Interdisciplinary Research and STEM-focused Social Science Curriculum Support Retention and Impact Perception of Science in Cohort of S-STEM Scholarship Students

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Abstract

A curricular approach to supporting low-income STEM Scholars is outlined and initial associations with retention, social and cultural capital, perception of science, self-efficacy, and outcome expectations are examined. Details are provided for the curricular support program based on interdisciplinary research, service learning, and an explicit examination of the interpretation of science based on culture and social location. We show that Scholars had increased retention and graduation within STEM majors compared to a control group. Further, Scholars self-report in surveys and interviews increased social and cultural capital, motivation, and related outcomes that they attribute to the interdisciplinary coursework that comprises the bulk of the program.

Introduction

Students Engaging In Scientific and Mathematical Interdisciplinary Collaborations (SEISMIC) is a program designed to support academically talented, low-income science and mathematics majors at Bridgewater State University (BSU). BSU is a public, Master's comprehensive institution, 40 minutes south of Boston, Massachusetts, USA by commuter rail. Founded in 1840 by Horace Mann as one of the nation's first Normal Schools for the training of teachers, the University maintains strong roots in education but has expanded over the past 20 years to be focused broadly on undergraduate education with an emphasis on Undergraduate Research. In 2019, BSU was honored with the Council on Undergraduate Research Campus-Wide Award for Undergraduate Research Accomplishments for developing a program of depth and breadth that documented impacts on traditionally underserved populations. Low-income students (37%), first generation students (53%), and students of color (27%) comprise significant fractions of the undergraduate student body. BSU supports STEM degrees in biology, chemistry, computer science, geology, mathematics and physics, with 1,221 students enrolled in those disciplines.

The SEISMIC program has supported 39 Scholars over 4 years with scholarships of up to $6,000 per year for the Scholar's sophomore through senior years. The first cohort of Scholars graduated in May 2020. The scholarship program is funded by the National Science Foundation S-STEM program, under grant NSF-DUE 1643475. SEISMIC differs from most S-STEM programs in that the core intervention associated with the financial support is curricular in delivery and diverse in academic disciplines, as opposed to more typical co-curricular approaches led predominantly by science and mathematics faculty.

The purpose of this paper is to describe the curricular support program provided by SEISMIC, to outline the grant's (including financial support) association with retention four years into a five-year project, and to highlight evidence (based on surveys and graduating senior interviews) that Scholars are connecting program curriculum to the overall framework and goals of SEISMIC. This larger framework focuses on the explicit development of social, cultural, and psychological capital through cohorts who share a curriculum that promotes a wide lens to view science and mathematics, not just as interdisciplinary across STEM fields but also from humanistic and social science perspectives. By integrating these diverse viewpoints through a curriculum with embedded undergraduate research and STEM service-learning, SEISMIC aims to retain Scholars who view science as multidisciplinary, applied to world problems, and responsive to local and global communities.

SEISMIC support components are integrated into three 3-credit classes and two 1-credit seminars. As is common in many S-STEM programs, Scholars are introduced to interdisciplinary research at the beginning of the program and conclude the program with senior-level undergraduate research, with interactions mostly with traditional STEM faculty. Unique to SEISMIC, the middle years of the program consists of courses taught within the Philosophy, Sociology, and Psychology departments. These courses examine the intersection of science and society and allow Scholars to connect to their lived experiences. The design of the program intentionally links the study of science to the values and perspectives of diverse stakeholders and contextualizes the study of science within a humanistic frame. Scholars learn about, and examine their own social, cultural, and psychological capital early in the program. In addition to undergraduate research experiences, Scholars perform curricular-based, STEM-focused service-learning activities to further cement the connection between science and society. In this paper, we show how this set of course-based interventions, that are diverse in academic perspectives, impacted a group of talented students who are traditionally underserved by STEM higher education.

