SAFE Passage to Social and Academic Support: First Year STEM Identity and Belonging Interventions for Under-resourced Students

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Introduction

As a whole, students with low socio-economic status display disproportionately lower levels of engagement and achievement in primary and secondary science courses and are often under- represented in college STEM majors (Niu 2017, Betancur et al. 2018, Rozek et al. 2019, Cooper & Berry, 2020). Even though students with low socio-economic status have distinct needs compared to other underrepresented groups (racial minorities, LGBTA+ students, students who identity as women), indicators of socio-economic status are strongly patterned by many of these other demographic variables, including race (Noel, 2018). Several intersecting challenges have been linked to a lack of students in STEM fields from a variety of underrepresented communities, which include stereotypes about science aptitude (Else-Quest et al. 2010, Good et al. 2012, Master et al. 2016, Wang & Degol 2017), persistent financial barriers to access opportunities and resources in scientific research (Seymour and Hewitt 2000, Foltz et al. 2014, Stewart et al. 2015), unwelcoming and sometimes hostile environments that lack representation (Hurtado et al. 1999, Yosso et al. 2009), and a lack of role models with similar backgrounds that can aid in STEM identity formation (Bystydzienski & Bird 2006). The consequences of economic, racial, and gender homogeneity in STEM fields has both broad social impact (exclusion of certain groups and individuals from a major economic force in global society) and technical and scientific costs, including a loss of talent in the science workforce and less innovative systems, ideas, and scientific solutions.

Higher education institutions, in partnership with government, non-profit, and private industries, have implemented a broad range of programs, scholarships, and support structures to increase student engagement in STEM majors and, ultimately, STEM professions, among a wide range of student groups (Mack et al. 2019, AAAS 2023). A rich body of research on such programs has revealed several factors which can influence STEM retention and graduation among members of under-represented groups, including low-income, first-generation, and racial and gender minorities (NAS 2011, Barbera et al. 2017, AAAS 2023). These range from boosting quantitative reasoning skills (Newsome-Slade et al. 2020; Stanfield et al. 2022) and social support systems (Baker 2013, Komarraju et al. 2010) to formal academic support programs (Ong et al. 2011, Atkins et al. 2020). Not surprisingly, students who receive significant financial aid have been found to be better retained in STEM majors than those without such an incentive (Barbera et al. 2017). However, several additional interventions have yielded promising outcomes such as efforts to enhance motivation and agency (Mau 2003) and to cultivate inclusive learning environments where students feel like they belong (Hurtado & Carter 1997, Hurtado et al. 1998, Johnson 2012, Gopalan & Brady 2019). There is a particularly strong link between STEM identity and belonging with academic success and persistence in STEM fields, especially among underrepresented minority (URM) students and those with low socio-economic status (Hazari et al. 2013).

Recognizing these variables, numerous strategies have been employed to increase access in STEM programs by addressing the root causes of unequal engagement and outcomes. Programs have been designed to increase role models for low-income or URM students, develop cost-free or supplemental opportunities to explore STEM topics and advance requisite skills for target groups, address financial barriers with specialized support or programs to reduce cost, and facilitate learning environment interventions designed to enhance inclusion and reduce negative experiences (e.g. microaggressions).

In the 2020 fall semester, Furman University, a small liberal arts institution in Greenville, South Carolina, was awarded a National Science Foundation (NSF) Scholarships in Science, Technology, Engineering, and Mathematics Track II grant (S-STEM) to support a Furman STEM Scholars program designed for under-resourced students, which, at Furman, includes students who identify as low socio-economic status (SES) and are often first generation, and/or under-represented minorities (URM) as defined by NSF (Blacks or African Americans, Hispanics or Latinos, and American Indians or Alaska Natives). The project draws from evidence-based best practices observed in literature on broadening participation in STEM disciplines.

Project Context

As a part of an institutional commitment to ensuring equitable and accessible opportunities for students to obtain STEM majors and careers, Furman University regularly monitors student success and retention data. Institutional data indicate that the most critical determinant of student success at Furman (as measured by retention, graduation, and GPA) is academic preparation prior to enrollment, including the number of college prep courses available (e.g. A.P., I.B.), a variable often influenced by local-level resources and correlated with multiple demographic traits like the socio-economic status of students (Price, 2021). Therefore, interventions to increase student success among under-resourced student groups in STEM at Furman must provide opportunities for students to enhance critical prerequisite skills, knowledge, or dispositions.

Once enrolled, among the institutional data most concerning are completion rates for gateway science courses for under-resourced students, which have demonstrated substantially greater attrition (withdrawal) or D/F grades among these groups. Based on institutional data from 2015-2018, grade assignments of W/D/F occurred at a significant rate (20%) for the introductory Chemistry sequence (CHM 110, CHM 115) and first Calculus course (MTH 145 or MTH 150). This issue is excessively acute for Pell recipients (30%), students from first generation (31%) and/or URM (36%) demographic groups. Research indicates that early frustration in the curriculum frequently correlates to a lack of persistence in a STEM major or at the institution; first year grades in math for under-resourced and URM students, for example, are significant predictors of retention to graduation in disproportion to well-resourced, white majority students (Musoba & Krichevskiy 2014; Riegle-Crumb et al. 2019). At the same time, data from 2015-2018 suggests that students at Furman who declare STEM majors in the first year-irrespective of their demographic groups-exhibit greater persistence to the second year (99%) than do students institution-wide (91%). Altogether, this data clearly indicates that interventions designed to enhance retention must target gateway science course completion, advising, and persistence in the first year.

To better understand these disparities, in the preparation of multiple institutional interventions, Furman implemented a survey of all students enrolled in gateway science courses in the fall of 2019 regarding self-concept (how do I compare to others?), self-efficacy (how confident am I that I can achieve X?), sense of purpose/

identity, and socialization with respect to math and science. Among respondents (~300), nearly a third (33%) indicated that they felt as though they did not belong in a Furman STEM course, that they were afraid to make mistakes or show weakness, or that their professor didn't understand them. In addition to efforts aimed at enhancing course preparation and success in gateway science courses, this data clearly highlights the importance of interventions that enhance belonging in STEM courses and learning environments.

Finally, one additional critical area of interest is post-graduation outcomes for students. Eighty two percent of Furman alumni strongly agree they had at least one professor who made them excited about learning. Given this strength, interventions to enhance access to STEM majors at Furman should include tailored opportunities for applied, experiential learning and mentoring opportunities with faculty.

