Pursuing Retention and Success Of Rural and Diverse Stem Students: A Qualitative Investigation of a Program Ecosystem and Undergraduate Participants

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Abstract

Beginning in 2016 and with funding from the National Science Foundation, the Rural and Diverse Student Scholars Program at George Mason University supported two cohorts of diverse undergraduate students from rural Virginia in their pursuit of a STEM degree. A holistic program design and individual components aimed to combine to support student success. In a qualitative study with journal prompts, focus groups and interviews, the program was assessed, and insights were gleaned regarding the participant population. Results reveal the importance of community and mentoring in supporting student persistence and success. Participants described being rural as part of their identity and many maintained significant relationships with home and family, even after matriculation. Conclusions from this study are consistent with scholarly precedent and have implications for colleges and universities serving similar populations.

Keywords
STEM education, retention, persistence, qualitative methods, student success, rural identity

Introduction

Persistence in STEM is a significant challenge, especially among students traditionally marginalized or underrepresented in STEM (Angrist et al., 2009; Tsui, 2007; Whalen & Shelley, 2010). Across the landscape of STEM higher education and research related to student persistence, much has been published related to race, gender and socioeconomic status (Cimpian et al., 2020; Lopatto, 2004; Mertens & Hopson, 2006; Nelson, 1996; Palid et al., 2023; Pender et al., 2010; Riggins & Frierson, 1996, 1996; Robnett et al., 2015, 2018; Tsui, 2007; Villa et al., 2013; Villarejo et al., 2008; Walton & Cohen, 2007). A recent systematic review from Palid et al. provides a thorough description of "STEM programs that produce positive outcomes for underrepresented minorities" (Palid et al., 2023). In recent years, scholars have started to recognize college students from rural communities as another population that merits attention.

Gibbons et al. describe results from a S-STEM program which provided support for rural Appalachian students (Gibbons et al., 2022). In their study, graduate student mentors and strategies for success were identified as particularly impactful. Stephens et al. identified practices that reduce social class disparities that consequently improved student college success outcomes (Stephens et al., 2015). Students' expectations regarding college are also different depending upon the setting of their high school (Li, 2019). Sims and Ferrare compared rural and urban first generation students to explore the various supports these two populates needed (Sims & Ferrare, 2021). While the study was not specific to STEM majors, it revealed the importance of identity and social capital variables in the student success equation.

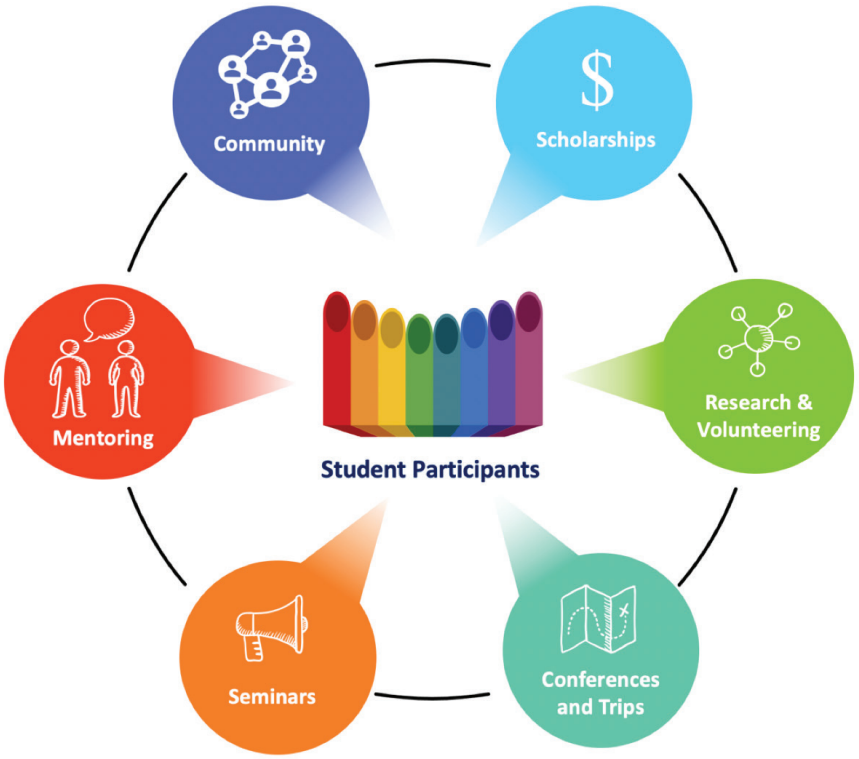
In a qualitative case study, Worsham et al. explored the college choice decisions faced by rural students interested in engineering majors (Worsham et al., 2021). Their research showed the importance of school and community as a resource and observed a dissonance between aspiration and expectation. Bryan and Simmons used Bronfenbrenner's ecological framework in a qualitative study of first-general rural students from Kentucky, identifying seven themes related to participant experience, many of which are related to relationships and identity (Bryan & Simmons, 2009). Much of the other literature on rural students focuses on secondary education, rather than college, and many questions remain regarding the mechanisms and interventions which effectively support students who came from rural areas in their pursuit of STEM undergraduate degrees.

Beginning in 2016, the Rural and Diverse Student Scholars (RADSS) Program has supported diverse STEM students from primarily rural parts of Virginia as they pursue a bachelor's degree at George Mason University (Mason). Mason is a suburban research-intensive public university located approximately 20 miles from the urban center of Washington, DC, on the eastern, mid-Atlantic coast of the United States. RADSS was funded from a National Science Foundation S-STEM grant, which provides scholarships and programming support (National Science Foundation, 2024). In collaboration with Mason's Office of Admissions, the RADSS program aimed to increase the number of students matriculating from rural parts of the state (Office of Management and Budget & Virginia Department of Health, 2005). At the beginning of the RADSS program in 2016, the number of students enrolling at Mason from rural VA high schools was very small; in fact, the RADSS program participants constituted a majority of the students coming from rural areas. However, since this program's inception, we observed an increase in the number of applications and matriculations from rural Virginia high schools; a detailed description of these results and the RADSS recruitment efforts was published in 2020 (Jones & Cleaver, 2020).