Literature Review

Several S-STEM programs have identified interventions that positively impact student success. For example, the S-STEM program at Robert Morris University (RMU) integrates living-learning communities, outreach, research, and development of better study, critical thinking, and time management skills into their program. RMU has reported that S-STEM scholars outperformed their peers in their STEM courses every semester (Kalevitch, 2015). This program at RMU also focused on identifying ways to improve student self-efficacy, indicating that it may lead to even higher levels of academic progress (Kalevitch et al., 2012). An S-STEM program at Louisiana State University (LSU), which provided academic support, professional development, mentoring, and opportunities for research and outreach, led to improved retention and graduation rates of its participants. The LSU S-STEM program largely attributed their success to its mentoring strategy (Wilson et al., 2012; Crawford et al., 2018).

Interdisciplinary collaborations benefit students, particularly when students participate in interdisciplinary work early in their studies within an intensive research-based experience (Stamp, Tan-Wilson & Silva, 2015; Piper & Krehbiel, 2015), especially for S-STEM programs (Canaria et al., 2012). An S-STEM program at the University of Maryland Baltimore County that incorporates interdisciplinary bioengineering research-related activities achieved retention and graduation rates in S-STEM students that was higher than mechanical engineering students not in the S-STEM program. S-STEM students also enrolled in graduate school at a higher rate than their peers (Zhu et al., 2020).

We have not found a significant body of literature that examines the impact of humanistic and social science curriculum specifically on undergraduate student STEM retention, STEM motivation, views of science, or self-efficacy. Our interests in pursuing this curriculum as part of our Scholarship program is based, in part, on research that illustrates the importance of demystifying the hidden curriculum and mitigating class cultural mismatch for first-generation and working-class college students (Anyon 1983; Soria 2015; Hurst 2010; Jack 2014; Rice et al., 2017; Stephens et al., 2012; Warnock, 2014). While first-generation college student background was not a selection criteria for the SEISMIC program, a high proportion of BSU students (and the Scholars ultimately admitted to the program) are from these backgrounds. Research suggests that efforts to support students around issues associated with coming from these backgrounds help support all students (King et al., 2017).

While STEM education presents opportunities for students, college imposes costs as well (Goldrick-Rab, 2016; Hurst, 2010). Scholarship support alleviates at least some of the financial burden and can be an important part of mitigating ongoing inequalities in college education, because first-generation students are more likely to take on greater indebtedness while in college than other students (Furquim et al., 2017). First generation and working-class college students also may experience what has been called survivor guilt (Piorkowski, 1983), breakaway guilt (London, 1989), or family achievement guilt (Covarrubias & Fryberg, 2015), as their educational experiences change their family relationships. Students often experience impostorism, a sense of doubt about their achievements (Austin et al., 2009; Bernard et al., 2017; Warnock, 2014). Across all disciplines, supporting students' sense of belonging, especially for students from racially diverse backgrounds who may not find faculty with whom they identify, can be critical to their academic success (Baumeister & Leary, 1995; Castellanos & Jones, 2003; Nora et al., 2011; Pyne & Means, 2013; Rendon, 1994; Stebleton et al.; 2014; Strayhorn, 2008; Strayhorn, 2018). Further, publications about efforts to support first-generation and working-class college students on our own campus, led by co-PI Colby King, highlight the role of social, cultural, and psychological capitals in helping college students make the most of their opportunities (King et al., 2017; King & McPherson, 2020).

STEM service learning is a high impact practice that leads to enhanced motivation, understanding of scientific concepts, confidence in sharing scientific knowledge and leadership, and improvement in communication, teamwork, and organization skills (Kuh, 2008; Carpenter, 2015; Grant et al., 2015; Gutstein et al., 2006; Rao et al., 2007; Najmr et al., 2018; Fitzallen & Brown, 2017). Other NSF-funded programs designed to enhance STEM retention also provide opportunities for service learning through STEM outreach activities. Students participating in the NSF-funded STAIRSTEP program at Lamar University served as role models and advocates for STEM studies as they engaged broadly in outreach activities in the K-14 community (Doershuk et al., 2016). Their community work served not only to attract other students to STEM, but also to develop their own communication and teamwork skills. Students in the previously mentioned NSF-funded programs at RMU and LSU also participated in STEM outreach activities as one component of multi-faceted programs designed to improve STEM retention (Kalevitch, 2015; Wilson et al., 2011).