STEM Scholar Interventions

The STEM Scholars program at Furman was designed to employ evidence-based interventions that reduce the impacts of pre-enrollment barriers and create a strong sense of belonging and community to close the gap in STEM performance among under-resourced students. The program leadership team developed a comprehensive set of stratified activities to enhance performance in gateway courses, increase self-confidence and belonging, and provide for social and academic integration, while building a modular advising program to ease the college transition. The primary interventions include:

Pre-Matriculation Experience

SAFE (Start an Amazing Furman Experience) Passage provides an eight-day pre-enrollment summer bridge experience designed to familiarize participants with college-level academic work, faculty research, and campus services. This on-campus "preview" provides unique access to science faculty (key to successful early advising), enables connections for subsequent research experiences, communicates information on academic and other forms of assistance, and catalyzes the development of collegiate interpersonal relationships. An AI-based diagnostic and pre-calculus review platform (ALEKS) was used during the SAFE Passage bridge experience to better prepare students and inform advisors regarding prudent enrollment choices in mathematics. Academic assistance, counseling, and other institutional student life services were also shared with STEM Scholars (e.g., access to free tutoring from faculty-recommended peers via the Center for Academic Success).

SAFE Passage builds on a strong body of literature that suggests that summer bridge or orientation programs can provide important requisite skills and knowledge for under-resourced students and can create a foundation for strong STEM identity and belonging (Cabrera et al. 2013, Williams & George-Jackson 2014, Johnson 2016, Barth et al. 2021). These experiences are notable for their ability to allow students to interact directly with STEM professionals and faculty and staff mentors, participate in experiential learning activities in STEM disciplines, connect with peers to build networks of support, and provide critical knowledge that allows for informed decision-making about STEM courses and careers. Programs like SAFE Passage provide students with a chance to experience what it is like to be a STEM student and to see themselves as part of a community of STEM professionals.

Pathways Seminar

The Pathways Initiative is a credit bearing (1 hour/term), 2-year seminar experience that brings a small group of students together to meet with their assigned academic advisor and a peer mentor once a week (50 minutes). As adapted to S-STEM, Pathways for Scholars is a cohort-based Pathways section created exclusively for each Scholars cohort. The 2-year curriculum includes (among others) discussions around interpersonal relationships, social identity, responding to failures, strengths training, and career exploration. In addition to the Pathways academic advisor (course instructor) and a Pathways peer mentor (upper-class student), STEM Scholars are supported by a Scholar program advisor as well. Once students declare a major (many as early as their second semester), they are advised by a third mentor within their major department. This team-based advising and mentoring process provides multiple and interconnected layers of academic support so that problems are identified early and resources are thus provided efficiently.

Cohort Course Enrollment

As an evidence-based approach (Carlone & Johnson 2007; Killpack & Melon, 2016; Griffin 2018) aimed at improving performance and preparation for subsequent work, each cohort collectively enrolled into a customized section of Chemistry 110 (Introductory Chemistry) structured around active learning pedagogies that implement strategies shown to enhance outcomes for low-income, URM, and first generation populations in particular via cooperative, group-based activities (Narum 2008; Freeman et al. 2014; Ruder et al. 2018; Stains et al. 2018). Two students who had previously completed the course (peer learning leaders) were embedded in the course and held weekly optional group learning sessions. A second strategy, aimed at strengthening academic agency while contributing to the development of a collaborative community of learners, involved the opportunity for cohort enrollment in a general education second semester foundational writing and composition course (First Year Writing Seminar) based on a science theme and taught by a STEM faculty member.

Cohort-based learning was strategically deployed to enhance STEM identity and belonging among STEM Scholars. There is a growing body of research that supports the benefits of cohort-based learning among first-year undergraduate students (Goldman 2012, AAAS 2023). Providing first-year Scholars with a consistent and familiar community of peers from which relationships can be formed and shared experiences appreciated allows each participant to feel included, develop networks of support, and interact in small-group settings with STEM faculty and student leaders. As Scholars develop these skills and knowledge in a trusted, safe community, they may become more confident in their abilities, capable of navigating learning challenges, and more invested in the STEM community and profession.

Compensated Summer Research

Finally, under the Scholars program, every participant is strongly encouraged to engage in the institution's guaranteed compensated summer research experience, and many students – at their discretion – opt for additional opportunities. Furman is a proponent of the "early and often" research model supporting STEM engagement, which results in improved outcomes for students (e.g., increased retention, learning gains) and faculty (e.g., improved efficiency of scholarship) using a scaffolded research approach (Stanford et al 2017; Detweiler-Bedell & Detweiler-Bedell 2019).

Research and Methods

Given the evidence that experiences in the first year of college can have a substantial impact on student enrollment in STEM courses, interest in a STEM major, and persistence and retention in STEM disciplines, this research focuses on the outcomes of first-year Furman STEM Scholar students in the following areas:

- enrollment and WFD rates in STEM couses
- engagement in undergraduate research opportunities
- grade point average (overall and within STEM courses)
- STEM professional identity
- Science community belonging
- Academic help-seeking behavior

Two cohorts of Furman STEM Scholars (FSS) were selected to begin in fall of 2021 and 2022. The selection process involved a multi-faceted approach relying on both quantitative and qualitative metrics beyond demonstrated need (Pell eligibility with unmet need). This included identifying financially eligible applicants

with standardized scores (when provided) exceeding SAT (1200), ACT (25), and an unweighted HS GPA of 3.0 (out of 4.0). Since Furman's general admission application is "test optional", however, and a disproportionate percentage of low-income students choose this path, a more holistic assessment was used to establish merit. In addition to quantitative data, applicants maximizing their high school STEM experiences in accordance with the opportunities available, including AP/IB courses and local STEM activities (e.g., participation in science fairs/clubs, research activities, etc.) were rated favorably. The aim was to enroll students intending to major in Biology, Chemistry, Environmental/Sustainability Sciences or Neuroscience, as reflected by required application essays addressing intended major and STEM career interests. Finalists meeting both academic and financial criteria for award were interviewed by the leadership team prior to selection as STEM Scholars (Table 1).

Based on the Common Data set, these cohorts differ from the general student body at Furman. Based on 2021 data, only 13.2% of Furman students were URM (299) by the NSF definition and 10.8% (238) were first generation. Since the 2016 cohort, the percentage of Furman students receiving Pell grants hovers just around 13.5%. To analyze STEM Scholars' outcomes with relevant institutional comparison groups, a control group (FSSC) for each cohort was also recruited. Students who had an interest in a STEM major and who had demographic and socio-economic variables that matched Scholar counterparts as best as possible were identified and invited to participate in the research project (Table 2).

A mixed-methods research methodology was employed for this study, including an online quantitative survey deployed twice in the first year of enrollment and a qualitative focus group for each Scholar and control cohort at the end of the first semester. The research study was reviewed and approved by the Furman Institutional Review Board and all participants completed informed consent documents before completing research activities.

Quantitative measures of interest include major declaration (which discipline and when), rates of undergraduate research participation, science course enrollment, and several GPA variables. In addition, several metrics of interest were included in a broader institutional survey conducted as a part of a two-year credit bearing advising and mentoring initiative for first- and second-year students (Pathways). Existing and validated survey questions were included in the survey from the following (see supplement A for specific questions):

- A simple one-item graphic measure of STEM Professional Identity developed by McDonald et al. (2019) with established test-retest reliability and internal consistency.
- Four items to measure STEM belonging focused on ways in which participants think about themselves as a scientist (Syed et al. 2019).