Drawing from literature precedent, the RADSS program was designed to have a holistic strategy to support participants once they matriculated to Mason. Effective interventions include summer bridge programs, mentoring, research experiences, tutoring, career counseling and awareness, learning centers, participation in workshops and seminars, academic advising, financial support, and curriculum and instruction support (Tsui, 2007; Whalen & Shelley, 2010) . All these strategies were utilized to support two primary cohorts of students beginning in 2016 and concluding in 2023. First, all student participants received an annual scholarship ($5,000 (2016-2021) or $6,000 (2021-2023) to assist with tuition expenses. Most participants attended a summer STEM Bridge Camp before beginning classes. Four students received specialized academic support from experienced mentors and all students participated in regular program activities. Monthly journal prompts encouraged reflection and a group of participants traveled to New York City for a conference in October 2019. Participants became Learning Assistants for undergraduate courses in the College of Science, attended traditional seminars on science content and seminars on career development, and some had mentored undergraduate research experiences. Overall, there has been a diverse ecosystem (Figure 1) of support for these students at Mason.

The theoretical framework for this study is the social-ecological model inspired by Bronfenbrenner (Bronfenbrenner, 1977, 1986). Bronfenbrenner's model was originally developed to apply to child development but is relevant to other social-ecological systems, like the RADSS program, and provides a means of exploring the various personal and environmental factors that influence individual behavior. In Table 1, we summarize the five components of the social-ecological model, its historical application to child development (Guy-Evans, 2023) and our specific application of the model to the participants in this scholarship program. An important difference between these two applications of the model is at the mesosystem level; in child development, parent-teacher interactions are relevant, however in the context of the RADSS pro-

Figure 1. Ecosystem of support in the RADSS Program



gram, where participants were adults, there was no direct interaction between RADSS program leaders and parents of participants.

Considering the social-ecological model, we aimed to better understand how the RADSS programmatic ecosystem corresponds to participant persistence in the College of Science. We sought to answer the following scholarly questions:

1. *How do the individual components and holistic design of the RADSS Program contribute to the retention of, and the timely completion of a degree for, rural and diverse Virginia students in STEM?*
2. *What insights can be gained about the program participants?*

These research questions are important because the reality of the participants' involvement in the program may or may not match the strategic program design from a theoretical perspective. For clarity, this study relates to education of students who describe growing up in a rural place not "rural education" in the sense of education in a rural area. This paper describes the longitudinal and qualitative assessment of the student experience and the primary program components related to persistence and success, defined as completion of an undergraduate degree.

Table 1. Application social-ecological model components to child development and the RADSS program and participants

Model Components	*Application to Child Development*	*Application to RADSS program and participants*
Microsystem	Child's direct contacts and interactions (child-parent, child-sibling, child-teachers, child-peer)	Participant direct interactions with peers, faculty, and family
Mesosystem	Interactions between child's microsystem (parent-teacher, teacher-peer, peer-peer)	RADSS group interactions and community
Exosystem	Formal and informal systems that indirectly influence child's microsystems (neighborhoods, parents' workplaces, social media)	Mason internal academic and physical structures (e.g. degree programs)
Macrosystem	Child's cultural upbringing (socioeconomic status, wealth/poverty, ethnicity)	Personal descriptors, rural and/or diverse identity, socioeconomic status and regional characteristics
Chronosystem	Environmental changes, historical events, and major life transitions (starting school, moving, parents getting divorced)	Starting college at Mason, changing majors, the COVID-19 pandemic

Methods

All research activity for this project was approved by George Mason University's Institutional Review Board (872083-12). Research instruments (journal, focus group, and interview prompts) are included in the supporting information.

Participants

The participants in this study joined the RADSS program at various times and represented different identities. When they first joined, all students elected to consent in writing to participate in the knowledge-building and research components of the program. Consent was reaffirmed annually in the first meeting each fall semester and prior to the focus groups and interviews. Due to the small numbers of participants and to preserve privacy, we summarize the participant details for the two cohorts in Table 2.

All students in Cohort 1 matriculated to Mason in September 2017 and ten members of Cohort 2 started classes in September 2018. The remaining 5 members of cohort 2 were added (from Spring 2019 to Fall 2019) to the program to replace those who left the program or left Mason. Figure 2 summarizes the longitudinal persistence data of the 25 students in the program.

Data Collection

Journal Prompts: Students responded to journal prompts during their first two years in the program. The prompts sought to explore the students' current perspectives and future plans, while also providing space for students to communicate any requests for support to the grant team. Journal prompts included topics related to:

- *Personal Reflection*, which included questions about identification as a rural or diverse student and as scientists, reasons for choosing Mason, and perceived growth in their field(s) of study;
- *Resources and Challenges*, which included questions related to students' awareness, and use of, resources on campus, experiences with coursework, navigating aspects of the university, and relationships with professors/staff; and
- *Research*, which included prompts related to students' interest in research opportunities.

Journal prompts were administered through Blackboard, the Learning Management System (Blackboard, 2022)

Table 2. Description of program participants and aggregate demographics.

