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ORIGINAL PAPER

Qualitative assessment of high-impact practices in a post-secondary STEM training program in the Southwest United States

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Abstract

Science, technology, engineering, and math (STEM) training programs generally include academic and professional opportunities for students to develop skills necessary for degree completion and retention in STEM related fields. Prior research points to a shortage of diverse students entering STEM disciplines in college and fewer students earning STEM degrees. However, little is known about qualitative aspects of training programs. This qualitative study fills in this knowledge gap as it explores embedded High Impact Practices of research, learning communities, collaborative projects, and assignments. Specifically, we assess the impact of a National Institute of Health (NIH) training program, designed for undergraduate students to enter biomedical doctoral degrees. Sixteen students enrolled in the program at a Hispanic-Serving Institution (HSI) in the Southwest United States share lived experiences of HIPs associated with their persistence and self-efficacy during the program. Our findings provide an impetus for funders, faculty, and administrators to weave HIPs into training programs, develop mentoring strategies, and coach students on overcoming imposter syndrome. Additionally, despite studies reporting quantitative outcomes of training programs, our research underscores the importance of qualitative methods so to best support minoritized populations completing their undergraduate degree and matriculating into graduate school.

Keywords High impact practices · STEM education · Training programs · Undergraduate students · Qualitative study · Hispanic-serving institutions

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Introduction

Evidence points to a lack of diverse students entering science, technology, engineering, and mathematics (STEM) disciplines in college (Huang et al. 2000; Reilly et al. 2019; National Center for Science and Engineering Statistics (NCSES) 2023). To exacerbate this issue, data also show that these students earn degrees at lower rates than majority gender, racial, and ethnic populations (Fry et al. 2021). This, in turn, results in a lack of diversity within STEM careers (Huang et al. 2000; Fry et al. 2021; National Center for Science and Engineering Statistics (NCSES) 2023). For example, the Pew Research Center's analyses show Black and Hispanic individuals comprise a small percentage of the STEM workforce in the United States compared to White populations (Fry et al. 2021). Data from the NSF show Hispanic workers representing 8% of the STEM workforce while representing approximately 19% of the United States population (Okrent and Burke 2021). Additionally, some women earn STEM degrees at a higher rate than men but degree attainment by gender is nuanced by ethnic and racial identity. As our national population is becoming increasingly diverse, the information presented here points to the dire need of increasing diversity amongst STEM majors, graduates, and the workforce.

To boost diversity within the STEM workforce, there are various initiatives for assisting underrepresented students in pursuing and completing a STEM degree (Ford et al. 2016; Hall 2017; Norris et al. 2020; Stofer et al. 2021). These initiatives consist of opportunities for students engage in research, complete internships, receive professional mentorship, and partake in career- and academic-related workshops. The program is designed for Juniors and Seniors in their final years of college. Diversity, as defined by the NIH and the National Science Foundation (NSF) is characterized as low representation of women, racial and ethnic identifies, and individuals with disabilities; racial and ethnic groups include Blacks or African Americans, Hispanics or Latinos, American Indians or Alaska Natives, Native Hawaiians, and other Pacific Islanders (NIH 2022; National Center for Science and Engineering Statistics (NCSES) 2023). The research training program, which is the focus of this study, is funded by the National Institutes of Health (NIH) with the intent to prepare a diverse pool of undergraduates to complete their baccalaureate degree and transition into biomedical research-focused higher degree programs such as doctoral programs (Hall 2017; National Institutes of Health 2022). The student participants are required to complete a faculty-mentored research experience over their two years and spend a summer completing an internship at a research institution (Hall 2017; National Institutes of Health 2022). Students also participate in a learning community course whereby each program designs experiences to enhance students' professional, academic, and research skills.

The NIH requirements of the program and the institution-specific added activities mirror what is known to higher education and student support professionals as Kuh's (2008, 2017) High Impact Practices (HIPs) of the Association of American Colleges and Universities (AAC&U). Scholarship points to HIPs contributing to success as it relates to students persisting

through their college career to degree completion (Kuh 2008, 2017; Kuh et al. 2017). Students engaged in HIPs develop confidence in their abilities and are likely to achieve strong academic outcomes. The HIPs, along with brief descriptions, are:

- *First-Year Seminars and Experiences,* opportunities for small groups of first-year students to meet with faculty or staff and participate in skill development activities
- *Common Intellectual Experiences*, curriculum involving broad themes and activities or assignments connected to the theme
- *Learning Communities*, students take courses together and often the courses are linked to a common topic or discipline
- *Writing-Intensive Courses*, students develop advanced writing skills that are often necessary for cumulative or capstone projects
- *Collaborative Assignments and Projects*, which occur as part of a course or as a co-curricular activity
- *Undergraduate Research,* students are active in faculty research labs and develop critical thinking and research skills
- *Diversity/Global Learning*, opportunities for students to think critically of their views and learn about cultures and identities other than their own; travel abroad opportunities
- *Service Learning/Community-Based Learning*, experiential learning often tied to a course; the projects allow students to apply what they learn and often solve a societal problem
- *Internships*, direct work experience
- *Capstone Courses and Projects*, culminating projects either at the end of a course or during a student's final year in college, *and*
- *e-Portfolios*, students maintain a collection of artifacts of their learning and co-curricular activities (Watson et al. 2016).

The program was introduced by the NIH in 1977 whereas the first 10 of Kuh's HIPs were introduced in 2008; e-Portfolios were added in 2017 (Watson et al. 2016). There is existent literature addressing benefits, including academic and social outcomes, of Kuh's (2008, 2017) HIPs yet the undergraduate training program has not been used as a study context to date. Further, to the best of our knowledge, there are no NIH-funded undergraduate training programs that cite these HIPs. Most program administrators or principal investigators of the training programs provide the NIH with participant graduation rates, demographics, and matriculation into graduate school.