Table 1

STEM Scholar Cohort Details

	Total	% Pell-Eligible	% First Generation	% URM
Cohort 1 (2021)	11	100%	27%	55%
Cohort 2 (2022)	12	100%	33%	33%

Note: Categories are not mutually exclusive; participants may fall into more than one category (e.g. First Generation and URM)

Table 1. STEM Scholar Cohort Details

Table 2

Control Cohort Details

	Total	% Pell-Eligible	% First Generation	% URM
Control Cohort 1 (2021)	15	60%	33%	53%
Control Cohort 2 (2022)	11	27%	27%	27%

Note: Categories are not mutually exclusive; participants may fall into more than one category (e.g. First Generation and URM)

Table 2. Control Cohort Details

Because the online Pathways survey was completed by a larger sample of first-year students in both 2021 and 2022, responses from students who indicated an interest in a STEM major (but who were not a Scholar or control group member) were collated to provide institutional reference data (REF).

STEM Scholars and control students were invited to participate in a 75-minute focus group at the end of their first semester to provide an opportunity for participants to share more about the variables of interest in the research project. These included questions about STEM identity and interest, academic readiness, STEM and institutional belonging, and responses to academic and personal challenges (see supplement B for focus group script). Ninety-two percent of STEM Scholars participated in a focus group (21 out of 23) and seventy-seven percent of control members participated (20 of 26). Each participant received a ten-dollar payment for their time. For each cohort of Scholar and control students, two focus group options were offered so that a total of eight sessions were completed.

Data Analysis

Descriptive and inferential statistics were employed to analyze quantitative data collected for this project. Institutional partners provided individual data for each STEM Scholar and control group participant about major declaration date and category, summer research participation in the summer after the first year, science course enrollment in the first year, and GPA. Science GPA was calculated using grades from courses in Biology, Chemistry, Earth and Environmental Science, Physics, Math, Computer Science, and Psychology (including Neuroscience). Where appropriate, t-tests, ANOVAs, and Tukey's HSD post-hoc analyses were utilized to detect statistically significant differences (at .05 and .10) among STEM Scholar and control groups.

Focus group transcripts from this dataset were auto-transcribed using Otterai and then cleaned by undergraduate student research assistants. An inductive coding approach was used by the first author to assign responses to categories based on pre-defined categories that corresponded with the central focus group questions. For example, to code responses to the question "Would you say that, at this point, you feel like you belong at Furman, like you have a place here?" responses were inductively assigned codes in the following three categories:

1.Strength of Response to Question

- Categorize the strength of responses to the prompt inquiring about whether or not students feel like they belong at Furman.
- Example categories include: emphatic no, tentative no, unsure, tentative yes, emphatic yes

2.Factors that Contribute to Belonging

- What specific factors contribute to feelings of belonging expressed by the students (the why)?

- Examples: campus landscape (trees make me feel like I'm home), development of friendships, care felt by faculty/staff member, connecting with someone "like me".

3.Factors that Contribute to Disconnect

- For those that noted a disconnect, what specific factors contribute to feelings that they don't belong (the why)?

- Examples: food is not like what I'm used to at home, roommate I live with doesn't understand me, I don't feel like I'm smart enough.

All responses were assigned specific descriptive codes to identify major themes, similarities, and differences among respondents within the pre-defined categories. These codes were developed iteratively, based on constant comparison of other text within the category.

Results

Descriptive statistics for academic outputs and inferential statistics for STEM identity and science belonging are included below, followed by insight from focus group sessions.

Academic Outputs of Relevance to Participant Success in First Year

Across both cohorts of STEM Scholars (FSS, n=22) and control students (FSSC, n=26), Scholars demonstrated:

- higher rates of STEM major declarations by the second semester of the first year (77% of FSS (17/22) vs. 42% of FSSC (11/26); p=.007).

- higher rates of engagement in summer research experiences after the first year (68% of FSS (15/22) vs. 15% of FSSC (4/26); p=.00004). This is particularly notable given that all students at Furman have a guaranteed compensated summer research opportunity.

- higher rates of enrollment in STEM courses during the first year (average 3.68 STEM course load for FSS vs. 2.88 for FSSC; p=.016)

- lower WDF rates in first-year STEM courses (5.8% (5/86) for FSS vs 6.25% (5/80); p=.436), despite the higher STEM course load per student in FSS.

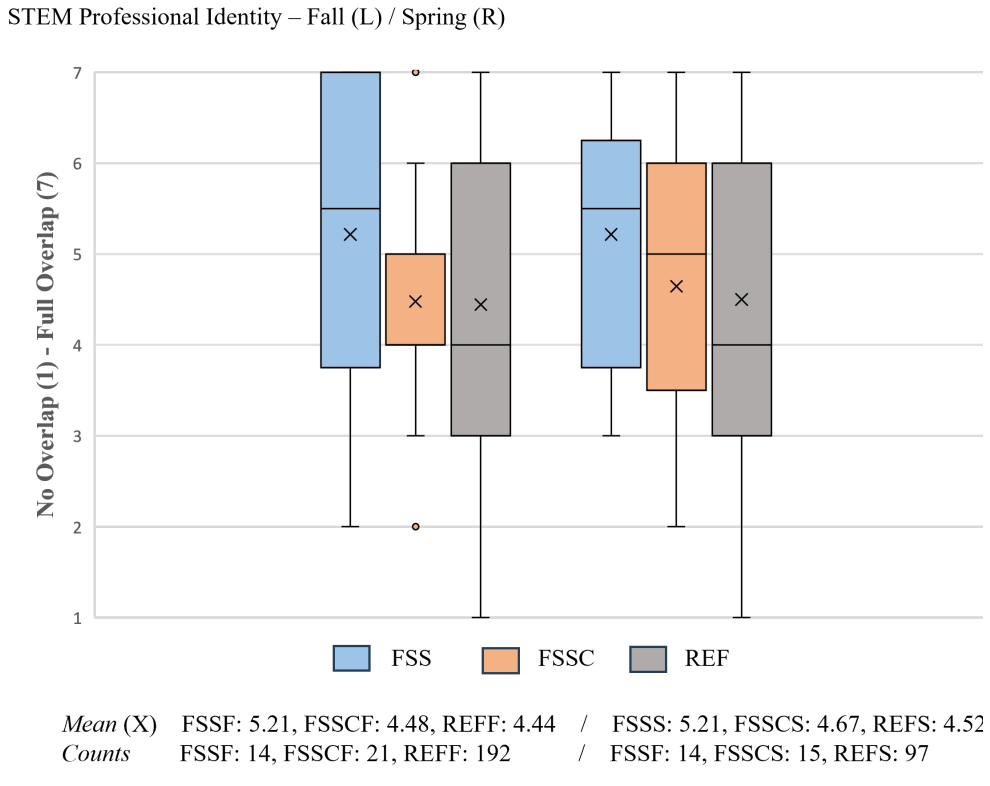

Figure 1. STEM professional identity scores for fall (F) and spring (S). STEM Scholars (FSS) consistently indicated higher rates at both sample points than control (FSSC) or institutional reference (REF) groups when depicting (graphically) their own alignment with a STEM professional. A one-way ANOVA revealed that there was not a statistically significant difference in STEM ID score between at least two groups (F(2, 224) = [1.49], p = 0.226) in the fall or the spring (F(2, 124) = [1.89], p = 0.308).

