, these experiences were reframed as essential preparation for professional STEM environments. Alumni noted that patience, time management, perseverance, and attention to detail, skills cultivated through these less glamorous aspects of research, proved indispensable in their current roles. These reflections mirror national findings that undergraduate research promotes the development of transferable skills that extend well beyond technical training (Lopatto, 2007; Taraban & Logue, 2012).

Several alumni expressed that they wished they had encountered additional dimensions of the research process earlier, such as grant writing, broader exposure to career pathways, or more extended research engagement across multiple semesters. Alumni who participated in research for longer periods reflected that sustained involvement allowed them to transition from skill acquisition to mentorship roles, reinforcing mastery and leadership. Prior studies similarly suggest that multi-year research experiences yield greater gains in confidence, independence, and professional identity than shorter-term participation (Bauer & Bennett, 2003; Thiry et al., 2012).

Despite differences in background, discipline, and career outcome, all of us viewed undergraduate research as a meaningful and affirming experience. Research participation helped many of us see

ourselves as capable scientists, particularly during moments of self-doubt or academic challenge. This sense of scientific identity and belonging has been identified as a critical factor in STEM persistence, especially for students from underrepresented backgrounds (Madan & Teitge, 2013; Hernandez et al., 2018). For several alumni, undergraduate research served not merely as an academic enrichment activity, but as a turning point that clarified goals, strengthened resilience, and expanded what felt possible within STEM.

Collectively, these reflections underscore undergraduate research as a space where learning extends beyond content mastery to include professional identity formation, confidence-building, and community. Writing together as alumni and mentor, we recognize undergraduate research as a shared journey, one shaped by mentorship, collaboration, and opportunity, that continues to inform how we approach science, careers, and mentoring others in STEM.

## Barriers Encountered and Overcoming Them

As alumni and mentor reflecting together, we recognized that our undergraduate research experiences were shaped not only by opportunity, but also by the barriers we encountered along the way. These challenges were varied, often deeply personal, and closely intertwined with our identities as underrepresented students navigating STEM environments. Rather than viewing these barriers as isolated obstacles, our reflections reveal how undergraduate research functioned as a critical mechanism for persistence, adaptation, and growth.

Several of us entered college from under-resourced high schools that offered limited exposure to advanced STEM coursework. Compared to peers who arrived with extensive Advanced Placement credits or prior laboratory experience, some alumni recalled feeling academically behind during their early semesters. This gap contributed to self-doubt and heightened pressure to "catch up," particularly in rigorous introductory STEM courses. Such experiences echo documented inequities in pre-college preparation that disproportionately affect students from underserved communities and shape early STEM trajectories (Hurtado et al., 2010; Stolle-McAllister, 2011).

Undergraduate research played a key role in addressing these preparation gaps. Engaging in hands-on research allowed alumni to apply theoretical concepts incrementally and repeatedly, reinforcing learning through practice. One alumnus reflected that research taught them how to break complex ideas into manageable components, gradually rebuilding confidence and competence. These experiences align with research demonstrating that undergraduate research enhances conceptual understanding while fostering self-efficacy, particularly among underrepresented minority (URM) students (Estrada et al., 2018; Hernandez et al., 2018).

For others, structural and logistical barriers posed significant challenges. Daily commuting limited opportunities to attend tutoring sessions, office hours, or peer study groups, while family responsibilities particularly during the COVID-19 pandemic further constrained time and emotional bandwidth. Several alumni described how undergraduate research offered both flexibility and structure, enabling them to build routines that balanced academic, personal, and family obligations. Research participation created consistent spaces for engagement and mentorship, which proved especially stabilizing during periods of loss or disruption. Prior studies similarly highlight the role of mentored research experiences in supporting persistence amid competing demands and external stressors (Thiry et al., 2012; Shanahan, 2018).

Psychosocial barriers were also prominent in our reflections. Imposter syndrome, the persistent feeling of not belonging or being "good enough" for STEM, emerged as a common challenge. Some alumni recalled questioning whether they belonged among high-achieving peers or doubting their intellectual capabilities despite strong performance. Undergraduate research served as a powerful

counterweight to these doubts. Through iterative experimentation, presentations, and mentorship feedback, alumni began to see tangible evidence of their abilities. Producing data, contributing to presentations, and mentoring newer students reinforced a sense of legitimacy and scientific identity. These experiences align with prior findings that undergraduate research supports identity development and belonging, particularly for students from marginalized backgrounds (Byars-Winston et al., 2015; Madan & Teitge, 2013).

Limited access to research infrastructure also surfaced as a barrier. Some alumni described institutional constraints, such as high student-to-equipment ratios or restricted research opportunities within their home departments. Undergraduate research outside those departments offered alternative pathways to gain technical experience and mentorship. Exposure to analytical instrumentation and interdisciplinary collaboration not only strengthened technical skills but also broadened alumni's understanding of how STEM training could translate across fields. Such cross-disciplinary access has been shown to expand career awareness and improve retention among STEM students (Russell et al., 2007; Taraban & Logue, 2012).

Across these varied experiences, mentorship consistently emerged as a central factor in overcoming barriers. Faculty support extended beyond technical instruction to include encouragement, flexibility, and advocacy. Alumni reflected on the importance of mentors who recognized external constraints and adjusted expectations accordingly, offering additional guidance or resources when needed. This form of holistic mentorship is widely recognized as a critical component of effective undergraduate research programs, particularly those aimed at broadening participation in STEM (Byars-Winston et al., 2015; Shanahan, 2018).