Our study addresses what such rates and numbers do not; that is, the lived experiences of the student participants. Through the use of focus groups, the qualitative approach of our study allowed for students, enrolled in the program at a Hispanic-Serving Institution (HSI) in the Southwest United States, to describe the effects of the HIPs that exist within their program and how they contribute to their persistence as students. The following research questions guided this study:

1. What are the experiences of this training programs' students regarding high-impact practices including undergraduate research, learning communities, internships, and collaborative projects and assignments?
2. What factors in this training program contribute to the students' desire to complete their STEM degree?

This study is critical to faculty, administrators, and funders of STEM undergraduate training programs particularly as it highlights the importance of HIPs and how they can be best utilized to ensure student persistence and success. The study fills in the gap of why HIPs are an important aspect of training programs by taking a qualitative approach, allowing participants to share their experiences. Additionally, the qualitative approach utilized will allow training programs to consider addressing the needs of student participants beyond simply ensuring quantitative measures are met. That is, the qualitative design gives a fresh perspective that quantitative assessment may not capture. The remainder of this paper reviews existent research surrounding HIPs and STEM training programs. Following this, study methodology, findings, and a discussion are offered.

Review of literature

This review concentrated on High Impact Practices (Kuh 2008, 2017), otherwise known as HIPs, and research associating undergraduate STEM training programs to HIPs. These practices are high impact as they promote student retention and increase degree completion (Kuh 2008, 2017; Seidman 2012). Much of the literature reviewed did not directly identify HIPs, but we looked for literature identifying four specific HIPs within STEM training programs; those being undergraduate research; learning communities; collaborative assignments and projects; and internships as these elements are cornerstones of the training program, the focus of the study.

High-impact practices (HIPs)

HIPs are utilized by institutions of higher education to bolster student retention, a metric reflecting how many students re-enroll from year to year with the goal of ensuring a student graduates (Seidman 2012). Retaining students is of interest to institutions yet can be challenging as the student population is increasingly diverse. HIPs (Kuh 2008, 2017) are interventions and experiences students participate in which have been demonstrated to produce successful academic and social outcomes. In other words, HIPs assist students in persisting from term to term.

Research demonstrates the importance of HIPs in student experiences and outcomes. Kuh (2008, 2017) and others ascertained that HIPs are intentionally designed for students to interact with their peers, campus staff, and faculty. Additionally, HIPs challenge students to explore their own perspectives and thoughts while being open to learning new ideas (Kilgo et al. 2014; Kuh 2008, 2017). Research has explored the impact HIPs have had on students' experiences

and academic outcomes. For example, Kilgo et al. (2014) utilized data from the Wabash National Study of Liberal Arts Education (WNS), a pre- and post-test instrument. Their study examined all HIPs except for e-Portfolios, which was added to the HIPs in 2017 (Watson et al. 2016; Kuh et al. 2017). Kilgo et al. (2014)'s analyses showed that two of the HIPs, collaborative assignments/projects, and undergraduate research, had significant effects at multiple campuses. Further, HIPs including diversity/global learning, internships, service learning/community-based learning, and capstone courses and projects also have positive effectives on student learning. This evidence underscores the importance of HIPs to assist students in remaining enrolled.

Other researchers have examined specific HIPs, such as Padgett et al. (2013) whose study also drew upon data from the WNS. Analyses showed an impact of first-year seminars and experiences on students' life-long learning. For example, by participating in first-year seminars, students in their data set had an increase in cognition. Yet another study suggested that students involved in HIPs were more likely to graduate college within six years (McDaniel and Van Jura 2022). Such research points to HIPs retaining and graduating students.

More recent literature has reviewed HIPs including e-Portfolios, added in 2017 (Kuh 2017). These are utilized by students to capture and document their academic journey and often include course assignments or projects relating to experiential learning (Kuh 2017; Watson et al. 2016; Yancey 2023). A case analysis reviewed HIPs embedded in two distinct post-secondary programs, one in the United States and the other in Spain (Ciesielkiewicz et al. 2020). Findings revealed the impact of e-Portfolios when embedded with service-learning, another HIP, allowed students to identify connections with academics and real-world experiences. Giering and Firdyiwek (2020) also explored the use of implementing e-Portfolios, finding that students only utilize them when prompted by faculty. Both studies suggest the need not only for intentionality but also calls for further research.

STEM training programs

Training programs are designed to assist students in developing credentials and qualifications necessary for post-graduate studies or job placements. These programs often incorporate elements of HIPs to broaden access to marginalized student populations by providing academic, research, and professional development opportunities with a goal of increasing representation in the STEM workforce or STEM graduate and/or doctoral programs (Ford et al. 2016; Norris et al. 2020; National Institutes of Health 2022). Reports and publications reviewing STEM training programs rarely name Kuh's HIPs.

Examples of training programs include NIH-sponsored grants; others include funding provided by the National Science Foundation (NSF), National Cancer Institute (NCI), Association of American Medical Colleges (AAMC), and other government or local agencies (Ford et al. 2016; AAMC 2022; National Institutes of Health 2022; NSF 2022). Funders seek evidence of how, and if, training program HIPs contribute to students' educational and career outcomes, requiring a number of student participants, student demographics, graduation rates, acceptance into and

completion of graduate programs (National Science Foundation 2022). This is particularly true for the training program. Hall (2017) conducted an analysis of several of the training programs across the country citing Ph.D. and M.D. completion rates of the programs' graduates. Additionally, the analysis provided the types of institutions housing these training programs, including level of research and if the institution was minority-serving, suggesting that underrepresented students participated in opportunities that they may not have had the possibility to do so without a training program.