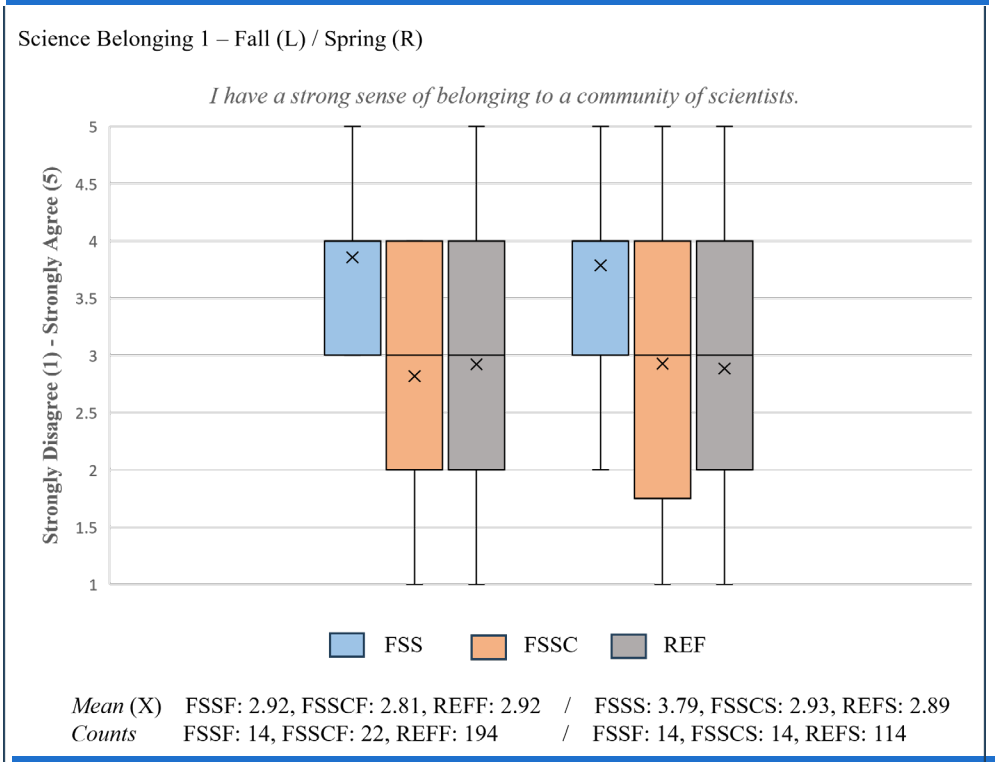

Figure 2. . Science belonging I scores for fall (F) and spring (S). For the fall there was a statistically significant difference between at least two groups (F(2, 227) = [5.64], p = 0.004). Differences between FSS and FSSC were significant (p = .01, 95% C.I. = .208, 1.870) and between FSS and REF (p = .003, 95% C.I. = .262, 1.607). For the spring there was a statistically significant difference between at least two groups (F(2, 139) = [5.07], p = 0.018). Differences between FSS and REF were significant (p = .013, 95% C.I. = .156, 1.644)

• FSS demonstrated slightly higher cumulative (3.44 vs. 3.3) and science course (3.26 vs. 3.25) GPA at the end of the first year, although not statistically so (p values of .352 and .969 respectively).

STEM Professional Identity (including STEM reference group)

STEM Scholars (FSS) consistently indicated higher rates of STEM professional identity in their first year than control (FSSC) or institutional reference (REF) groups (Figure 1) when depicting (graphically) their alignment with a STEM professional (see supplement A for survey question). This was especially pronounced in the first semester, following the summer bridge program (SAFE Passage), although not statistically so. Note that because students were not required to respond to either the fall or spring online survey or forced to answer all questions within that survey, sample sizes may vary among semester and sample group.

Science Belonging

Scores for science belonging followed a similar pattern as those for STEM professional identity, with FSS indicating higher rates of belonging within the broader science community. Results are provided for all four primary dimensions (Figures 2-5) used to measure science belonging. Tukey's HSD post-hoc tests were conducted following an ANOVA for each item to determine differences between groups. Statistically significant differences exist between FSS, FSSC, and REF groups in all four dimensions.

I have a strong sense of belonging to a community of scientists.
I derive great personal satisfaction from working on a team that is doing important research.
I think of myself as a scientist.
I feel like I belong in the field of science.

Focus Group Insight

Focus group conversations helped to better understand differences in STEM identity and belonging between STEM Scholar and control groups. Although students from both Scholar and control groups recognize in themselves about half of the characteristics they admire in STEM professionals they know, groups differed markedly with respect to key components of STEM and institutional belonging and help-seeking behavior. Representative quotes from focus group participants (edited with descriptors (Scholar 1) or pseudonyms to protect confidentiality) are included for further detail.

Laudable Characteristics of STEM-Affiliated Mentors

Focus group participants were asked to identify individuals that influenced their interest in STEM, list the