Characteristic	*Cohort 1 (Hydrogen)*	*Cohort 2 (Helium)*
Total student participants	10	15
Underrepresented minority	3 (30%)	7 (47%)
Identified as a woman	8 (80%)	11 (73%)
From rural Virginia	10 (100%)	12 (80%)
Graduated on or before May 2023	8 (80%)	5 (33%)
Changed major from STEM	0	5
Academic suspension	1*	4**
Left Mason before graduating	2 (20%)	5

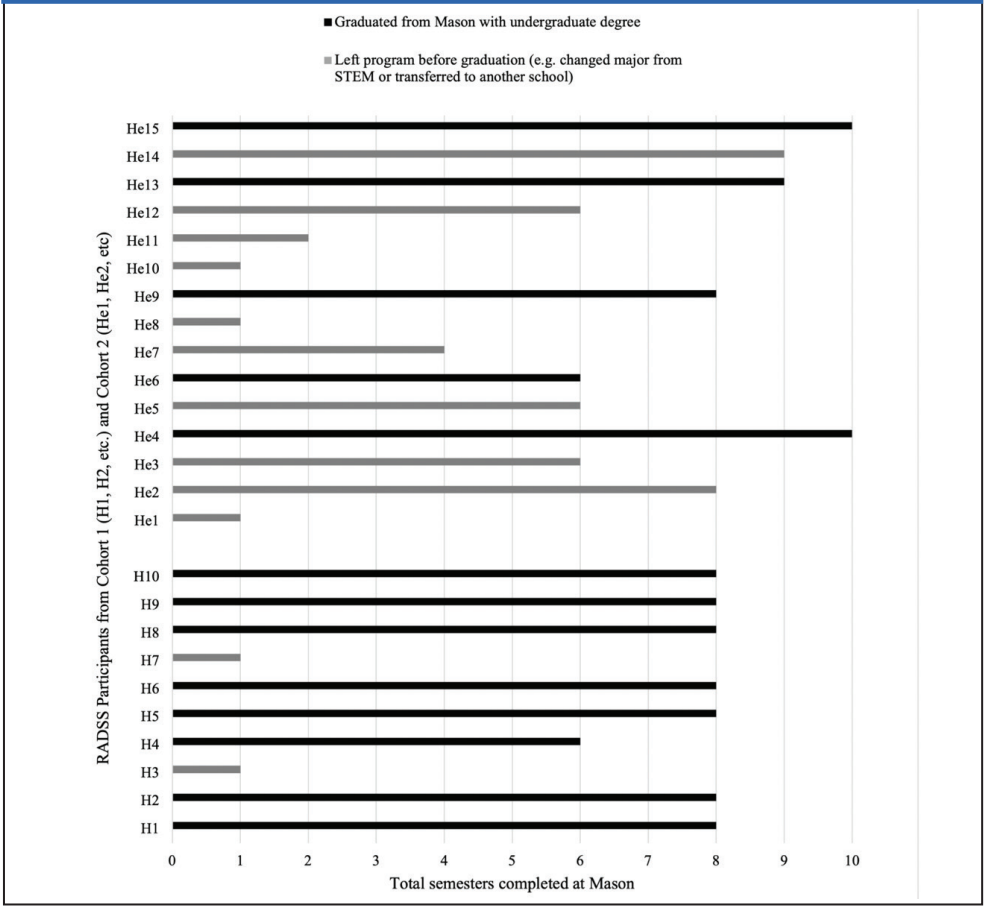
** Suspension resolved within 2 semesters,*
*** 2 suspensions were resolved, while 2 were unresolved and resulted in leaving Mason*

utilized at Mason, and students submitted written responses electronically. Either 3 or 4 prompts were administered each semester, with each prompt containing 2-3 questions.

Focus Groups: During the spring 2019 semester, Dr. Emenike visited Mason to conduct in-person focus groups with RADSS participants. The students in the Hydrogen cohort were in their second year at Mason, while the students in the He-cohort were in their first year. The questions asked in the semi-structured focus group were related to students' experiences at Mason thus far (including with coursework, academics, and extracurricular activities), the support they had received or accessed (at the university or specifically thought the RADSS program), challenges they had faced (or were facing), and types of support of activities they were interested in for the following year. Based on students' availability, Dr. Emenike facilitated a focus group of 5 students, 4 students, 2 students, and conducted an individual interview with one student.

Interviews: During summer 2021 and the fall 2021 semester, Dr. Emenike conducted individual, virtual interviews via Zoom. Most students in the Hydrogen cohort had recently graduated with their degree from Mason in May 2021, although a couple had been delayed in their progress by the pandemic. Students in the Helium cohort were in various stages of their degree progress: some were "on track" to graduate in May 2022, some had taken time away from campus in AY 2020-2021 to avoid remote learning during the pandemic, while others were planning to spend an extra year due to a variety of factors – changing majors, challenges with coursework during the pandemic, etc. Dr. Emenike conducted 13 individual interviews.

Figure 2. Summary of semesters completed while in the RADSS program. Participants are identified from Cohort 1 (e,g, H1, H2) or Cohort 2 (e.g. He2, He3). Note, the x-axis of this graph relates to total semesters in the RADSS program. Students in the cohorts did not all start in the same semester or at the beginning of their time at Mason.



Data Analysis

Responses to journal prompts were submitted in electronic format by the student. Deidentified responses were imported into NVivo 12 (QSR International, 2022), a qualitative data management software. The audio recordings from focus groups and interviews were transcribed, and the de-identified transcripts were imported into NVivo. Emergent codes were created in an iterative fashion during the data analysis process. A constant comparison method (Corbin & Strauss, 2014; Glaser & Strauss, 1999) was employed to ensure that new data added to codes was consistent, and codes were updated or revised to reflect new data that was included. We worked with and mentored four undergraduate research students to code the journal prompts over a three-year period. Dr. Emenike continued analysis of the focus group and interview data using with the constant comparison method, creating additional emergent codes, as needed. Quotes are attributed using pseudonyms and have been edited to remove false-starts and filler words. Occasionally, we edited quotes (denoted with brackets) to clarify references to time, location, and other people. Rather than listing real names as identified by the speakers, faculty and program leaders are identified by their title and last initial.