A goal of the SEISMIC program is to determine if participation in STEM service learning impacts self-efficacy and outcome expectation, both of which impact motivation. Self-efficacy is an individual's belief in their ability to achieve goals (Bandura, 1977; Bandura, 1986) – in this case, outcomes related to leading STEM activities in the community. Self-efficacy positively impacts motivation and ultimately performance (Bandura & Locke, 2003). Individuals with high STEM self-efficacy perform better and persist longer in STEM disciplines relative to those with lower STEM self-efficacy (Rittmayer et al., 2008; Byars-Winston et al., 2010; Hanauer et al., 2016). Additionally, health science self-efficacy correlates with career interests of middle school, high school, and early college students (Peterman et al., 2018). Outcome expectations are the personal belief in the effect of an action on achieving a particular outcome (Bandura, 1986). Positive outcome expectations serve as incentives that motivate and promote future behavior (Bandura, 2001). Students with high outcome expectations tend to explore STEM career paths and believe that success in STEM studies will allow them to be successful in the future (Betz & Voyten, 1997; Fouad & Smith, 1996; Fouad et al., 1997). One can infer that a student's outcome expectations related to STEM service learning would be linked to the extent to which they continue to engage with the public. Overall, both self-efficacy and outcome expectations influence the development of career interests, which, in turn, affect career choices.

1. Student is eligible for Pell Aid in the Fall Semester, as determined by the Total Family Contribution from FAFSA.
2. Student's total GPA at the end of the Fall Semester > 3.0.
3. Student earns a B or better in one of the following courses in the Fall Semester: BIOL 121 (General Biology I), CHEM 141 (General Chemistry I), COMP 151 (Computer Science I), MATH 150 (Pre-calculus), MATH 161 (Calculus I), PHYS 243 (General Physics I)

Table 1. Eligibility Criteria for Application as a SEISMIC Scholar

The SEISMIC Program

Beginning in Summer 2017, cohorts of 8 to 11 SEISMIC Scholars entered the Scholarship program. As required by the NSF S-STEM program, all students were academically talented, and were recruited based on their high grades in introductory, college-level science and mathematics classes and financial need. The full requirements for eligibility are listed in Table 1. Students who were eligible were contacted by the grant PIs and their academic advisors. The application process included three short written essays addressing their interests, strengths and weaknesses, and the potential financial impact of the scholarship. Applicants also provided a faculty reference and participated in an informal informational interview.

To date, 39 Scholars have been supported by the program. Selected Scholars received $6,000 scholarships for up to three years to help to defray college expenses, estimated at $28,132 for Massachusetts residents living on campus. Overall, 54% of Scholars identify as female and 54% are students of color. Scholars are delineated by race and ethnicity in Table 2. Twenty-three of the 39 Scholars (59%) are first-generation. All students were low income, as defined by eligibility for Federal Pell Aid at their admission to the program, although to date three students subsequently lost Pell Aid eligibility after their first year in the program due to changes in their family's financial situation. These Scholars remained active in the program although they no longer receive scholarship assistance.

At program entry, students in each cohort expressed a range of activities related to their disposition to higher education. When applying to college, students in each cohort visited between 1 and 10 schools before applying

White, Non-Hispanic	15
Black	14
Hispanic	4
Asian	2
Native American	1
Two or more races or ethnicities	1 (reported as Black and Hispanic)
Not Reported	2

Table 2. Race and Ethnicity of SEISMIC Scholars

to college, with an average across the three cohorts of 3 campuses. Students in each cohort applied to an average of 4 colleges as well, though many of the SEISMIC Scholars applied only to 1 school, with the average being increased by just a few students in the program who applied to 10 or more colleges. Ten of the eleven students in the first cohort, and five of the eight students in the second and third cohort who responded to the question reported having taken a test prep course before applying to college.