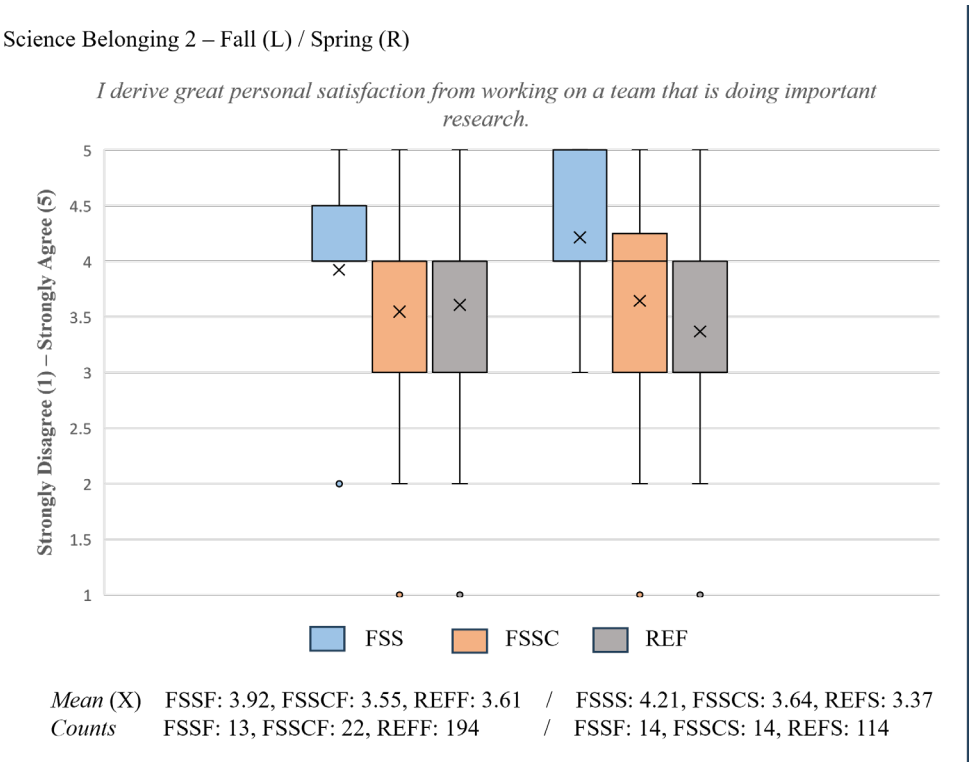

Figure 3. Science belonging 2 scores for fall (F) and spring (S). For the fall there was not a statistically significant difference between at least two groups (F(2, 226) = [.76], p = 0.470). For the spring there was a statistically significant difference between at least two groups (F(2, 139) = [4.67], p = 0.009). Differences between FSS and REF were significant (p = .007, 95% C.I. = .192, 1.50).

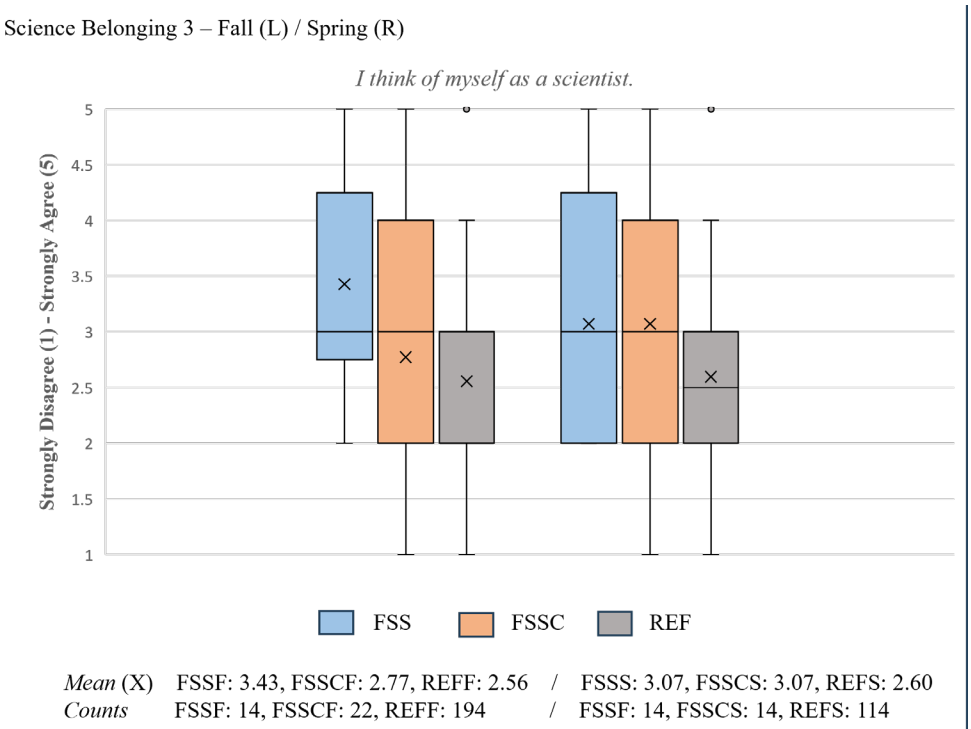

Figure 4. Science belonging 3 scores for fall (F) and spring (S). For the fall there was a statistically significant difference between at least two groups (F(2, 227) = [4.12], p = 0.018). Differences between FSS and REF were significant (p = .015, 95% C.I. = .138, 1.606). For the spring there was not a statistically significant difference between at least two groups (F(2, 239) = [1.88], p = 0.156).

qualities and characteristics that they admire about those individuals, and then note which of those characteristics they felt they personally possess at the time of the interview. Responses to this question provide insight about how closely participants view themselves to those they most notably associate with a STEM profession.

Although STEM Scholars did identify more notable characteristics of those individuals they listed (avg. 5 vs. 3.82 for control, p=.014) and indicated possession of characteristics listed in greater volume (avg. 2.81 vs. 2 for control, p=.033), the percentage of possession to identification (how many characteristics a participant said they possess divided by the number of characteristics listed) was almost identical (avg. 55% for FSS, 56% for FSSC, p=.461). That is, both FSS and FSSC participants indicated they possess about half of the characteristics they admire about STEM professionals that influenced their interest in STEM in their first year as a college student. Some of the most frequently cited mentor characteristics included having a passion and enthusiasm for their work, maintaining a focus on helping others, possessing a strong work ethic, fostering a curiosity for exploration and discovery, having a high level of expertise, and pursuing solutions to important natural or social challenges.

STEM and Institutional Belonging

Focus group participants were asked whether they felt like they belong at Furman, what belonging means to them, and whether or not there were particular groups of people, spaces, or courses in which they felt like they belonged more than others. Responses to these questions produced consistent and notable differences between FSS and FSSC groups.

FSS participants were uniformly positive when responding to the question about belonging at Furman, many emphatically so. FSS students enthusiastically attributed part of their belonging to the STEM Scholar program, especially the bonding that occurred and connections forged to the broader community during the summer bridge experience (SAFE Passage).

> *"I couldn't really imagine what this experience would be like without the STEM Scholar group because I was really nervous, like, for the week that we came to campus for SAFE Passage, because I didn't want to go to college before I had to. But then I ended up meeting like my best friends and having a really great time and yeah, probably the Scholar group is like the best thing that could have happened for me coming here." (Scholar 1)*

Many Scholars spoke of the significant role colleagues in the program play in their well-being and talked about how the program has helped them feel like they are wanted and desired as students – that they have something to contribute and be proud of.