One of the biggest components of a training program include opportunities for students to participate in research, which is one of the 11 HIPs. However, research is just one of the HIPs. Most studies explore HIPs in isolation, but there is some research associating Kuh's (2008, 2017) HIPs to STEM training programs. A multimodal study exploring undergraduate STEM education programs funded by the National Science Foundation showed few of the programs utilize HIPs other than undergraduate research and only one implemented e-Portfolios, the most recent HIP (Ives et al. 2023).

A separate study conducted by Stofer et al. (2021) explored a geosciences training program available for underrepresented students enrolled in at a two-year college. The purpose of their qualitative study was to identify student participants' experiences of the program and engaging in the HIPs. Findings emphasized students, who were of underrepresented backgrounds, appreciated the coursework, research, their internship, and being with a learning community as the most important HIP-aspects of the program. However, students desired more clear and consistent communication between the program staff and faculty and some students desired a better connection to their research mentor (Stofer et al. 2021). Researchers argued the important of their study as being pivotal in increasing pathways for students to transition from two-year colleges in pursuit of a bachelor's degree (Stofer et al. 2021).

Morales et al. (2017) explored faculty motivation in mentoring undergraduate students in research training programs. Faculty mentoring is a large part of undergraduate research experiences, one of the HIPs (Kuh 2008, 2017). Utilizing survey data, their analyses drew upon multiple institutions and yielded mixed results (Morales et al. 2017). That is, faculty who desired to increase diversity in representation in STEM fields were more interested in being a mentor to an undergraduate student whereas faculty who thought mentoring students was time-consuming were less likely to serve as a mentor. These findings suggested that faculty who desire to serve as mentors receive adequate training and support to work with their student mentee.

More recently Stormes et al. (2022) conducted a study at a large minority-serving institution (MSI), exploring the academic and graduate school outcomes for students participating in an NIH Building Infrastructure Leading to Diversity (BUILD) training program. Utilizing a comparison group of similar students not enrolled in the BUILD program, as well as BUILD participants, analyses showed that students who did participate in the program had better academic outcomes, which included attempting and earning more college credit and having higher cumulative GPAs. Similarly, students in the BUILD program were more likely to graduate from the college and apply to graduate school. Despite these findings,

however, analyses indicated no difference between BUILD and non-BUILD students in matriculating into a doctoral program.

Another article pertinent to this study comes from Oseguera et al. (2022) who studied a STEM scholar program for underrepresented students. Their research examined factors contributing to students who completed a STEM scholar program at a large, research-university. The program offered various academic and social interventions. Findings suggested that students who dropped out of the scholar program did so for non-academic reasons. For example, participants who reported higher feelings of well-being were more likely to persist through the program than those who reported lower levels of well-being. Another key finding was that students who identified as underrepresented minorities (URM) expressed lower interest in scientific research, which was a component of the program, yet these same students were just as likely to persist through the scholar program as their non-URM peers.

These studies provide context regarding the influence of undergraduate training programs on students, especially for those of underrepresented and marginalized backgrounds (Morales et al. 2017; Stofer et al. 2021; Stormes et al. 2022). As eluded, these programs provide opportunities for students to learn in community, participate in research, and prepare for graduate programs. Marrying these ideas together demonstrates the important of HIPs, embedded in training programs, to produce a diverse and qualified STEM workforce. More importantly, literature reviewed underscores the importance of training programs for advancing opportunities for students especially those of underrepresented identities and backgrounds.

Gaps in knowledge

The review of literature sets the foundation of the study. Most notably, there is a disconnect between training programs and HIPs as programs do not specifically name or embed HIPs in their practices. This is especially important in addressing the need for training programs to prepare a workforce that is representative of the diverse US population as HIPs have been demonstrated to advance student experience and outcomes, ranging from retention to degree completion (Kuh 2008, 2017). Further, as noted, funders of training programs often require quantitative evaluation metrics, with a substantial gap of students' experiences, attitudes, and feelings. Research surrounding the impact of training programs has largely assessed quantitative outcomes including degree completion, doctoral matriculation, and publication rates as well as students' grade point averages (Ford et al. 2016; Hall 2017). Moreover, funders require these data as well as other quantitative metrics including number of students and faculty mentors, monetary expenditures, and student demographics. This study adds to the body of literature by utilizing a qualitative method to discover students' experiences during their time in a training program. Additionally, despite research regarding HIPs in short-term research and graduate programs, there is scarce literature on undergraduate training programs. Finally, the gap in knowledge of the intersection

of student experiences and identities will be addressed as we assess a two-year undergraduate training program at an HSI.

Methodology

The qualitative study utilized a narrative inquiry (Tracy 2019) approach, in which researchers view participants' stories as fundamental to their experiences. Specifically, we studied one cohort consisting of Junior and Senior students enrolled in the training program who participated in two focus groups to orally communicate their stories and lived experiences. This was the best method for the study as, noted above, evaluation of the program was primarily conducted through quantitative assessment and surveys. A narrative inquiry approach allowed participants to share information that could otherwise not be captured. As the study focused on one cohort of students, the sample size of 16 could not be extended. This aligned with the narrative inquiry approach, giving all participants the opportunity to share their lived experiences. Participation included all 16 students; seven of the students were Seniors while the remaining nine were Juniors. All participated together in both focus groups.