Scholars begin the program in the summer between their first and second years at BSU and participate in the following three 3-credit classes and two 1-credit seminars. Course curriculum is described in detail in the SEISMIC Curriculum section below.

1. *Chemistry 299: Scientists at Work* (CHEM 299), taken the summer before Sophomore Year, is a 5-week, writing-intensive, three-credit exploration of interdisciplinary research consisting of 23 hours of classwork and over 70 hours of laboratory research work.
2. *Natural Sciences 160: Building Capital for STEM* (NSCI 160), taken in the fall of Sophomore Year, is a one-hour weekly seminar that assists students in identifying and expanding their social, cultural and psychological capital through readings, reflection, and discussion.
3. *Philosophy 261: Science, Values and Society* (PHIL 261), taken in the spring of Sophomore Year, is a writing-intensive, three-credit course that examines the intersection of science and society, both in terms of how scientists and non-scientists understand and create knowledge and how science history and practice of science embodies decision making that reflects the values, priorities, and power structures that exist within a society.
4. *Psychology 230: Cultural Psychology* (PSYC 230), taken in the fall of Junior Year, is a three-credit, service-learning based course in which students explore how culture shapes people's perceptions and experiences, with a specific emphasis on the culture of science and its implications for who becomes a scientist and what knowledge is generated.
5. *Natural Sciences 360: Next Steps in STEM* (NSCI 360), taken in the fall of Senior Year, is a weekly one-credit seminar designed to help senior SEISMIC Scholars connect their classroom and co-curricular activities together, understand and explain the interdisciplinary connections of their work, and position themselves for applications to jobs, graduate or professional schools after graduating.

Timing	Summer prior to Soph. Year	Fall Soph. Year	Spring Soph. Year	Fall Junior Year	Fall Senior Year
Course	CHEM 299: Scientists at Work (3 credits)	NSCI 160: Building Capital for STEM (1 credit)	PHIL 261: Science, Values and Society (3 credits)	PSYC 230: Cultural Psychology (3 credits)	NSCI 360: Next Steps in STEM (1 credit)
Primary Learning Outcome	Introduce Interdisciplinary Research including collaboration, working in a lab, communication skills	Identify pathways to careers including social support and available high impact practices	Examine how science and mathematics interact with society, including ethics and the identification of knowledge	Apply theories of social, cultural, and psychological capital & STEM motivation to STEM outreach	Scholars connect previous work inside and outside SEISMIC, contextualize that work within a broad lens
Additional Benefits	Fulfills Second Year Seminar and Speaking Intensive Requirements	Support Scholars in connecting with one another in shared experiences.	Fulfills Humanities and Writing Intensive Requirements	Fulfills Social Science and Multicultural Requirements	Increases chances students will successfully enter STEM workforce
Connection Between Elements	SEISMIC activities begin with a team-based introduction to research	Scholars examine their own social location, develop plans for building capital and supporting one another	Research context enhanced with study of societal relevance, differing viewpoints	STEM out-reach is the context for lessons about societal relevance, STEM motivation, and Capital	Scholars practice communicating about work through SEISMIC in oral and written forms for future employers or grad programs

Table 3: SEISMIC Program Activities. Beginning in the summer between the first and second years, cohorts of SEISMIC Scholars participate in structured activities that connect across the program to produce Scholars who have experience applying their knowledge in interdisciplinary ways in the community and through research. The approach of the program to use a wide discipline lens outside of traditional STEM courses assists Scholars in seeing the relevance and responsibilities of STEM fields.