Results

In this section, we present the key results related to the components and holistic design of the RADSS program. While one of the goals of the RADSS program was to support retention of the student, we take the student perspective and discuss results with respect to persistence. We also present data regarding the RADSS participants and the effects of the COVID-19 pandemic on their persistence and degree progress.

Program Components

First, the summer bridge camps were a significant part of the cohort experience. Eight of the initial 10 students from the first cohort attended the Math Bootcamp and STEM Bridge Camp in July 2017. For the first group, these summer experiences began to knit the cohort together. Looking across the table at Patricia, Frederick said in the focus group, *"[Patricia] and I were friends coming in the first day [of the semester], and that helped a lot having people that I-- that I knew here coming on my first day."* Patricia also said, *"My favorite part of STEM camp was that STEM camp is where I met my best friends that I have now, and I am very grateful for that. It gave me a chance to meet people who have similar interests as myself."* In a response to a journal prompt about the camps, Jennifer said,

> *"I think it gave me a good introduction to, like, some friends to begin with, 'cause, um, we went to the STEM Camp before freshman year, and that was really helpful to get some friends. It also helped me with study methods and stuff my freshman year, and I had friends within the RADSS program that were, like, taking similar classes. And we would, like, meet and study and do stuff like that. I enjoyed the RADSS program because I feel like it just provided me a sense of community within the program."*

In the second cohort, only three students were able to attend the camps before their first year and those who did reported making connections with other students not in the RADSS program.

> [Henrietta]: *"I don't know anyone in RADSS that was in the boot camp, but the people that I met at the boot camp last summer, I still know and I still talk to now, and I think that made transitioning into college a little easier when it comes to friends because I already knew people when I started classes."*

Students expressed gratitude that they had the extra practice in the summer before their first year of college. Many felt underprepared for college level courses and the Math Bootcamp and STEM Bridge Camp increased their confidence. Elaine said, *"Going to the Math Bootcamp helped me tremendously, as it helped me pass the entire math placement test easily going into Calc 1". Jennifer noted, "My favorite part of the boot camp was getting a feel for the professors . . . and getting an idea of what I should expected once the year started."*

Second, the RADSS-sponsored trips were some of the highlights of the participants' experiences when they reflected on their overall time at Mason. They shared that these trips to urban areas, like Washington DC and New York City, taught them about new opportunities and perspectives.

> [Patricia]: *"We got to go to Columbia University, and we heard some really incredible speakers. But then we also just went and got pizza, and we stayed in the hotel. And we rode on the train, and I never rode on a train before. That was really fun."* [...] *"It was a women's conference, so that was really fun, too, to just go with all these women and, you know, empower each other in our fields, um, and see all these women who had succeeded and gone on to further education and overcame their backgrounds and everything, which was really cool."*
>
> [Henrietta]: *"We went to New York in 2019, and I've never been to New York before. And we went to the [Smithsonian Air and Space Museum] to listen to the women that helped with Apollo 11. It opened my mind to the opportunities that I have."*
>
> [Tia]: *"I had never really noticed or understood how kind of easy it is to just go to DC. You can just go there [laughter]. You can just, on a weekend, decide that you want to get your Metro card and just hop on the [Mason] shuttle to get to the Metro Station, and then just go to DC. And just spend however long you want there. And that, like, kind of blew my mind a little bit because I don't know how to use Mason transportation all that much, but I've really been, like, getting into it because Mason has so much [opportunity] there so I can discover and learn."*

Third, some students had significant experiences and research opportunities in the summers. One RADS scholar wrote in response to a journal prompt about one summer experience that was coordinated by a RADSS faculty member, Dr. B, a biologist. *"In addition to my bank job, I worked at Riverside Tappahannock Hospital in Tappahannock, Virginia once a week in the lab this summer. In the lab, I got to assist on simple tests, such as complete blood counts and prothrombin time tests. . . . In July, Dr. B, my friend Alexa, and I went to Sapelo Island in Georgia. Here, we assisted Dr. B in teaching marine biology to high school students from Georgia and helped students in their field experiences." In response to the same journal prompt, Leigh wrote, "I was a counselor for FOCUS summer camps with Professor K. I also worked as an intern at the Potomac River Fisheries Commission in Colonial Beach. I participated in a segment of research with the Department of Natural Resources through my internship. In this research, we counted various species caught in a beach seine. I learned how [the state] collects its data for their fisheries and how the information is applied and disseminated to Mason."*

Fourth, many students described the importance of the relationships they developed with faculty leading the RADSS program. In his interview, Behrem said, *"I found that, um, one of the most important things is how close you get the professors. [. . .] and I think it's good to have a kind of a mentor especially in such a large institution where you have many options. They kinda narrow it down for you. And Dr. J really helped me a lot with that."* In a focus group, Leigh explained how she appreciated the support of a former program leader: *"coming into the program, when Dr. S was still here, he helped me a lot to network with other students that, um-- that were mostly, like, juniors and seniors. And they helped me navigate through and-- how to take my classes and that really, really, helped more than any adviser could."*

In an interview, a RADS Scholar shared how RADSS program leader Dr. J helped them in an academic and medical crisis. *"I had to get a [medical procedure] in the middle of the semester. And I had to take a week out of school, and . . . it was very challenging because I had to work with, like, all my professors to make sure that, like, I could get my work done and I had one [graduate teaching assistant] that would not budge. He told me that since it's [this procedure], I should be able to do my homework and study for my exam after the surgery. [laughter] And luckily, um, Dr. J talked to him, and it got sorted out. But that was very challenging because I was very stressed, and I was also dealing with, like, medical stuff at the same time."*