The program

The focus of this study is the NIH-sponsored training program which offers opportunities for undergraduate students who are in their Junior and Senior year and includes the following HIPs (Kuh 2008, 2017; National Science Foundation 2022):

- Undergraduate Research: Students participate in faculty-mentored research projects throughout their duration as a student. Often, this requires the student to work in a lab while receiving compensation. This culminates with seniors being required to present their research at the annual SACNAS conference.
- Learning Communities: As part of the learning community, students are enrolled in a class with both groups e.g., the students who are in their Junior year and Senior year. Content presented in the class includes workshops and seminars designed to increase students' research and professional development skills and to assist them in applying for doctoral programs.
- Collaborative Assignments and Projects: Within the class, students often work with each other on projects which allows them to listen to their peers and build upon their own understanding of research, academics, and professional development. Additionally, these students work in research labs and often collaborate with other undergraduate students as well as graduate students, post-doctoral staff, and faculty.
- Internships: Students complete a research-based internship between the summer of their Junior and Senior year.

The program and has been in existence at the institution since 1977. The program has been successful since its infancy; to date, 396 students have been a part of this training program at the institution and 379 of these students graduated. In any given year, the program has capacity for 18 students.

Participants and setting

This undergraduate training program is situated at a large, public institution in the Southwest United States is designated as an HSI and Minority-Serving Institution (MSI); over half of the student population identify as Hispanic. The institution has a Carnegie classification of R2- High research activity. Situated in the borderland region with Mexico and Texas, it is a land-grant and space-grant institution and maintains branch and extension campuses throughout the state.

There were 16 students enrolled in the program during the 2022–2023 academic year. All consented to participate in the study. Table 1 provides descriptors of these student participants, e.g., demographics, class standing, and academic major. Of the 16 student participants, 75% identify as Hispanic. Seven of the students were Seniors while the remaining nine were Juniors. Most students were pursuing a bachelor's degree in biology (n = 7). As noted, students enrolled in the program prepare to apply for acceptance into a biomedical research-focused higher degree programs. Most graduates of the program directly enter a research-focused doctoral program and not a master's program. The study was approved through the local Institutional Review Board (IRB). Ethical considerations included ensuring data collection was completed in a space with no training program leadership present so that student participants could freely share their experiences. Additionally, recordings of focus groups were destroyed upon transcription. These data were stored in secure electronic folders and participant names were removed.

Table 1 Descriptive statistics of study participants

Demographics	*n*	Academic major[a]	*n*
Gender		Animal science	1
Female	10	Biochemistry	1
Male	6	Biology	7
		Biology and biochemistry	2
Ethnicity/race		Chemical engineering	1
White	3	Computer science	1
Hispanic	12	Environmental science	1
Unknown	1	Fish, wildlife, and conservation ecology	1
		Horticulture	1
Class standing			
Junior	9		
Senior	7		

[a]Sorted in alphabetical order

Data collection and design

The first focus group provided data revealing students' perspectives pertaining to HIPs of the program. The second focus group allowed students to share how these HIPs contributed to, or detracted from, their ability to persist as a student. Both focus groups were in-person and lasted approximately one hour. Additionally, data were collected through university databases in which students' demographics were obtained. Historical data regarding the program were acquired through institutional administrators and observed by the research team. Data collection and subsequent analyses were conducted by an evaluation team affiliated with the university; the team has no direct involvement with the execution of the training program so to ensure no conflict of interest nor biases.

Data analysis

Thematic analyses were used in this study. Focus groups were recorded and auto transcribed and used as data. The research team read the transcripts and manually revised any errors. From there, an open-coding process was used whereby researchers read the transcripts and assigned a short description to elements of text (Merriam 2009; Tracy 2019). These descriptions were grouped into categories resulting in final themes, which are presented as findings. To ensure credibility (Tracy 2019), triangulation was met as the researchers and program leadership reviewed emerging themes. Additionally, we ensured validity and credibility by using thick description through participants' exact quotes in the forthcoming results section. (Lincoln and Guba 1985; Tracy 2019) will be used to supplement the findings. Finally, while the bulk of our data were collected through focus groups, we collected and observed demographic information through university databases. These are reported in summary form.

Results

To illustrate the findings of the study, each of the research questions will be answered. Descriptions of findings includes participants' exact quotes shared during data collection e.g., focus groups, allowing to amplify their unique, individual experiences pertaining to the training program. To protect confidentiality, only a student's class year will be attributed to the quote. Being that the students were in different stages of their academic career, some findings are applicable to Juniors whereas some to Seniors.

Research question one

What are the experiences of this training programs' students regarding high-impact practices including undergraduate research, learning communities, internships, and collaborative projects and assignments?

Undergraduate research

Students reflected how they developed and strengthened their research skills because of the training program, which requires 15–20 h of working in a lab each week. By conducting research, students felt their level of confidence increase, as a junior described, "I learned that research is not that intimidating, and I actually really like it. I really like it." Additionally, students expressed gaining knowledge of how to efficiently read scientific papers and when to use technical skills, such as conducting experiments in their labs. Another student explained:

> Since I've gotten into [the program] like, there's more trust than what I can do. And so now I'm able to um a wider variety of experiments, and I have more confidence in doing those kind of things, and like I frequently like help, other members of the lab. – Junior

Overall, several students reported enjoying doing research, contrasting from feelings of apprehension towards research before starting the program. A senior studying commented: "Oh, I just like talking about research now." This theme was also reflected in students expressing they looked forward to pursuing a doctoral degree because they now feel comfortable doing research.