> *"Being a part of the STEM Scholars program is the only reason I have friends. I'm not good at talking to people or making friends or, like, approaching people. So, like, if it wasn't for SAFE Passage, I don't know, like, I would not have my best friends." (Scholar 2)*
>
> *"Okay, so the STEM Scholar thing, like the program as a whole - if I didn't have that, it would definitely not feel like home. I feel like I would just be in my room all the time. All the time!" (Scholar 3)*

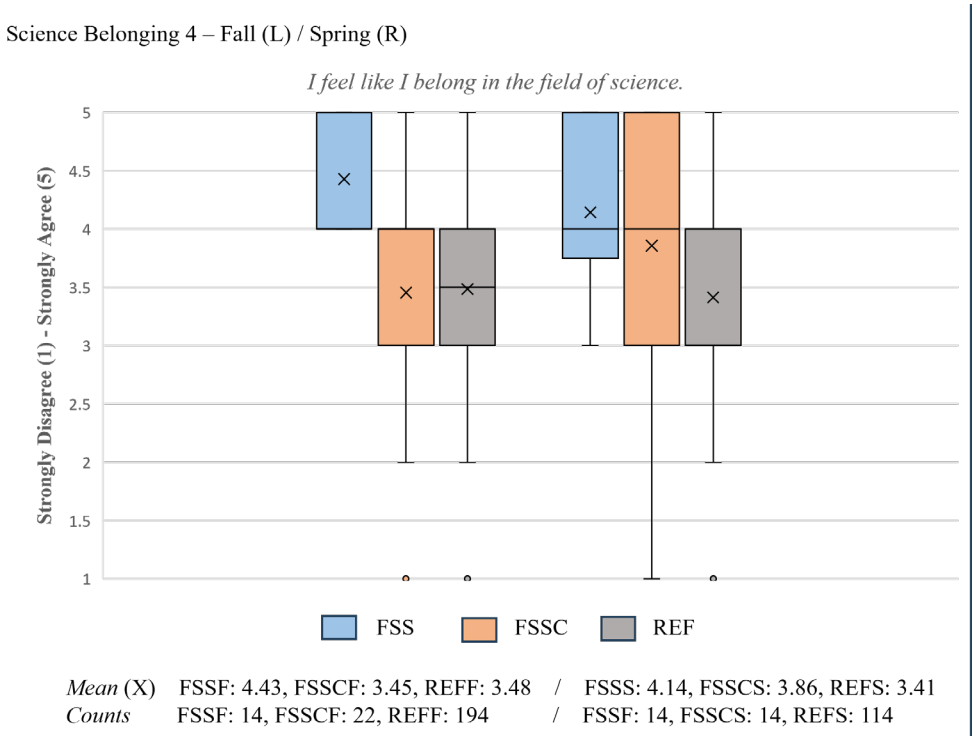

Figure 5. Science belonging 4 scores for fall (F) and spring (S). For the fall there was a statistically significant difference between at least two groups (F(2, 227) = [5.13], p = 0.007). Differences between FSS and FSSC were significant (p = .023, 95% C.I. = .109, 1.839) and between FSS and REF (p = .005, 95% C.I. = 244, 1.645)). For the spring there was a statistically significant difference between at least two groups (F(2, 139) = [4.17], p = 0.039). Differences between FSS and REF were significant (p = .059, 95% C.I. = .022, 1.484).

STEM Scholar students also highly emphasized relationships with faculty and staff as major contributors to their feeling of belonging, some noting how helpful it was to meet with many of these mentors during the summer bridge experience (SAFE Passage).

> *"I mean, I thought SAFE Passage was pretty helpful too because we met so many professors. You can just go talk to them about research now. I mean, you just email someone and they will respond like that. I haven't had any professors just ignore an email. I'm sure it helps that we are in the program [STEM Scholars]." (Scholar 4)*

On the other hand, several control group members expressed a weak or nonexistent sense of belonging at [institution name] during the focus groups. In most cases this was attributed to feeling like they were disconnected to certain aspects of the broader community (racial minority, cultural minority, socioeconomic minority). Those that did express belonging almost always linked this to a strong social network (ROTC, cheer team, other club) even though the groups listed include a more disparate range of groups than those noted by STEM Scholars, which almost exclusively focused on the STEM Scholar program to serve this community purpose. Although mentioned by a few, control group members did not note connections with faculty and staff nearly as frequently as STEM Scholars, and more frequently cited other peer social groups as the central factors influencing current belonging.

> "It seems like predominantly pretty affluent people here and it's kind of a culture shock for me because I constantly am, like, working. Like even in high school, I always had a job, like 30 hours a week or more. I pay all my tuition and stuff completely myself without any help from my parents. And like, I have an on-campus job also. And it seems like I'll bring it up and I'll be, like, 'I have to go to work' and it, like, baffles my friends. So, there's definitely that socio-economic gap. It's like a culture shock in and of itself. I don't know, I would say, if anything, the only community I've sort of found is actually, like, the music department, which is ironic, because like, I'm here for STEM. (Control 1)

Furthermore, control group participants noted more disconnection factors than STEM Scholar participants, part of a consistent trend in this section of the focus group conversation. Members of both groups mentioned the challenges of being a racial or socio-economic minority on campus. Members across both groups also shared feel-

ings that they were not of the same intellectual aptitude as the "typical" Furman student. Even still, the impact of this challenge seemed more pronounced among control group participants who discussed numerous aspects of this challenge, including concerns about representational diversity among students, faculty, and administrators; a lack of opportunity to engage with and maintain cultural traditions (around food, celebrations, customs); and stronger feelings of homesickness.

"When I came, I was like 'oh my God, there's like, a lot of white people.' And then my Mom was like, be careful of what you say-she was telling me she's like, be careful, because some of them you know, might be racist, or some of them might be arrogant, and they don't understand where you're coming from." (Control 2)

"And then there's been times when like, in the dining hall, I would ask what kind of meat this is and the person there is like, 'I don't know.' I have them go to the back and ask what kind of meat this is because I can only eat Halal and then, like, half of it is not Halal. We don't have anything Halal here. So, I don't even get my protein from, like, meat anymore. It's just kind of like the salad every day." (Control 3)

Although some of these same challenges were noted by STEM Scholar members, Scholars hinted that they were mitigated somewhat by their strong sense of community and shared experience among their Scholar peers. These relationships were anchoring their belonging in aspects of the STEM Scholar community.

"Because there are so few black students here it is very, very cliquish. I don't really know how to, like, get in with them. Luckily, in the STEM Scholars there are four and like, you know, they're like my besties. But it's very difficult because, like, you can join NAACP but they're already all friends and all like seniors so it's very hard to connect into that." (Scholar 5)

"Because I am in the Scholars program and taking some of the same classes, you tend to find out that, like, a lot of people who major in any STEM discipline, we're all pretty similar, like in terms of motivation and work ethic. So, while I might question it sometimes [belonging at Furman], that's kind of what makes me feel like, yeah, like I do belong. I do feel like I chose the right school." (Scholar 3)

Although equal time was not dedicated to a discussion of future goals among all focus group sections, STEM Scholar participants seemed more prepared to answer this question, in general, than control group participants. Most control participants had to think about the question before responding and would sometimes first respond (perhaps in jest) by saying something like "that is too far ahead right now – I'm just trying to make good grades this semester". There was a clear trend in the STEM Scholar group towards plans for graduate school, which, while present, wasn't as strong in the control group.

Comfort with Peer and Institutional Support

Focus group conversations provided additional insight into the nature of support networks among participants and comfort in using peer and institutional support resources. When asked about navigating a significant challenge in the first semester, STEM Scholar students regularly noted that they relied on a trusted faculty mentor or another member of their Scholar cohort for support to mitigate their challenge. Although responses to questions about Furman support resources (tutoring, counseling, residence life) of greatest value were similar across all groups, members of the STEM Scholar cohorts consistently noted seeking the counsel of their instructors and the FSS student peer mentor counselors that were involved in the summer bridge experience as well as the peer learning leaders from their cohort-based Chemistry 110 course.

