NSF S-STEM: Energizing New STEM Career Pathways in Idaho

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Introduction

Our study is part of the *first* National Science Foundation (NSF) Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) Track 3 grant funded in Idaho. We aim to *recruit* and *retain* promising undergraduate engineering and computer science (ECS) students with demonstrated financial need through a consortium of three institutions: Boise State University (BSU), College of Southern Idaho (CSI), and College of Western Idaho (CWI). Our grant was awarded in October 2022. We began awarding scholarships for the spring 2023 semester to students at BSU, followed by awarding scholarships across our three consortium institutions for the fall 2023 semester. We completed three of six years in our award period during the fall 2025 semester.

Our *recruiting* efforts have focused on high school visits, events at CSI and CWI, and partnering with TRIO programs at BSU. We have awarded approximately 250 scholarships to 135 students as of spring 2026. We award *last dollar* scholarships up to $10k per academic year per student based on unmet need, which we define as cost of attendance (COA) minus student aid index (SAI), grants, and other scholarships. We have awarded scholarships to a total of 89 students for the 2025-2026 academic year, 44 students at BSU, and 45 students combined from CSI and CWI. Our scholars are 25.8% female, 69.7% male, 1.1% non-binary/non-conforming, and 3.4% prefer not to answer/no answer. Scholars range from first and second year (freshman and sophomore) at our three consortium institutions and third and fourth year (junior and senior) undergraduate students at BSU.

ECS programs in which our Scholars are enrolled include: civil engineering, computer science, electrical and computer engineering, general engineering, materials science and engineering, and mechanical engineering. All programs are direct admission except for mechanical engineering at BSU. Students are classified as pre-mechanical engineering until completing as series of core prerequisite courses with a 2.6 grade point average (GPA), after which they are admitted to upper division and reclassified as mechanical engineering students.

The cornerstone of our *retention* efforts has been a Vertically Integrated Projects (VIP) course focused on Leading Innovative Energy Design, which serves as a platform to build community across our three consortium institutions, engage in ECS research, and provide professional development skills building. BSU Scholars enroll each semester in this one-credit course while receiving scholarship funding. This course may be taken for credit across multiple semesters and can be counted towards Scholars' ECS technical elective credits. Our VIP course is available and open to all students in STEM and non-STEM majors through the Office of Undergraduate Research (OUR) at BSU. We have now offered our VIP course over nine semesters. Our instructional team continues to refine how the course is offered across our three consortium institutions, with an emphasis on career exploration, academic success, and durable skills building.

Our Scholars work alongside a lead faculty member, who guides them through scientific inquiry of innovative solutions to energy design challenges. Scholars develop and present research posters based on literature reviews to showcase their work at two undergraduate-centered events at BSU, one in fall semester and one in spring semester.

One unique aspect of our program is that Scholars from CSI and CWI are able to participate in our VIP course, which is offered synchronously via Zoom. Scholars from CSI and CWI participate in research experiences while not being required to officially enroll in our VIP course. Our approach to providing Scholars from CSI and CWI access to resources BSU has allowed them to build connections with their peers and research-focused faculty members, and encouraged transfer pathways.

Research

The STEM community has sought ways to broaden participation for generations (National Academies of Sciences and Medicine, 2016). Many students are unfortunately met with biases in STEM disciplines and an institutional culture that is difficult to navigate (Ohland et al., 2008). We have a deep understanding of the relationship between students' identities and self-efficacy as STEM professionals as a way to overcome these barriers and strengthen their progress to earning an ECS degree. Understanding how our intervention impacts these factors allows us to engage in ongoing improvement to support *retention* efforts for students who often get lost or stuck in the ECS pipeline.

Research is a required element of an NSF S-STEM Track 3 award and our efforts have focused on three questions:

(1) How does participation in our VIP course impact Scholars' identity as STEM professionals?
(2) How do Scholars' identity as STEM professionals relate to their ability to use the STEM language of current professionals?
(3) How does the impact of participation in our VIP course differ by Scholars' identity and initial institutional enrollment (i.e., starting at CSI or CWI versus starting at BSU)?

Our efforts to date have focused on Scholars participating in our program and we present results to each research question. We are in the process of identifying other ECS students who are not participating in our program to include as a matched group for comparison. We are also in the process of correlating these results with other academic success indicators such as GPA and retention.

Research Question 1

We research best practices for supporting Scholars' identity development as ECS professionals and have been tracking their progress over the last three years as part of this work. We administer three surveys to all Scholars in our VIP course at three *time points* during the academic year (i.e., early fall, mid-winter, end of spring). A total of 54 individual scholars completed all three surveys at a minimum of two time points, which equates to 180 responses.