Learning communities

Students were asked about being in a learning community as the Junior and Senior cohorts take a semester-long course together the full two years they are in the program. They expressed appreciation to be in a learning community as their peers could relate to their lived experiences especially as it pertained to being an underrepresented student or a student with multiple demands e.g., research, academics, personal, as one participant described:

> I think that it's really nice to have like a group of students to like, understand your same experience, like most of us like, come from like a disadvantaged background, right? So, we can already bond over that, and how that affects our academics, but also like a whole group of students who knows what it's like to balance research and school, and a whole bunch of students who are like are in your major. So, we have shared experiences. And so, it's just nice to be able to like, connect. – Junior

Other students commented that the community is valuable as they learn about their peers' research, allowing them to increase awareness of other ways to advance science. This is supported through a quote from the second focus group:

> It's cool to see that other people are doing cool research as well. Um, I think, even though we're not in all in the same majors like more or less, we can all agree that we like, or maybe not like, research. So, it's nice to have other people that we can vent to and talk to and stay out with, even if it's not in the [program], even after the [program]. – Senior

Overall, students appreciated being in a learning community with one another, whether that be for support, to share similar experiences, or simply for being motivated to achieve their own academic goals, as a senior major reflected: "I feel like I'm held to a higher standard, being around people who also try very hard academically. So that's definitely made me try harder in my classes that I probably would have otherwise."

Collaborative assignments and projects

Students appreciated the opportunity to work with their peers on collaborative assignments and projects. This general sentiment was reflected by all student participants, yet they noted a group project that occurred when they initially entered the program as Juniors. Students noted this project, an ethical debate, being useful to cultivate friendships with their peers, corresponding to the idea of learning communities. The following quotes support this:

> I think, for the debate thing, I think what was helpful maybe was defending your work in front of a crowd, in front of peers. Um, our PIs were there. People were asking questions and we had to defend what we were arguing, which is similar to like a thesis defense. Um, so that was helpful. – Junior

> I think that especially with like the debate, because we just got into the program, a lot of us were super new, so forming those connections with all the other students was mostly beneficial, I think. Because we were all a little bit quiet and shy. It was a good opportunity. We were able to talk about our experiences in research. – Junior

Despite the positive feedback regarding the interpersonal connections made because of collaborative projects, students felt that the content and duration of some of the collaborative projects could have been more effective, as a Junior stated: "even though I didn't find the [assignment] to be particularly helpful, I did like um collaborating with other people in the [the program.]" This suggests the students assign value in cultivating interpersonal relationships as a result of these collaborative assignments.

Internships

Students are required to complete a summer research internship between their Junior and Senior year. This often results in a student working at a different institution for several weeks over the summer. The internship is usually paid and the program may provide additional support to offset additional expenses. As a result of the focus groups, it was revealed that all seven Seniors as well as two Juniors completed summer internships. Students expressed fondness of their internships, often referred to as Research Experiences for Undergraduates (REUs). One student reflected that without the program, they likely would not have had the summer internship:

> For the summer internship applications, I could—I thought it was easier for me to describe that I was interested in something, and that the [program's] reputation- its goal was to help me as long as I tailored that in. I wanted to do neuro-generation, or neuroscience, [for my summer internship] but I've never done it here [at home institution]. So, I think that kind of helped me with like the reputation of [the program], that its goal is to get people into graduate school and given me that edge. – Senior

Imposter Syndrome Others shared similar sentiments; namely, they believed they could compete against other graduate school applicants as the program allowed them to secure a summer internship they may not have otherwise. Despite the overwhelming appreciation for the internships, there were some unintended consequences from summer internships. This was revealed as students described having imposter syndrome:

> It really is something that happens when you go to your summer REU. Because there is [sic] all these students that come from distinguished universities, and you're just a student that came from [name of home institution]. So, when they came to the introductions during the first week at your summer REU, these students are like, "Oh, I'm from [name of institution]" or "I'm from [name of institution]." And there's some of them there, and once you list your uh institution, you kind of just have like this imposter syndrome for the first several weeks. And, you kind of question 'Should I really be here?' – Senior

Research question two

What factors in this training program contribute to the students' desire to complete their STEM degree?

Mentor support

This topic emerged for many of the students who spoke of how their faculty mentors provided holistic support- teaching research skills, asking about their well-being, or connecting them with professional development opportunities:

> Dr. (name) was also my first mentor. Something that I found very helpful was his office is right there. We talk almost every day. So, he doesn't just give advice on research. He's also really great with scheduling or just like anything school or even non-school related. So, that's been very helpful. – Junior

Some explained how their mentor assisted them with their required individual development plan (IDP) at the start of the academic year. Other support provided by mentors was not as direct, such as the importance of the general lab environment that the mentor oversaw as a junior explained: "the environment itself is really constructive and promotes learning, and it correlates with my schoolwork."

Another area within mentor support that resulted in students' persistence was the ability to ask mentors for letters of reference for graduate school or summer internship programs. Another student described how their mentor helped navigate financial struggles:

> So, we only got two weeks of pay for that program instead of the entire pay.. It was actually the other institution and [my] mentor who really like worked at it to try to get it at least that two weeks-worth of pay. – Junior

Overall, most students felt their mentors contributed to their persistence and success.