"Joseph is actually like the peer teaching assistant in our chemistry class, so he always has like a peer-to-peer learning session during the week. Our group of Scholars usually always go to that. And that's very helpful. And then also, I'm very lucky, because most of my Scholar friends are very smart, so I can ask them questions if I'm confused or anything. And we have group study sessions, like just about every single night. We go to like, an empty classroom, and we'll just be there and working on problems." (Scholar 2)

"Susan was one of the counselors during the summer SAFE Passage, like, we always go to her and ask her for advice and share our heartbreaks. Because she's like our mom." (Scholar 6)

"It's almost that sense of not being left behind. I feel like it's definitely the faculty just going out of their way to make sure that you're okay. For me, like, if I need help, I always go to my professors. Like, I feel like I'm living in my professors' office hours for emotional support." (Scholar 1)

As a whole, control group students indicated less comfort seeking help from a professor or other academic support resource on campus (e.g. Center for Academic Success, peer tutors). Only one participant in the STEM Scholar group noted a strong hesitancy to seek help from a professor, although several participants expressed these sentiments in the control group. Control group students were more likely to suggest that they were dealing with challenges they had encountered in their first semester on their own. However, participants in both groups expressed an awareness and comfort in using the mental health support resources on campus.

"I have a really hard time asking my professors for help. That wasn't something I was used to or told that I could even do. And it's kind of like unfamiliar territory. I still find it weird to ask for help from professors. I grew up in a setting where like, you do your own thing. So like, you have to work by yourself. Like I don't know, it was like stigmatized - getting help was like a bad thing." (Control 4)

"The professor is like, really smart, so that's very intimidating because sometimes I feel like there are things I need to know on my own. Or like even just vocabulary, when I speak, that I don't really know yet. And she's really great. I'm just intimidated by how smart she is. But my best friend on campus, I do go to her for advice-it's more just ranting. Because sometimes I just need to like, let everything out. And then I just figure it out because usually I would solve problems on my own. Basically, I just vent to my friends and then I just find a solution myself." (Control 5)

Discussion and Conclusion

Results from this research suggest that the STEM Scholar program is yielding successful results in several areas identified in the literature to influence STEM success and retention among under-resourced students. Compared to control and reference group counterparts in the first year, STEM Scholar students are enrolling in more STEM courses, declaring STEM majors earlier, demonstrating low rates of attrition, participating in experiential learning opportunities at much higher rates, and maintaining a strong overall GPA. This research confirms previous findings that suggest the efficacy of interventions focused on gateway science courses, the development of peer support networks, and initiatives to enhance belonging.

We propose that differences in survey responses between STEM Scholar and control and reference groups in the first semester after enrollment may be linked to one of the central STEM Scholar program interventions-the summer bridge program (SAFE Passage). STEM Scholars indicated higher rates of STEM identity, identification as a scientist, and a sense of belonging in science than students in reference and/or control groups. The week-long bridge program was intentionally designed to reinforce STEM identity and belonging through cohort building activities, student research exposures, field trips, and social bonding activities. Focus group data suggest that this one week was critical for many Scholar participants by creating a bonded peer community, lowering the threshold and anxiety associated with interactions with faculty, and creating a sense of pride associated with program membership. For example, although all Furman students have an opportunity to engage in a compensated summer research experience, STEM Scholars take advantage of this at a much higher rate. One explanatory factor may be in the way the program connects scholars with potential mentors early so that they feel more confident and prepared to apply for these opportunities. Furthermore, our data suggest that STEM Scholars self-identify as scientists to a greater degree and thus may be more comfortable entering a research space than other students.

At the conclusion of their first year, STEM Scholars continued to demonstrate higher levels of belonging to the

community of scientists and in science more generally, as well as satisfaction with team-based research, than students in reference and/or control groups. These persistent differences between Scholars and other students with STEM interest indicate that program interventions focused on cohort-based learning and enhanced mentoring and advising within STEM-affinity groups are having the intended effect. Focus group data provide helpful clues about the success of these interventions. Scholars noted the value of group struggle and support through challenging material, the ease at which formal and informal group study sessions were organized because of an already established social network, and how comfortable they felt seeking and securing experiential research experiences with faculty.

Focus group conversations further illuminate the mechanisms through which program interventions create meaningful outcomes. STEM Scholars were able to identify laudable characteristics of STEM mentors at similar rates to their control counterparts. Similarly, members in both groups said they currently possess about half of those same characteristics themselves (55 and 56%). We believe this indicates that students in both groups recognize and place similar value on the defining characteristics of STEM professionals and see themselves in possession of those characteristics at equally similar rates. And yet, even with this similar baseline, notable differences between the two groups with respect to STEM identity and belonging were clear in focus group analysis, confirming distinctions exhibited in the survey data reported above. This suggests that intervening experiences may influence STEM identity and belonging for STEM Scholars. Of particular significance, not only did STEM Scholars indicate stronger levels of belonging within STEM courses and communities, but they suggested higher rates of institutional belonging overall. Furthermore, STEM Scholars were less likely to share feelings of disconnection, more prepared to discuss post-graduation plans, and felt more confident in and willing to utilize peer, instructor, and institutional support resources. Focus group participants provided clues about the factors that contributed most to these differences.

First, the degree to which the summer bridge program reduced anxiety and increased familiarity and comfort in the college environment should not be understated. STEM Scholars consistently noted how the experience boosted their confidence, allayed their fears, and increased their appetite for learning and research. Several indicated that the opportunity to participate in the special weeklong experience made them feel like they were valued, important, and that their potential was being recognized. Scholars noted how their membership in the program itself provides a sense of legitimacy and confidence, further enhancing their motivation and determination to invest in a STEM pathway. Activities during this week were focused on two primary goals – building community and facilitating connections to STEM learning, research, and mentors. Focus group data confirm that this two-pronged intervention strengthened both science belonging, but also facilitated positive connections to the broader institution as well.

Second, the peer and institutional community building that started during the summer bridge experience and continued through cohort-based learning opportunities appears to build significant resilience among participants. In particular, STEM Scholars noted how critical this community is-among their peers in the program, with upper-level student peer mentors, and with faculty in STEM departments. One positive effect of the community that has emerged through the STEM Scholar program appears to be the normalization of close personal relationships with peers, mentors, and faculty, which helps to ensure an awareness of and use of academic and personal support resources. This affinity-based community of support helps to mitigate a sense of isolation, difference, or disconnect that all participants acknowledge because of the various under-represented aspects of their identity. Although students in both Scholar and control groups identified and discussed challenges in their first semester, there were clear differences among the groups with respect to confidence in their ability to navigate those challenges, comfort in seeking and using support, and assurances that they were not alone. Control students shared far more feelings of isolation and uncertainty about whether they belong at Furman and in the STEM field in general and were much more likely to feel the need to tackle their challenges on their own.