As further evidence to this point, Jocelyn explained, *"I mean the only thing I've really done is like the [RADSS] meetings and meeting with Dr. J like every month. That really helps me. It feels like she's like a mentor. Like she helps me a lot, so. And I could talk to her and like how my classes are going."* When asked if she had any other mentors outside of the RADSS program, she said no, and when asked if she was interested in having any mentors outside of the RADSS program, she responded, *"Hopefully along the way."*

Related to the value of faculty mentoring and support, many students struggled with their choice of major. For some students this change was accompanied by a lot of stress and turmoil, Henrietta said in her interview, *"I was a bit heartbroken in changing my-- in the thought of changing my major because, um, I like [the idea of] having the title Medical Laboratory Scientist 'cause it's, it's more specific than just Biology. But as I understood that I'm still gonna do what I wanna do, and me changing my major is not me changing my life goals or my career, um, I kind of felt a little better about it since, I'm still gonna be on the same path."* Jocelyn said, *"I like biology but then sometimes I do think about changing my major, because I have to take a lot of chemistry classes and sciences."* And Jonathan summarized his difficulty deciding a major: *"at first-- I changed my major, like, two or three times. [laughter] Um, I was in physics at first, then chemistry, and then I, and I, I was, like, on the edge between, like, biology and neuroscience. So yeah, I just stuck with neuroscience."*

Finally, the scholarship itself was perceived to be very valuable to many participants. Each participant received $5,000 per year ($2,500 per semester) and was eligible for additional research support during the summers; in the final year of the program, the scholarship was increased to $6,000 per year ($3,000 per semester). For many this scholarship was a major factor in deciding to enroll at Mason. In a journal entry, Celeste wrote, *"Once I received the scholarship for the RADSS program, it basically*

sealed the deal on what college I was attending." Responding to the same prompt, Leigh wrote, *"I decided to enroll in Mason because I have a very persuasive mother and I was offered this scholarship."* And Devin wrote, *"I first became interested in Mason when it came up in my search for colleges in Virginia that had good STEM programs and also when a Mason representative came to my school, and I heard about this scholarship. I finally decided to enroll when I knew that Mason had every major that I could ever possibly be interested in studying."*

When asked in her interview how important was the financial scholarship associated with this program and how important was that in her decision to come to Mason, Jocelyn replied, *"It was very important. George Mason really wasn't my first choice to come to. And then once I applied, and then I got the scholarship, it made a big, huge difference, [. . .] like I didn't have to pay anything for my first year of college."*

In his interview, Paul described the RADSS scholarship as *"a blessing"*, but also recognized that he had other financial needs. *"I mean, the RADSS scholarship helps a lot, but I still gotta be able to pay, like, rent right now, you know. The landlord is not being considerate during the pandemic, so. So that's why we're moving down to another house this upcoming month."*

Holistic Approach to Supporting Students

The RADSS program took a holistic and multi-faceted approach toward supporting the student participants and encouraging persistence in their STEM major and minor programs. For those individuals who completed the program, the holistic and comprehensive nature of RADSS was important. Frederick mentioned several program components in a journal entry,

> *"When deciding where to attend, my decision was not a hard one. I was accepted into many colleges, and offered various scholarships, but none compared to the RADSS program. It was not only the financial support of the RADSS program that was helpful, but the support team [I was] involved with. I really liked the benefits of team of professors, financial aid, and a peer mentor that's always available to help. That sealed my decision to attend Mason.*

Two years later in a focus group, Frederick reflected that *"at first, my background was kind of almost holding me back, um, because I was pretty, pretty scared, but pretty excited when I chose to go here. Like I said, RADSS had a really big, big deal in that."*

Feeling poorly prepared for college courses was a common theme for participants. Devin said in her interview, *"for my rural background, like I think it actually like hindered me in the beginning because, for me, I was I would say almost clueless about what college was like because I don't feel like my high school gave me the ability to like do well in my classes."* In deciding to switch away from a math major, Devin also noted in her interview, *"I think the math major was more difficult for me especially because, like, coming from a rural background, I-- math was not as heavily pushed in my school as it is in, like, schools from this area [in northern Virginia]."*

Over the first six years of the program, multiple RADSS participants had failed semesters, five were placed on temporary academic probation, and four decided to leave Mason and the program. In a focus group, Leigh said, *"I think this program is really helpful with it because I don't think, like, without this program, I would still be here at this point in time."* And in her focus group, Breanne shared this story:

> *"My first semester was a little rocky because I was thrown into a class where I had never touched the stuff before. And I, like, couldn't get out of it in time so, like, I ultimately failed it which, like, really brought my self-esteem down. And I like-- I contemplated on, like, going home and not coming back and, like, RADSS has, like, really helped me, like, get myself back on track. So, like, this semester, it's a lot better. I'm more involved. I'm doing more things with the organizations I'm in, and it's a-- I feel a lot better."*

In her interview, Cameron described the role of the RADSS community in her success in college. She said,

> *"Like I've said a billion times the [RADSS] community was a huge part, um. The faculty mentors, Dr. J was amazing, throughout my time at Mason. She was encouraging. She pushed-- if I was not, you know, reaching my greatest potential, she would tell me what to do, what I need to do to get to where I want to go. Um, just listening, if I needed to talk about something to an all-around wonderful person to have throughout, you know, undergrad. As well as, like my-- the other students in my cohort, we came in as freshmen together. And then you know, a bunch of us got to graduate together and had classes together all four years. . . we could study together, we could, you know, talk about classes. And then there are a lot of guest speakers and things like that, that would have at meetings that introduce new ideas, or tell us about opportunities that we didn't really think of ahead of time whether it was a job path or a school path or any type of thing for the future. So it kind of broadens your perspective on whatever your field is."*