Networking

Students expressed persistence as it related to the networking opportunities afforded through the program. In fact, many of the students stated they would not have the ability to meet other professionals, students, or faculty if it were not for the training program; that, as an underrepresented student, they would not have access to such resources. One student reflected on working in their mentor's lab resulted in expanding their network:

> I think that [the training program] helped me with networking outside of the classroom and research in the lab. Like, I've been able to see a lot of other professors that I have classes with at least that work in the same hall as me. – Junior

Networking opportunities were provided for many students by their mentors, who hosted occasional lunch and learn seminars or had other undergraduate or graduate students working in their labs, as described:

> Outside of research, we have lunch together every Friday. The whole lab. And, sometimes [my mentor] will invite like other faculty members or just people on campus. Undergrads. Grad students. Everybody. And it's a really great way to get to know people. – Junior

Another student, a junior, commented that by having the requirement to work in their mentor's lab, they benefitted from meeting people: "I guess it would be the connections. Before I didn't know any animal professors or students and now I want to say I know half of the animal teachers, professors." Additionally, those students who completed a summer internship at a different institution cited the networking that resulted. Most noted, they acknowledged meeting other students and learning from faculty and doctoral students at the respective institution.

Self-efficacy

During both focus groups, students articulated increased self-efficacy in research and intent to pursue graduate school because of the training program.

> I guess for me it's given me like clout, I guess. Not like in a mean way but for summer applications, I realized that as soon I joined [the program], I got into every program I wanted to get into, but before [the program] initially, I didn't get into any program. So, it gave me a lot of clout in a sense. – Senior

Most noteworthy, students reported a shift of self-beliefs, thinking they were not capable of doing research before the program. Working in a lab on various tasks, however, allowed them to increase their self-efficacy in research. A senior student shared: "[the program] is a good opportunity to build research skills," and continued to say:

> What I've learned about myself is, I guess is that I'm capable. I definitely had a lot of doubts coming into it, but I guess I've learned that I am capable of learning, and um like being a better researcher.

Another student shared they were not planning on pursuing a doctoral degree until they began the program, mentioning they never thought they would even have the chance of being accepted. The program challenged this student and fostered their self-efficacy. This theme also emerged with some of the senior students reflecting on presenting their research at conferences; by articulating their research they developed confidence in themselves as well as the belief that can share research in other settings. In closing, a senior shared: "in general, the [program] has pushed me to be a better student, academically and scientifically, which I would not have been otherwise."

Funding

For many students, one of the motivating factors for joining the program was the funding it provided. Compensation is provided to students as a stipend throughout the academic year as well as tuition assistance:

> I thought there was a lot of benefits, and the tuition being covered was a big motivator 'cause I knew that it would guarantee a degree. Getting paid was kind of extra, but the tuition was very nice because it pretty much covers everything. – Senior

There is also financial support provided to the labs in which the students work, and a senior stated: "In my lab there's no funding, besides me… it allows me to get a lot more experience, to be able to design much more complex projects, because we have some money to do that now." As such, this student related funding to being able to gain experience to make them more competitive for graduate school applications. Similarly, another student shared how they were given their own research project as a result of the program's funding:

> For me, I was already working in a research lab and my professor said it would be better to do the [program] because you get more funding and you get more into the research, like you get your own project. – Junior

Perhaps most salient was several students sharing they were able to focus more time on academics, research, and planning for their futures as they had less of a need to worry about money issues, complemented by this quote: "I was already in a lab not getting paid and also it was really hard to manage time with work, school and research."

Discussion of results

This study highlighted the lived experiences of underrepresented students enrolled in an NIH-funded undergraduate STEM training program, consisting of four HIPs: learning communities; collaborative assignments and projects; undergraduate research; and internships. Many of the findings of the study confirm prior literature of HIPs studied *in isolation* of training programs, such as the impact of learning communities and undergraduate research experiences as having a positive effect on students (Kilgo et al. 2014; Kuh 2008, 2017; Stofer et al. 2021). This study demonstrated HIPs as being critical components of the program and fills in the previously mentioned knowledge gap which does not associate HIPs with training programs.

As noted, one significant finding of this study was imposter syndrome which was not previously observed in the program's historical data. Imposter syndrome reflects high achievers experiencing persistent self-doubt (Bravata et al. 2020). This was revealed in this study in two ways. First, Seniors specifically articulated having imposter syndrome while completing summer internship experiences. Additionally, it can also be inferred from both Juniors and Seniors who shared they did not think they were capable of doing research. Knowing the students had these feelings throughout their time in the program provides critical information for researchers and faculty executing STEM training programs as to consider students' self-doubt before, during, and after their time in the program.

Finally, this study confirms prior literature exploring impacts of training programs for underrepresented students; that is, undergraduate research experiences and learning communities as contributing to student persistence (Stofer et al. 2021). On the contrary, funder requirements of STEM training programs typically require quantitative reporting, such as the number of student participants, graduation rates, and acceptance into graduate school. This is a novel study which amplifies the voices of majority Hispanic-identifying students within the training program at an HSI in the Southwest United States. This qualitative research complements quantitative measures and allows for holistic considerations of similar training programs.

Limitations

Limitations associated with this study is that the findings do not reflect all 16 participants' experiences. The scope of this qualitative study was not to generalize findings, however, but to accurately reflect the lived experiences of most

of the participants. Saliency of findings was achieved through thematic analyses. As the purpose of the training program is for students to pursue a doctoral degree, an additional limitation of this study is that all student participants were currently enrolled in the program and not yet graduated. Some of the seniors were in the process of applying for graduate school but did not have plans solidified. Thus, specific outcomes were not captured in this study.