We first used the validated *STEM Professional Identity Overlap* measure (McDonald et al., 2019), which asks Scholars to select an image that best represents how much their personal identity overlaps with that of a STEM professional. We also use the same measure to have Scholars predict how they think they will identify by graduation. The other two measures are adaptations of the *Science Identity Scale* to assess belonging, and *Science Self-Efficacy Scale* (Stieha et al., 2019), both of which have been successfully used to measure the impact of other S-STEM awards BSU. These two measures have not been formally validated, though we have used them previously with our Scholars and demonstrated sufficient sensitivity to assess changes over time.

Scholars' sense of STEM identity is rated on a scale of 1 (little overlap) to 7 (strong overlap). We found that their current sense of STEM identity and their predicted future identity increases as they participate in our program (Figure 1). Both scores show an upward trajectory, while the difference is more stark in their current sense of identity. Scholars' sense of belonging and self-efficacy as ECS professionals also improves over time (Figure 2). Both of these measures also demonstrate growth over time. We are in the process of performing inferential statistics of these data.

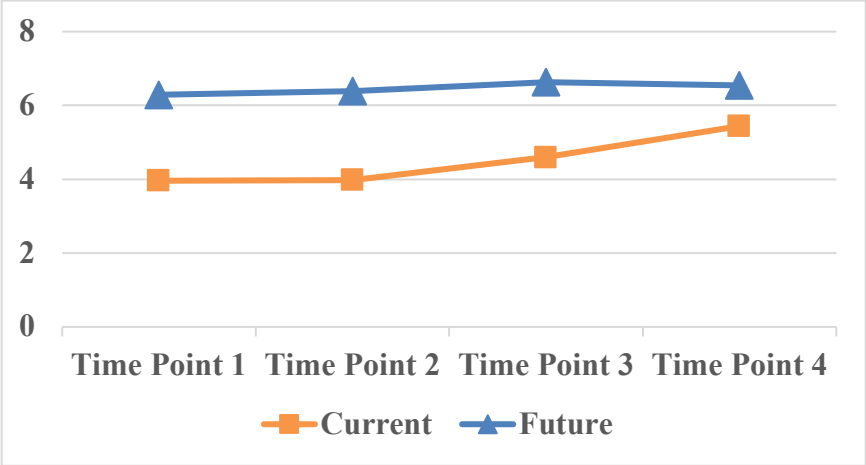

Figure 1: Changes in Scholars' current and future STEM identity over time.

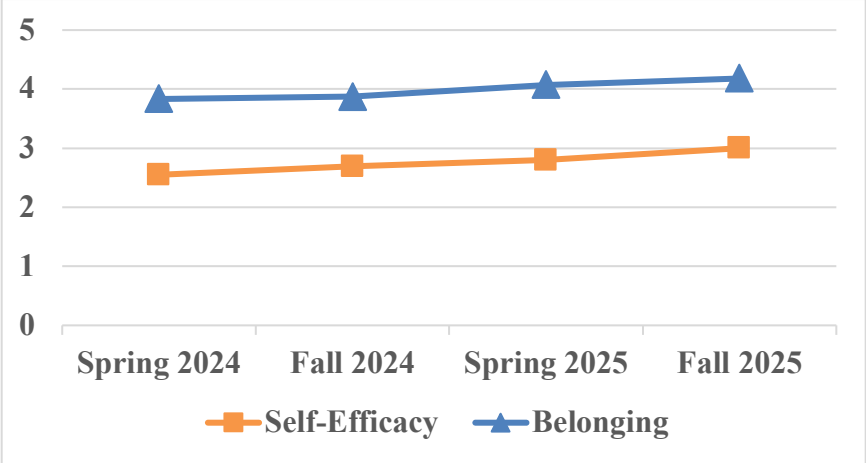

Figure 2: Changes in Scholars' self-efficacy and belonging over time.

Research Question 2

We examined Research Question 2 over the 2023-2024 academic year. Scholars were organized into teams and identified a topic for further scientific inquiry in the fall 2023 semester. Each team presented their topics during the regularly-scheduled 75-minute VIP class time at the beginning of the spring 2024 semester as a way of recruiting other Scholars. We immediately noticed that Scholars spent more time talking *about* content, rather than engaging in actual argumentation. Student presentations were held on Zoom and recorded, which allowed us the opportunity to review and reflect on what Scholars did well, and where they could improve. Scholars made very few conclusions or statements that could be considered argumentative claims

despite doing an excellent job telling each other about their ideas. They told each other facts *about* their area of inquiry ideas without ever stating why their work was *meaningful* or *why* anyone else should join their team.

Argumentation is a unique genre that has received much attention from researchers in a variety of fields (Benetos & Betrancourt, 2020; Davies et al., 2022; Wuryaningrum, 2020). There are some qualities that can generally be trusted to make a strong argument, while the context of these fields does not impact the definition and use of this genre. Providing opportunities for Scholars to identify these elements in published work, along with practice developing their own, can support guiding them to craft strong scientific arguments. Prior research in STEM literacy development emphasized the importance of providing direct instruction in literacy skills to undergraduate students (Archila et al., 2022; Öberg et al., 2022; Perla et al., 2023; Wu et al., 2020).