Sabrina joined the RADSS program in the fall of her sophomore year. When asked to describe her experience in the program the following semester, she said, *"The RADSS Program has been really, really helpful because I've gone to conferences. I've gone to, like, these little events [inaudible] had that opportunity to, like, network and meet a bunch of people that, like, sort of had similar experiences and were interested in similar things."*

Patricia was in the RADSS program for all 4 years of her undergraduate program. When asked to describe how the RADSS program played a role in her time at Mason, Patricia said,

> *"RADSS really helped me professionally. I mean, we've done resume workshops. They've helped with, 'Well, these are the classes you should take, and these are like the professors.' And, um, we did that STEM conference in New York. That was really awesome. And Dr. J helped me get that research position in Dr. H's lab, and I now have my name on a paper because of it. So that's awesome. . . we just really got that professional foothold that a lot of other students didn't have. And Dr. J has actually helped me a lot emotionally. She supported me through a lot of things, like having to retake organic chemistry."*

Responding to a similar question, Behrem said this about how RADSS was connected to his overall undergraduate experience.

> *"RADSS played a huge part not only financially with the help of the scholarships and everything, but with the guidance of Dr. J and her supporting staff. We would have [. . .] monthly or semester-wide meetings, where they would tell us about research opportunities. And tutoring opportunities. We shared a lot of conversations about what type of classes to take, what professor to take, and where we were in our undergraduate career. So, I would definitely say RADSS helped a lot because of all my friends that I made at Mason. I was supported by a [. . .] focused community of teachers and students."*

Characteristics of Participants

As described in Table 2, the 25 participants in the RADSS program aligned with multiple identities, including rural and/or diverse, many of which are underrepresented in STEM. A majority of participants described diversity as a reason they opted to come to Mason. After graduating, Behrem reflected, *"I think one of my most favorite things about George Mason is that it has a ton of diverse students. Like, for almost every diverse group of people, you can find that there's a club for them, you know. So that's one of the first things that I did as a diverse student."*

While 100% of Hydrogen and 80% of Helium were from rural Virginia, we observed in journal prompts, focus groups and interviews that many of the student participants in the RADSS program identified themselves as rural. The responses (in Table 3) illustrate the various ways participants described identifying as rural when responding to journal prompts their first semester in the program. In a different journal entry, Elaine wrote about the differing perspective of what is "the city": *"when I refer to Fairfax as "the city" I get random angry people telling me that it is the suburbs."*

Paige shared how some other students have pointed out that she has an accent, sometimes as a joke. She said in a focus group, *"I guess I adjust my voice depending on like where I am . . . I actually feel like when I talk southern up here, it makes me feel less-- it makes me seem less intelligent, so I try to pronounce every syllable."*

Table 3. Four entries responding to the journal prompt, "Do you consider yourself rural?"	
Participant	***Select responses***
Jennifer	*"I describe myself as coming from a rural area because my high school is right next to a cow field, the hallways were always muddy and smelt like cow manure, and there were many kids who worked early on the farms and came to school after they finished. I myself don't consider me as a rural person, it just so happened that I lived right across from a dairy farm. I never minded being born and raised in a rural area, but it has pushed me to live in the city."*
Patricia	*"I do describe myself as coming from a rural area because there are not a lot of opportunities in [my hometown] and I left so that I could have more."*
Leigh	*"I did come from a rural area because there were fields of trees and grass basically everywhere and almost everyone was related."*
Elaine	*"My life back at home was fairly bleak, so coming here was a nice way experiencing life more and knowing that there is more to the world than just my bedroom."*

Jocelyn also shared in her interview, *"My roommate, she's from the city. She always tells me I'm country [laughter]. She's like, 'You can hear it in your voice.' I was like, 'No, you can't.' And she was like, 'Yes, you can.' And so like yes, . . . well maybe I am rural."*

The student participants also describe significant connection to their families. In her focus group as a second-year student, Leigh said,

"I talk to my parents-- I literally talk to my parents every day and I tell them, like, what's going on, and they give me advice 'cause, like, neither of them have been to college and they haven't really experienced anything, so I guess they kind of can experience it through me or they support me in whatever way they can."

During her first 2 years at Mason, Jocelyn regularly made the 3-hour trip to her hometown every weekend. And while in school, she would talk to her mom or her grandmother every day. *"I talk to my mom. I tell them how I'm doing in school and my mom always asks me. She's like, "I couldn't do that work."* And participants described their parents as important influences in their lives and that their support is significant. For example, in her interview, Cameron said, *"My parents have known that I am not going back [to where I grew up] since I was like five, like they are aware. They're very, very supportive of anything I want to do."*

Pandemic Shifts

In this final section of results, we present results related the COVID-19 pandemic which impacted both cohorts of this program. When the world shut down in March 2020, Hydrogen was in their third year and Helium was in their second year at Mason. The 2020-2021 academic year was primarily virtual for most of the participants, with some exceptions for in-person labs. Many students of the Hydrogen cohort had moved near Mason's Fairfax campus. Those Helium students who had planned to live on campus were required to move back home and take classes remotely classes for the year.