Conclusions

In this paper, we introduced HIPs as embedded in an NIH-funded STEM training program at an HSI in the Southwest United States. This qualitative study amplified the voices of 16 students, demonstrating how HIPs contribute to their persistence. These HIPs include undergraduate research, learning communities, collaborative projects, and assignments. The findings suggest the role of community amongst students and faculty mentors as largely contributing to persistence and imposter syndrome as a barrier. The findings of this study have several implications. Most notably, prior research points to a shortage of diverse students entering STEM disciplines in college and fewer students persisting through to degree completion. Such a shortage adds to a growing problem of lack of representation within the STEM workforce. This study, as being situated at an HSI and consisting of majority Hispanic-identifying participants, demonstrates the possibility of increasing the pipeline of underrepresented students into the STEM workforce, thus filling an important gap in knowledge. The persistence and experiences of these students can provide faculty and funders insight for future developments of training programs. Furthermore, this study encourages practitioners and faculty to advise students of underrepresented identities, to apply for such training programs. As this study demonstrated, students may be reluctant to apply for programs due to experiencing imposter-syndrome. This observation provides an opportunity for training program leadership to consider utilizing the HIPs as they work to improve underrepresented student persistence and educational attainment.

The findings emerged from this study provide an opportunity for empowering future research. Namely, mentoring was a contributor towards student persistence in the program, confirming prior literature of STEM training programs. Further studies may consider adding an additional HIP of mentoring. Figure 1 provides a visual depiction of the four HIPs assessed in this study with an additional one, suggesting five impactful practices of undergraduate STEM training programs to be undergraduate research, learning communities, collaborative projects and assignments, internships, and mentoring. Additionally, this study was qualitative in nature, supplementing other program-specific evaluation methods. By amplifying the voices of the students who participated in the focus groups, leadership and researchers were able to learn of students' experiences while still in the program. Additional qualitative methodologies and data collection could be fruitful in assessing students' experiences after they complete the program and are enrolled in their biomedical doctoral program. Finally, it is important for future research to continue exploring any intersectionality of underrepresented identities and student experiences.

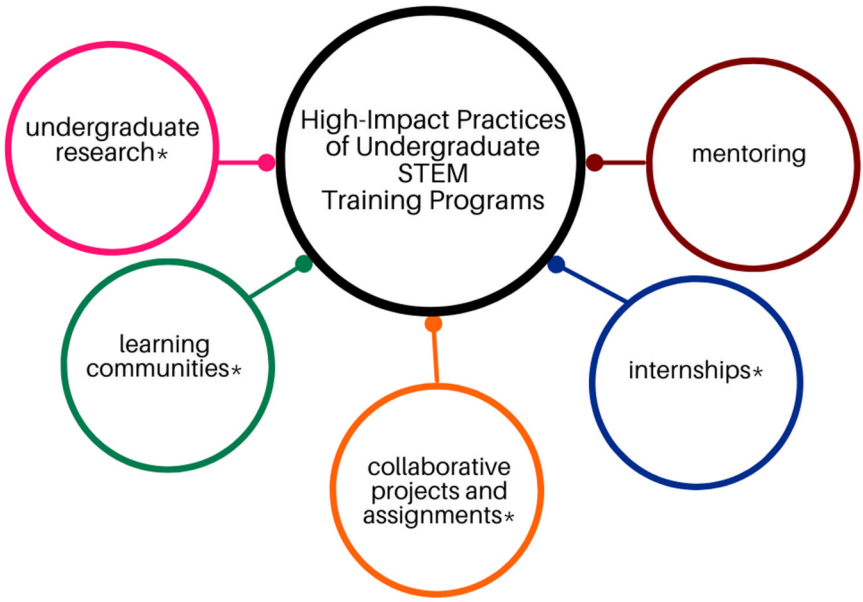

Fig. 1 High-impact practices of undergraduate STEM training programs. Visual depiction of impactful practices of two-year undergraduate STEM training programs. *Note* *denotes Kuh's (2008, 2017) high impact practices; mentoring is the proposed addition based on findings from our study

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Data availability The data that support the findings of this study are available on request from the corresponding author, ML. The data are not publicly available due to information that could compromise the privacy of research participants.

Declarations

Ethical approval The study was approved by the New Mexico State University Institutional Review Board (IRB) protocol #2206004092. All research was performed in accordance with relevant guidelines and regulations pertaining to human subjects.

Informed consent Informed consent was obtained from all participants. All participants were adults.

Conflict of interest The authors declare that they have no conflict of interest.

References

Association of American Medical Colleges (2022) Summer undergraduate research programs. https://www.aamc.org/professional-development/affinity-groups/great/summer-undergrad-research-programs

Bravata DM, Watts SA, Keefer AL, Madhusudhan DK, Taylor KT, Clark DM, Nelson RS, Cokley KO, Hagg HK (2020) Prevalence, predictors, and treatment of impostor syndrome: a systematic review. J Gen Intern Med 35:1252–1275

Ciesielkiewicz M, Chan C, Nocito G (2020) ePortfolio and service-learning: a tale of two cities connected by two high-impact practices. https://doi.org/10.3991/ijet.v15i05.12087

Ford M, Abraham L, Harrison A, Jefferson M, Hazelton T, Varner H, Cannady K, Frichtel C, Bagasra O, Davis L, Rivers D, Slaughter S, Salley J, Ford ME, Abraham LM, Harrison AL, Jefferson MS, Hazelton TR, Frichtel CS, Rivers DE (2016) Mentoring strategies and outcomes of two federally funded cancer research training programs for underrepresented students in the biomedical sciences. J Cancer Educ 31(2):228–235. https://doi.org/10.1007/s13187-015-0825-0

Fry R, Kennedy B, Funk C (2021) STEM jobs see uneven progress in increasing gender, racial and ethnic diversity. Pew Research Center

Giering JA, Firdyiwek YB (2020) E-Portfolios: deepening student engagement in learning. In: Handbook of research on fostering student engagement with instructional technology in higher education. IGI Global, pp 167–184. https://doi.org/10.4018/978-1-7998-0119-1.ch010

Hall AK (2017) Educational outcomes from MARC undergraduate student research training. In: Diversity in the scientific community volume 2: perspectives and exemplary programs. American Chemical Society, pp 3–11

Huang G, Taddese N, Walter E (2000) Entry and persistence of women and minorities in college science and engineering education. Research and Development Report. NCES 2000-601. National Center for Education Statistics.