The quantitative and qualitative results that have emerged from this research suggest that the Furman STEM Scholar program, based on interventions that reduce college transition anxiety; build peer and mentor networks in STEM; provide gateway science course cohort learning; and layer multiple levels of advising and experiential learning has a strong positive influence on academic achievement in the sciences and both STEM and institutional belonging in the first year. Data from this program provides evidence that institutions can increase engagement, belonging, and help-seeking behavior among under-resourced students by first creating systems and structures that facilitate small affinity-based cohorts of student learning and programming. As this research has demonstrated, these carefully fostered communities can create a sense of belonging and connection that transfers to the institution and broader community of learners therein.

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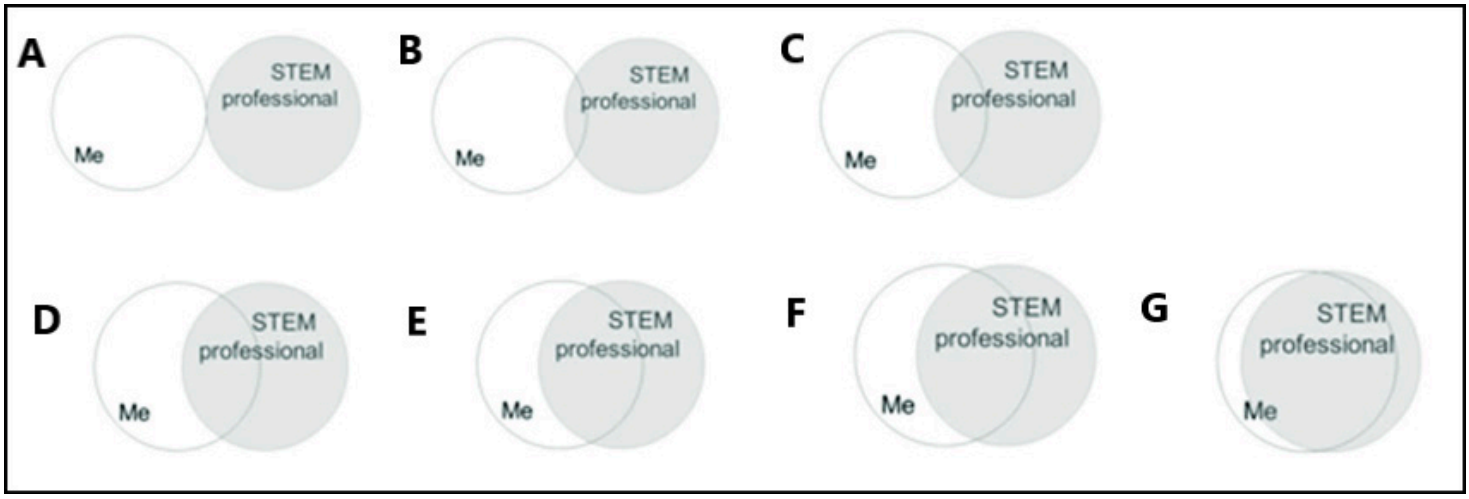
Supplemental A

STEM Professional Identity

Derived from: McDonald MM, Zeigler-Hill V, Vrabel JK and Escobar M (2019) A Single-Item Measure for Assessing STEM Identity. Front. Educ. 4:78. doi: 10.3389/feduc.2019.00078 https://www.frontiersin.org/articles/10.3389/feduc.2019.00078/full

Select the picture that best describes the current overlap of the image you have of yourself and your image of what a STEM professional is.



Science Belonging

Derived From: Syed, M., Zurbriggen, E. L., Chemers, M. M., Goza, B. K., Bearman, S., Crosby, F. J., ... & Morgan, E. M. (2019). The role of self-efficacy and identity in mediating the effects of STEM support experiences. Analyses of Social Issues and Public Policy, 19(1), 7-4.

Using the following scale (Strongly Disagree1 – Strongly Agree5), to what extent are the statements below true of you?

1. I have a strong sense of belonging to a community of scientists.
2. I derive great personal satisfaction from working on a team that is doing important research.
3. I think of myself as a scientist.
4. I feel like I belong in the field of science.

Supplemental B

First Year Focus Group Script

Let's start our discussion by thinking back to the "good ol' days" of high school.

- In what ways do you think your high school experience has prepared you to be successful in college?
- In what ways do you think your high school experience could have better prepared you to be successful in college?
  - Follow-up: Are there particular areas of your college learning experience that you feel less or more prepared for? What about your course work in particular?

Specific subjects or topics? Target this towards STEM preparedness, if possible.

Each of you is here because you have some interest in a STEM field of study. We often choose our personal and professional paths because someone inspires us to do so.

- Think for a moment about particular people who may have influenced your interest in a STEM field. These could be people you know (uncle) or people you don't know (Bill Nye). I'd like for you to write those down for me. (use note cards: include student name and names of people)
  - Follow-up: On that same card, please list the traits, skills, or characteristics that you appreciate about the person/people you noted? Have these people shaped your ideas about what it means to be a scientist or what a scientist does? What traits or values do you have in common with that person/those people?

Not only do you each share an interest in STEM disciplines, but you each chose to come to Furman! Now that you've been here for a couple of months, I'd like to ask you about your experience thus far with STEM courses and as a student in general.

- Who is currently enrolled in a STEM course of some nature? Whether or not you are currently in a course, what challenges have you faced or what challenges do you expect to face in your STEM courses at Furman or your STEM career in general? What obstacles will you have to overcome or struggles do you anticipate? If you aren't currently in a course, think back to your high school courses or what you've heard from your [institution name] peers about the STEM courses they are in.
- Thinking more broadly, can you share about a specific time when something didn't go the way you expected this semester, what you did when you realized it, how you felt, and what you did after the fact?
  - Did you talk to anyone about how they navigated the same or a similar challenge for guidance or support?
  - Who do you usually go to for suggestions or advice when you encounter a challenge? Why do you go to that person/those people instead of others?
  - If you were to encounter this same challenge in the future, what specific strategies might be most helpful for you in navigating it? What people, groups, offices, or organizations at Furman might be able to help?

- I'd like to hear more about your experience beyond your courses. Would you say that, at this point, you feel like you belong at Furman, like you have a place here?
  - (If yes) Can you tell me more about this? What does belonging mean to you? Can you give me an example of when you felt like you belonged? Is this a general feeling of belonging or a particular group of people that make you feel you belong? Are there certain spaces, groups, courses, or community members you feel more connected to?
  - (If no) Can you tell me more about this? What does belonging mean to you? Can you give me an example of when you felt like you didn't belong? Are there specific aspects of your experience that have made you feel that you don't belong or certain spaces, groups, courses, or community members who contribute to you feeling that way?

To conclude our time today I'd like to ask you to think a few years into the future. Although you've just started at Furman, let's imagine you are getting ready to graduate in 2025.

- What is one goal that you have for your post-Furman future? In what ways is your Furman experience contributing (positively or negatively) to that goal right now?