Intervention: SEISMIC Curriculum

Unlike many S-STEM programs, SEISMIC delivers its student support largely through curricular structures. Scholars begin the program in the summer between their first and second years at BSU and participate in three 3-credit classes and two 1-credit seminars. These five classes were designed to work together and promote several themes on which the SEISMIC grant was based. These five classes integrate and promote an interdisciplinary, multicultural approach to science and mathematics, reinforcing classroom discussions with significant writing, service learning, and research experiences. Taken together, the five classes provide a framework for student support that works across courses and disciplinary approaches as illustrated in the table below.

The first program element of SEISMIC is a 5-week summer research experience connected to a three-credit seminar course, *CHEM 299: Scientists at Work*. CHEM 299 fulfills Scholars' Second Year Seminar (SYS) requirement and is taken in the summer between the students' first and second year of studies. The course structure is nearly identical to the First Year Seminar supporting a research-intensive summer bridge program for new first year students reported in Waratuke and Kling (2016). SYSs at BSU are three-credit, discipline specific, writing or speaking intensive classes to be taken in a student's second year with the goal of introducing students to higher level academic studies and inquiry. The use of a SYS within SEISMIC is natural, as we are on-boarding rising sophomore level students into a program that emphasizes interdisciplinary research and communication skills.

Through CHEM 299, students work in interdisciplinary research teams of approximately three Scholars and are supported by a faculty and senior undergraduate mentor. The undergraduate mentor is typically a rising senior science or mathematics major who is conducting research in BSU's Adrian Tinsley Program for Undergraduate Research Summer Program, which provides a paid ($4,500) 10-week summer research opportunity to approximately 50 students across the university each year. SEISMIC has been fortunate in recent years to utilize senior SEISMIC Scholars as the undergraduate research mentor. The course and research experience run in parallel for five weeks in July and early August, culminating at a University-wide research celebration where both the Adrian Tinsley Program and SEISMIC students present their research.

Because the SEISMIC Scholars are joining senior undergraduate research mentors in the final five weeks of their own work, frequently SEISMIC team projects are able to join in, or explore directions related to, the senior undergraduate student research. This partnership provides a synergy where our Scholars contribute to the senior undergraduate researcher's project, while also pursuing a distinct research project of their own.

The structure of the seminar is non-standard in that "class-time" and "research-time" are joined. Scholars come to campus three days per week and meet for 75 minutes first with each other and the CHEM 299 instructor. They then spend approximately 5 hours per day in their research lab groups, sometimes with the faculty research mentor, but nearly always with the senior undergraduate mentor. This provides over 90 hours of combined class and research lab time.

CHEM 299 curriculum is centered around three types of assignments. First, there are two "hot topic" papers, which are two-to-three-page, research-style papers exploring a hot topic of research in the Scholar's field. Second, there are daily blog assignments where students are provided a reflective prompt and tasked to write 1 to 3 paragraphs, sometimes supported by pictures and data. These fifteen blog assignments involve a combination of assignments asking students to

1. Reflect on their feelings and experiences approaching and conducting research,
2. Prepare for the next phase of the research, for example, to prepare questions they do not understand to ask the faculty mentor the next day, respond to readings about the research, etc., and
3. Explain parts of the research to a variety of audiences.

Lastly, when writing about their research, students were asked to write a series of explanations, of increasing technical detail, on each of the major sections of a scientific poster, including questions on the background, methods, and results of their work. Students were then able to connect and repurpose many of these blog entries in the third major assignment, which was a team-produced scientific poster and oral presentation at the conclusion of the program.