Reflecting on the year she was at home, Elaine shared in her interview, *"I think definitely having to live at home made a much bigger impact on my grades and things. I had to completely change the way I studied because before, I was never really time efficient."* And she also talked about how her rural town didn't have fast internet access. *"I have poor overall internet [at home]. Sometimes I drop off of Blackboard connections, but it's pretty easy to relog on and it kind of works again."*

Patricia, who then lived in Fairfax, didn't visit family during COVID in order to keep them safe. *"So [at home] I live with my mom and my older brother, but we live right beside my grandparents. So they're our neighbors and, of course, we see them every day all the time. And I was scared coming from Fairfax, this big city with the big amount of [COVID] cases, that I would get it, even if I was asymptomatic, and take it home and give it to my grandpar-*

Table 4. Four responses responding to the interview prompt, "What did you plan to do in your summer 2020 that you couldn't?"	
Participant	***Select responses***
Cameron	*"Yeah, so I had applied to a lot of internships, kind of research opportunities for the summer, all of which were canceled."*
Elaine	*"Unfortunately, I spent many, many, many days and hours applying to a ton of summer internship opportunities, and of course all of those were cancelled which was really unfortunate. I was able to kind of find some research opportunity at school, but it was online and it wasn't like a thing that I would probably have picked first."*
Patricia	*"I actually applied to a few different internships, which is what I was expecting to do. I applied to one [in] Richmond [Virginia] that was global health based, which I really wanted. […]. So I really was excited about that. I was also working in a research lab up until right before the pandemic at Mason. It was really fun. I was kind of expecting either to continue with that or to get an internship. … But of course, they all got canceled.* [In summer 2020, Patricia was hired to work in a COVID testing lab through a roommate's friend.] *[… The job] definitely wasn't what I was expecting, but it was a really great experience 'cause I got experience in basic lab work, pipetting, [and] making dilutions of chemicals. […] it was really cool to like see myself excel in a situation that was totally unexpected but very welcomed."*
Behrem	*"I couldn't do a lot of physician shadowing because they were really limiting hospitals to essential personnel only. The same goes for research. I had a research opportunity in spring 2020 with Inova Hospital. And towards the first half of the semester, I was on-site in Inova Hospital in Fairfax, doing my research. But then due to the pandemic, I had to do my research remotely from home, so I had to set up VPN and do everything at home."*

ents. And so I really didn't wanna do that."

One RADS Scholar explained their decision to take a leave of absence during 2020-2021 academic year. *"I just felt like, um, I wasn't really getting the full experience of being in college. I just didn't wanna take a chance and do it online because I'm more of an in-person, hands-on learner anyway. I feel like since I know that that's how I learn, I probably made the right decision for myself to not-- to take a year off."*

There were significant repercussions from the year online. The program leaders observed students struggling to adapt to the online learning environment, multiple failures at first and sometimes second attempts of key courses, such as Organic Chemistry. Two students opted to take a leave of absence from classes, and it was generally more challenging for the cohorts to meet together and with program leaders. Rather than in-person meetings or seminars or events, the RADDS program held virtual events via Zoom in the 2020-2021 and 2021-2022 academic years; in the latter year, this was despite the fact that many students had returned to campus. We modified the research procedures to add questions related to the pandemic to the semi-structured interviews, which were completed in the summer and fall of 2021.

[Henrietta]: The *"pandemic has hindered some things. Because last year, we were trying to do more as, um, as a community, to do more with each other and to interact with each other. And so with us not having to be, um, in-person a lot, that kind of hindered some things." I really appreciate those [RADSS leaders] that have sent out resources and [shared] ways to help us, whether it's for tutoring or whether it's for financial reasons, whether it's just to communicate. Because, um, one of the things that we discussed in our little meetings was that being home was tough. And so they've even tried to have a virtual ice cream social. I wasn't able to make it, but the thought of it was very neat."* Henrietta was referring to the supplemental emergency scholarships the RADSS program provided mid-semester in spring 2020 as well as the virtual events we held in the 2020-2021 academic year.

In the interview, the students responded to the prompt "What did you plan to do in your summer 2020 that you couldn't?" Students talked about mostly missed opportunities for research and internships and expressed frustration and disappointment when programs and positions were canceled. Some students were fortunate enough that their positions could be completed virtually, or they were able to arrange other virtual or in-person experiences that contributed to their professional development. Example responses to this interview question are provided in Table 4.

Discussion

The RADSS program aimed to retain rural and diverse student participants, supporting them through to graduation with an undergraduate STEM degree; Figure 2 communicates the different persistence experiences of these cohorts. The data presented in Table 2 and Figure 2 show successful academic progress and graduation of 80% of the first cohort, Hydrogen. This group experienced the pandemic in their 3rd year (6th cumulative semester) at Mason; all were firmly entrenched in their major programs and seemed to adapt well to virtual classes during their senior year. The average time to graduation for Hydrogen was 3.88 years, which is shorter than the average for Mason (4.36 years).

The second (Helium) cohort's experience was profoundly impacted by the pandemic, which occurred in the spring semester (4th cumulative) of their sophomore year. Some Helium students opted to take a leave of absence from Mason and others failed some of their classes during the 2020-2021 academic year, which delayed graduation by 1-2 semesters. Two students elected to leave Mason completely in the years post-pandemic. In total, only 5 of the 15 participants (33%) in Helium completed their undergraduate degree; in comparison to the Hydrogen, this starkly lower graduate rate demonstrates the profound effect of the pandemic, which may be considered part of the chronosystem in the social-ecological model. Occurring so early in their college life, the pandemic had greater effect on Helium than on their older peers. Fortunately, of those students from Helium who did complete a degree, the average time to graduation was 4.30 years, which is nearly the same as for Mason.

We posed two scholarly questions related to the RADSS Program at Mason. The first asked how the individual components and holistic design of the RADSS Program contribute to the retention of, and the timely completion of a degree for, rural and diverse Virginia students in STEM. Examining the longitudinal data we collected, some program components were more valuable than others in contributing to student persistence. In Figure 3, the relative importance of the various ecosystem components is graphically displayed.

Mentoring and community were the most significant forms of support; these two overlapped and were a part of the mesosystem. Academic and well-being support were valued program components that contributed to the Community and Mentoring circles. For most of the Hydrogen cohort, the Summer Bridge Camp was the beginning of their community, and our data confirms the value of this program component. Led by faculty mentors and including community building activities, conferences and trips were subsequently important and overlapped with both community and mentoring. Primarily mesosystem and microsystem components, these trips away from typical social and academic environments may also be interpreted as part of the exosystem. Seminars and research were of lower importance; notably, these components were very impacted by the pandemic and that may be evident in these results. The scholarships were moderately important and overlapped slightly with research; grant funds were used to help 4 students participate in summer or academic year research. While scholarships at the microsystem level were valuable, they were not enough to support persistence. Most students who left the program did so for reasons other than financial.