We held three workshops throughout the spring 2024 semester aimed at particular literacy skills that would support Scholars' scientific argumentation. Each workshop was held during the regularly-scheduled 75-minute VIP class period via Zoom and recorded. We describe each workshop below.

(1) Identifying your purpose and claim: We held our first workshop during week five of the spring 2024 semester. Our goal was to introduce Scholars to the concept of a purpose statement and support their understanding of it being an essential element in effective scientific writing. We defined a purpose statement as "the point toward which everything converges in the writing" (Goodson, 2017, p.157). We discussed that this might have been previously introduced to them using such terms as "argument", "pitch", or "thesis". We discussed that most purpose statements serve two goals: (1) tell the reader the intention of the writer; and (2) identify the importance or need of the work about which is being written.

(2) Identifying your purpose and claim in published writing: Our second workshop was held during week seven of the spring 2024 semester. Scholars began exploring existing literature on their topics of scientific inquiry once they established the purpose of their research. Our goal for this second workshop was to provide Scholars a framework for dissecting STEM writing to ensure efficient use of their time when reviewing published writing for supporting their claim. Our workshop began with explicitly telling Scholars that an entire academic article is rarely read from beginning to end by experts in their fields. We explained that experts more often begin reading a scientific journal article by skimming through the abstract, jump to the discussion or conclusion, and decide how much to read if the article is relevant to their needs.

(3) Organizing your writing to support your claim: Our third workshop was held during week ten of the spring 2024 semester. Our goal for this final workshop was to provide strategies for Scholars to revise their writing to ensure organization and structure leading to a well-supported argument. Reverse outline strategies from Goodson (2018) were utilized, which relies on identifying key sentences. This strategy involves identifying the main idea of a paragraph and ensuring that all other sentences in that paragraph support that key sentence.

Our Scholars gave oral presentations at the end of the spring 2024 semester and we identified how their scientific argumentation developed following implemented intervention (three, 75-minute workshops). Scholars worked in small groups and decided how presentation responsibilities would be divided. The same number of Scholars who presented at the end of the

spring 2024 semester (13 individuals) as did at the end of the fall 2023 semester. This included four female Scholars and four Scholars from CSI and CWI who spoke during the end of fall 2023 semester presentations. This number increased to five female Scholars overall and five Scholars from CSI and CWI who spoke during the end of spring 2024 semester presentations.

We found that only 52% of Scholars surveyed in the fall 2023 semester prior to the three-workshop intervention selected one of the three key literacy skills as important to being a successful engineer or computer scientist. This increased to 65% of Scholars surveyed in the spring 2024 semester following the three-workshop intervention. Student growth on the STEMS SWAS similarly increased from the fall to spring semester (Table 1).

Table 1. Survey results showing shift in Scholars' attitudes toward writing.

	Fall 2023 Semester		**Spring 2024 Semester**	
	Cohen's *d*	***p* value**	**Cohen's *d***	***p* value**
Writer Self-Efficacy	0.079	0.633	0.540	< 0.001
Writing Beliefs	0.021	0.914	0.401	0.058
Writing Motivation	0.016	0.909	0.223	0.039

We found that workshops focused on argumentation in STEM improved Scholars' beliefs about the value of writing and their attitude towards writing (Wright et al., 2025). Mastering the skill of argumentation is essential for communicating effectively as ECS professionals, which leads to career advancement (Akkus et al., 2013). Our work demonstrates that a minimal intervention (three workshops), in terms of time resources (225 minutes of class time), can have an impact on students' ability to engage in scientific argumentation. Our framework shows promise of making replication, implementation, and integration within existing program-specific ECS courses (Miller et al., 2024).

Research Question 3

We are in the process of analyzing data to answer our third research question, as this requires collecting more data over a longer period of time. Our initial results show that identity and sense of belonging begins, and remains stronger, for Scholars who started at BSU, though Scholars from CSI and CWI follow similar trajectories. We found, by contrast, that self-efficacy of Scholars who transferred from either CSI or CWI surpasses that of their peers who started at BSU.

Conclusion

Our holistic approach (linking financial supports with career exploration, academic success, and durable skills building) to what is the *first* NSF S-STEM Track 3 funded in Idaho has had positive impacts on our Scholars. We support academically talented students who have financial need with scholarships and provide focused durable skills building interventions that show promise by positively impacting their identity, improving their self-efficacy, and increasing their sense of belonging as STEM professionals. We anticipate similar positive trends as the number of Scholars in our program increases and we make data-driven decisions about interventions that best serve their aspirations as ECS professionals.

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