Following the introduction to scientific research in the summer period, Scholars completed *NSCI 160: Building Capital for STEM* in the fall semester of their second college year. To assist students in identifying and expanding their social, cultural, and psychological capital, we explicitly introduce and explain these terms to students in NSCI 160 and help students reflect on their experiences as young adults navigating the college experience. We work from Putnam's (2001) definition of social capital as consisting of the "connections among individuals—social networks and the norms of reciprocity and trustworthiness that arise from them" (p. 19). We emphasize how a more diverse social network can be valuable (Erickson, 2003; Granovetter, 1973). We discuss cultural capital following Bourdieu's (1986) definition, to include education, style of speech and dress, and physical appearance, and illustrate to students that cultural capital can be understood as what an individual draws on to know how to "fit in" in various social settings, while also recognizing that Yosso (2005) illustrates how students of color bring several forms of cultural capital from their homes and communities that higher education institutions ought to acknowledge and value. We teach that psychological capital is an emotional resource that includes confidence and resilience, is critical for overcoming the challenges, and is "an individual's positive psychological state of development" (Luthans et al., 2007, p. 542). Subsequent courses and experiences were designed to provide Scholars with opportunities to build capital through mentoring, service learning, and undergraduate research experiences.

In practice, this course combined both abstract and practical content to support student's capital development. Students read social science articles about the value of diverse social networks and the role that cultural capital plays in helping a person navigate an institution. Leaders of campus offices were brought into class sessions, and students were also assigned to engage with campus offices of their choosing, including study abroad, academic support, and others. For their final assignment in this course, students were asked to write a reflective essay in which they defined and explained the three capitals, and also discussed why these may be especially critical factors for college students from first-generation-to-college and/or working-class backgrounds.

In their NSCI 160 essays, students shared thoughtful definitions and reflections which demonstrated their conceptual and practical understandings. One example of a straightforward explanation that a SEISMIC Scholar wrote is, "Each of these capitals offers something different to first-generation and working-class college students. In order to be truly successful, a student should understand and work to increase these types of capital." While another student shared an example that illustrates their subtle understanding of why these capitals are critical, but also why developing these capitals while a student can be challenging. This student wrote, "A very good example is, if a group of friends invite me to go to the movies, they have enough money to spend on themselves and for extra activities. However, I will say no because I can't afford to spend the little money I have. In this situation I'm missing out on socializing/networking and potentially making friends with people that could be in the same field of interest as me. It's important to have support groups for students like me."

The role of *PHIL 261: Science, Values, and Society* is for SEISMIC Scholars to understand how science does not stand apart from the society in which it is conducted. Many assume science to be an objective enterprise, with scientific methods and thinking providing certainty and authority. Rather, the history and practice of science embodies decision making that reflects the values, priorities, and power structures that exist within a society at a given time and social location. Some of the values that drive science are intellectual values, like discovery and application, but other values and questions that drive science, like "what is important to know," reflect power, religious, and cultural norms, as well as the distribution of resources available. From the decisions that drive human experimentation to the priorities that underlie environmental conservation, a key part of the SEISMIC training process is for Scholars to see that scientific methodology contains value judgements at every turn, value judgments that they will be making as future practitioners of science.

PHIL 261 scaffolds the process of learning to critically examine the scientific enterprise, culminating in a major project where students examine a specific topic of their choosing, identifying the places where values play an important role, how the activities and results of the scientific investigation affects others, and generating policy suggestions. Students start with small assignments from a variety of perspectives on science: reading, reading response questions, and small group discussion. Students then complete a series of reflection papers that take on bigger questions on the role societal and individual values play in a general scientific area such as medical AI or industry funding of scientific research. To design their final individual project, students meet individually with the course instructor multiple times to develop a specific area of interest to the student.