Ives J, Falk J, Drayton B (2023) Broadening participation in STEM through equity-minded high-impact practices: a multimodal systematic review. Higher Educ 1–21. https://doi.org/10.1007/s10734-023-01165-y

Kilgo CA, Ezell Sheets JK, Pascarella ET (2014) The link between high-impact practices and student learning: some longitudinal evidence. High Educ 69:509–525. https://doi.org/10.1007/s10734-014-9788-z

Kuh GD (2008) High-impact educational practices: what they are, who has access to them, and why they matter. Report from the Association of American Colleges and Universities

Kuh GD (2017) Foreword: and now there are 11. In: Eynon B, Gambino LM (eds) High impact ePortfolio practice: a catalyst for student, faculty and institutional learning. Stylus, Sterling, VA

Kuh G, O'Donnell K, Schneider CG (2017) HIPs at ten. Change Magazine Higher Learn 49(5):8–16. https://doi.org/10.1080/00091383.2017.1366805

Lincoln YS, Guba EG (1985) Naturalistic inquiry. Sage Publications, Newbury Park, CA

McDaniel A, Van Jura M (2022) High-impact practices: evaluating their effect on college completion. J Coll Stud Retent: Res Theory Pract 24(3):740–757. https://doi.org/10.1177/1521025120947357

Merriam SB (2009) Qualitative research: a guide to design and implementation. Jossey-Bass

Morales D, Grineski S, Collins T (2017) Faculty motivation to mentor students through undergraduate research programs: a study of enabling and constraining factors. Res Higher Educ 58(5):520–544. https://doi.org/10.1007/s11162-016-9435-x

National Center for Science and Engineering Statistics (NCSES) (2023) Diversity and STEM: women, minorities, and persons with disabilities 2023. Special Report NSF 23-315. Alexandria, VA: National Science Foundation. Available at https://ncses.nsf.gov/wmpd

National Institutes of Health (2022) Maximizing access to research careers undergraduate - student training in academic research (MARC U-STAR) (T34). U.S. Department of Health and Human Services https://grants.nih.gov/grants/guide/pa-files/par-17-068.html

National Science Foundation (2022). Funding search. https://beta.nsf.gov/funding

Norris KC, McCreath HE, Hueffer K, Aley SB, Chavira G, Christie CA, Crespi CM, Crespo C, D'Amour G, Eagan K, Echegoyen LE, Feig A, Foroozesh M, Guerrero LR, Johanson K, Kamangar F, Kingsford L, LaCourse W, Maccalla NM-G, Márquez-Magaña L (2020) Baseline characteristics of the 2015–2019 first year student Cohorts of the NIH building infrastructure

leading to diversity (BUILD) program. Ethnicity Dis 30(4):681. https://doi.org/10.18865/ed.30.4.681

Okrent A, Burke A (2021) The STEM labor force of today: scientists, engineers, and skilled technical workers. In: Alexandria. National Science Foundation, VA

Oseguera L, Rios JDL, Park HJ, Aparicio EM, Rao S (2022) Understanding who stays in a STEM scholar program for underrepresented students: high-achieving scholars and short-term program retention. J Coll Stud Retent Res Theo Pract 24(3):773–809. https://doi.org/10.1177/1521025120950693

Padgett RD, Keup JR, Pascarella ET (2013) The impact of first-year seminars on college students' life-long learning orientations. J Stud Aff Res Pract 50(2):133–151. https://doi.org/10.1515/jsarp-2013-0011

Reilly D, Neumann D, Andrews G (2019) Investigating gender differences in mathematics and science: results from the 2011 trends in mathematics and science survey. Res Sci Educ 49(1):25–50. https://doi.org/10.1007/s11165-017-9630-6

Seidman A (2012) College student retention: formula for student success, 2nd edn. Rowman & Littlefield Publishers

Stofer KA, Chandler JW, Insalaco S, Matyas C, Lannon HJ, Judge J, Lanman B, Hom B, Norton H (2021) Two-year college students report multiple benefits from participation in an integrated geoscience research, coursework, and outreach internship program. Commun Coll Rev 49(4):457–482. https://doi.org/10.1177/00915521211026682

Stormes KN, Streicker NA, Bowers GK, Ayala P, Urizar Jr GG (2022) Impact of undergraduate research training programs: an illustrative example of finding a comparison group and evaluating academic and graduate school outcomes. Scholarship Practice Undergrad Res 5(3):25–36. https://doi.org/10.18833/spur/5/3/8

The Carnegie Classification of Institutions of Higher Education (n.d.) About carnegie classification. https://carnegieclassifications.acenet.edu/

Tracy SJ (2019) Qualitative research methods: collecting evidence, crafting analysis, communicating impact. John Wiley & Sons

Watson CE, Kuh GD, Rhodes T, Light TP, Chen HL (2016) ePortfolios–the eleventh high impact practice. Int J ePortfolio 6(2):65–69

Yancey KB (ed) (2023) ePortfolio as curriculum: models and practices for developing students' ePortfolio literacy. Taylor & Francis