Collectively, our reflections illustrate that undergraduate research did more than impart technical skills—it provided a context in which barriers could be confronted constructively. Research participation fostered resilience, time management, confidence, and a sense of belonging, enabling alumni to persist despite academic, logistical, and psychosocial challenges. These narratives reinforce prior literature demonstrating that structured, mentored undergraduate research experiences can serve as powerful interventions for closing opportunity gaps and supporting URM student success in STEM (Estrada et al., 2018; Hernandez et al., 2018).

## Collective Reflection and Implications for Undergraduate Research

Reflecting together as alumni and mentor, we recognize undergraduate research not merely as an academic enrichment activity, but as a relational and developmental process that shaped how we understood science, ourselves, and our place within STEM. Across our collective experiences, undergraduate research functioned simultaneously as a site for technical learning, identity formation, and resilience-building, particularly in the context of navigating structural and psychosocial barriers common among underrepresented students.

One of the most salient insights emerging from our shared reflections is the centrality of *process* over product. While publications, presentations, and technical proficiency remain important outcomes of undergraduate research, our experiences suggest that the most enduring impacts often lie in less tangible domains: confidence in problem-solving, comfort with uncertainty, and the ability to persist through failure. These elements align with broader literature emphasizing that undergraduate research promotes ways of thinking and behaving like a scientist rather than simply mastering content knowledge (Seymour et al., 2004; Lopatto, 2006).

Mentorship consistently emerged as a defining feature of these experiences. From the alumni perspective, effective mentorship extended beyond instruction in laboratory techniques to include encouragement, flexibility, and recognition of students' external realities. From the mentor's

perspective, guiding undergraduate researchers, particularly those from underrepresented backgrounds, required intentionality, patience, and a willingness to adapt expectations in response to students' lived experiences. This reciprocal dynamic underscores mentoring as a relational practice rather than a hierarchical one, echoing prior scholarship on culturally responsive and inclusive mentoring in STEM (Byars-Winston et al., 2015; Shanahan, 2018).

Our collective reflections also highlight the importance of *belonging* in sustaining STEM persistence. For several alumni, undergraduate research served as the first environment in which they felt recognized as capable contributors rather than peripheral participants. Opportunities to design experiments, present findings, and mentor peers reinforced a sense of scientific legitimacy that countered imposter syndrome and self-doubt. These experiences resonate with research demonstrating that identity development and a sense of belonging are critical predictors of persistence among URM students in STEM (Estrada et al., 2018; Hernandez et al., 2018). Importantly, the benefits of undergraduate research were not experienced uniformly or instantaneously. Sustained engagement, often across multiple semesters, appeared to amplify its impact. Alumni who participated longer described a progression from skill acquisition to leadership, mentorship, and professional confidence. This observation supports findings that multi-year research experiences yield deeper cognitive, affective, and professional gains than short-term participation (Bauer & Bennett, 2003; Thiry et al., 2012). These reflections suggest that institutions should prioritize structures that enable continuity and long-term engagement, particularly for students balancing competing demands.

From an institutional perspective, our experiences point to several implications for designing inclusive undergraduate research programs. First, access matters. When research opportunities are framed as optional, unpaid, or reserved for honors students, participation may inadvertently exclude those who could benefit most. Second, mentorship training and support are essential to ensure that faculty are equipped to engage students holistically. Finally, undergraduate research programs must be flexible enough to accommodate students with commuting responsibilities, employment obligations, or family care roles.

Collectively, these reflections reinforce undergraduate research as a powerful equity-oriented practice when implemented with intentional mentoring, sustained engagement, and institutional support. Rather than positioning undergraduate research solely as a pipeline to graduate school or scholarly productivity, our Dialogue highlights its broader role in fostering confidence, belonging, and adaptability, outcomes that remain valuable regardless of students' eventual career paths.

**Conclusions**

This Dialogue brings together the voices of undergraduate research alumni and their faculty mentor to reflect on the pivotal role of undergraduate research (UR) in shaping academic pathways, professional identities and persistence in STEM. Across diverse backgrounds and career trajectories, our shared experiences underscore undergraduate research as far more than a high-impact educational practice, it is a relational space where confidence is built, belonging is cultivated, and potential is realized.

As alumni, we reflect on undergraduate research as a formative experience that helped us navigate challenges ranging from limited pre-college preparation and structural constraints to imposter syndrome and competing personal responsibilities. Through sustained engagement in research, we developed not only technical competencies, but also resilience, adaptability, and a clearer sense of self within STEM. For many of us, research was the first context in which we saw ourselves as capable contributors to scientific work, a realization that continues to influence our professional lives.

From the mentor's perspective, these reflections reaffirm the importance of intentional, inclusive mentoring practices. Supporting undergraduate researchers, particularly those from underrepresented backgrounds, requires attention to students' lived realities, flexibility in expectations, and a commitment to long-term development rather than short-term productivity. When undergraduate research is framed as an accessible and supportive process rather than an exclusive opportunity, it can function as a powerful mechanism for equity and persistence.

Collectively, our reflections suggest that the impact of undergraduate research is amplified when students are engaged over multiple semesters, embedded within mentoring communities, and provided opportunities to progress from learners to leaders. Institutions seeking to broaden participation in STEM should therefore prioritize sustained access to research experiences, mentorship support, and structural flexibility that acknowledges the complex realities many students navigate.

Rather than offering a prescriptive model, this Dialogue highlights lived experiences that illuminate how undergraduate research can shape trajectories in meaningful and lasting ways. By centering alumni voices alongside the mentor's perspective, we hope to contribute to ongoing conversations about how undergraduate research programs can be designed not only to produce knowledge, but also to nurture confidence, belonging, and opportunity for all students in STEM.

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