Our data indicates "Research" was a small contributor to the overall program landscape (Figure 3); this is referring to student undergraduate research experiences (UREs), which was a specific goal of the RADSS program. Significant funding was allocated to support UREs for participants. In the first two and a half years of the program, we held regular group and individual meetings regarding research opportunities. While some pursued research early and gained experience in summer 2019, most students in both cohorts opted to wait to pursue research and, as a result, the pandemic impacted their intention to join a research group or secure a research internship. The data shown in Table 4 demonstrates students' experiences with cancelled or altered opportunities. We hoped to add results specific to rural students to the wealth of support for this

Figure 3. Depiction of actual ecosystem of support for students in the RADSS program. Components that were more important are shown with larger circles and those which merged in the students' experience are shown to overlap.

high impact practice (Kuh, 2008; Lopatto, 2010), but the pandemic limited the data we could collect on this type of support. While our data on providing research support is inconclusive, there is ample literature precedent regarding the value of research experiences for supporting retention and success in STEM, especially among underrepresented minority groups (Horsch et al., 2012; Ishiyama, 2001; Kaul & Pratt, 2010; Nagda et al., 1998; Schneider et al., 2015; Stanford et al., 2015)

Our results are consistent with other similar studies of rural identifying, and often first-generation, college students. The work of Gibbons et al. identified the instrumental role of mentors and their emotional support as contributing student success (Gibbons et al., 2022). The authors also noted a high value in peer relationships. Feeling included in the academic community was also identified by Stephens et al. as an important goal for programs aimed at supporting rural students (Stephens et al., 2015). Our results complement these works, providing further evidence of the major role of community in supporting STEM student outcomes.

Our second research question asked what insights can be learned about the program participants. Many of the participants identified as "rural," or coming from a rural area, and recognized themselves as different and sometimes less prepared from high school than their peers. These observations are consistent with the work of Means et al., who observed rural African American students sometimes did not have the "know how" to be successful in college (Means et al., 2016). The participants also highly valued diversity and for many, that was a major reason for deciding to enroll at Mason. While some participants identify as rural, some students relocated multiple times during their secondary education years and it is entirely possible those alternative life experiences influenced their identities. The participants also had a strong relationship to home and family; many stayed connected to family on a regular basis, especially in the early years, and traveled home often, consistent with literature precedent (Stephens et al., 2015; Worsham et al., 2021). For some participants, these relationships were significantly challenged by the pandemic, where learning from home became difficult or impossible.

Limitations

Our findings are not meant to be generalizable because we are working with qualitative data and a relatively small sample of students. We did not collect the same data from all participants; for example, some students did not respond to all the journal prompts, some did not participate in the focus groups or interviews; our claims are based upon those students who did provide various data. For students who left Mason or changed to a non-STEM major, we only have data from when they were a participant in the RADSS program and we do not have their summative reflections of the program. Program leaders only have anecdotal data regarding why students left Mason or the RADSS program; data regarding this topic was not collected as part of the research study. Our study was not designed to investigate intersectionality (Cho et al., 2013; Mitchell et al., 2014), such as when a student identifies with more than one underrepresented group and identifies as rural (e.g., a black female from a rural area); we did not parse our data by gender, race/ethnicity, or first generation. Given these limitations, the study generated findings that could be used in subsequent research to further investigate the degree to which these support structures contributed to success and persistence individually or through interaction with the other structures.

Conclusions and Implications

The holistic nature of the RADSS program and its components at the micro- and mesosystem levels combined to create a supporting and nurturing environment for rural and diverse Mason students in the College of Science. Often scholarships are not enough of an intervention to support persistence and graduation in STEM majors; community building activities and thoughtful academic and personal mentoring are vital components and should be included in similar programs. In additional, all stakeholders (students, staff, and faculty) should be adequately compensated for their time and energy investments related to these activities.

Rural students have intersectional identities which merit recognition and thoughtful interventions. Many large research universities across the country (e.g. The Ohio State University, Columbus, OH) are located in urban areas and also enroll sizable student populations from rural areas. Other schools are geographically located in more rural communities. Moreover, a rural student could attend a school in an urban or suburban location far from their home, and that school might not even know to consider this part of their students' identity. The results described here may be useful to faculty and administrators at any of these schools as they come to appreciate the rural identity of their students and how that identity plays a role in the equation related to persistence and graduation.

Abbreviations

RADSS: Rural and Diverse Student Scholars

NSF: National Science Foundation

STEM: Science, Technology, Engineering, and Mathematics

S-STEM: Scholarships in Science, Technology, Engineering, and Mathematics

IRB: Institutional Review Board

URE: Undergraduate Research Experience

Declarations

Availability of data and materials

Research instruments including journal prompts, focus group and interview questions, are provided in the Supporting Information.

The datasets generated and/or analyzed during the current study are not publicly available due to restrictions in the IRB approval but are available from the corresponding author on reasonable request.

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Competing Interests

The authors declare no competing interests related to this paper or research study.

Authors' contributions

Dr. Jones outlined the original concept and research questions, helped with coding and data analysis, and wrote the Introduction, Participants subsection of the Research Methods, Results, Discussion, and Conclusions sections. Dr. Emenike led the qualitative analysis, collected and processed all data, validated student codes, and wrote the other subsections of the Research Methods section. Both authors mentored student researchers and selected data for the Results. The authors worked together to revise the article and reviewed the article prior to submission. Both authors read and approved the final manuscript.

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