In their junior year, SEISMIC Scholars take *PSYC 230: Cultural Psychology,* where they make up about a third of the class alongside psychology majors or other students taking the course to meet core curriculum requirements. The course covers the typical information that one would get in any other course on cultural psychology, including both cross-cultural issues (i.e., variation between cultures) and multicultural issues (i.e., how cultures co-exist in a single society). What makes this SEISMIC section of the course special is that each topic is discussed through the lens of the culture of science. For example, an important topic in cross-cultural psychology is understanding the differences between individualist and collectivist cultures. In the SEISMIC section of the course, students read research that demonstrates how American universities promote individualistic cultural norms (e.g., Stephens et al., 2012), which can create barriers for students from collectivist backgrounds, thus limiting the diversity of scientists. As another example, when learning about stereotypes, we read and discuss research demonstrating how stereotype threat impacts women and racial minorities in STEM fields (e.g., Shapiro & Williams, 2012). When learning about how culture can shape visual perception (e.g., Nisbett & Masuda, 2003), students consider the bounds of objectivity in scientific research that is based on visual observations. In this way, students realize the implications of the lack of diversity in STEM fields, both for the STEM workforce and the knowledge that they create.

These realizations fuel their service-learning project, wherein students in PSYC 230 work in small groups on STEM outreach projects that they share at a community event and after school program. Specifically, SEISMIC Scholars developed and led STEM outreach activities at an

Open Lab Night event attended by more than 500 community members, and for an after-school program for 4th and 5th grade students from the Gilmore School, a local elementary school with 82.5% of students identifying as African American, and 11.7% identifying as Hispanic. Outreach activities have focused on a wide variety of topics, ranging from the use of DNA evidence in forensic science to building circuits out of playdough. These projects offer students the chance to both observe and shape the culture of science as they represent what science is to a diverse group of children. Through class discussion and reflection papers, students connect their learning about the culture of science to their science outreach experiences.

NSCI 360: Next Steps in STEM served as a final culminating point for student work over their three years in the program. The broad objectives of NSCI 360 are to help students identify their immediate post-graduation plans, to begin the steps to achieve those plans, and to connect their research, class, and project-based work to their upcoming plans. As part of making that connection, we emphasized communicating their research experiences to a wide variety of audiences and being able to identify interdisciplinary aspects of their research and studies over their entire time at BSU. Our goal was to help students articulate what their training helps them bring to the table in different research or industry areas, with an understanding of and appreciation for skills and training that complements that work.

Scholars begin by drafting a post-graduation Plan A and Plan B, with steps and timelines that include application deadlines, requesting letters, writing materials, and studying for exams. Students request that faculty be ready to write letters later in the year, practice interviewing, and write elevator speeches that connect their Plans to their work as a Scholar at BSU. Two longer writing assignments conclude the semester, each with an intended audience of prospective interviewers. One asks students to explicitly explain the skills and capabilities they developed in their research or other projects and how these techniques are applicable to their proposed Plans. The second has Scholars position their work within an interdisciplinary context; in effect, to describe either the interdisciplinary nature of the research itself, or connections this scholarship makes to other disciplines through application or techniques.

Two cohorts have completed NSCI 360 to date. Both required substantial help in a number of these tasks. While students generally had resumes, most first resume drafts did not include significant sections highlighting technical details that employers or graduate programs would want to see. Scholars also had a difficult time talking about themselves and their skills. We worked to overcome this inhibition by having students practice talking about their research or interests to one another in small groups, and by formally writing (and planning) answers to key technical questions likely to come up during interviews.

In total, the curricular nature of the SEISMIC program was designed to require students to examine science from a number of perspectives, including perspectives from outside traditional scientific disciplines. Students were explicitly introduced to concepts of social and cultural capital alongside efforts to teach about working in teams on interdisciplinary projects. Given the multiple writing and speaking assignments and opportunities, Scholars were required to build communication skills throughout the program, with consideration for a variety of audiences, from technical experts in and out of their fields to the general public. As such, the program was designed to help Scholars develop in a particular direction as they were supported financially in STEM studies.

Research Study Design

As we study SEISMIC, we seek to learn whether the program's unique combination of financial and curricular support increase retention and STEM graduation. We also seek to understand how SEISMIC participants attribute their personal growth to grant program activities and curricula. To examine these issues, we have employed a mixed-methods approach where we 1) compared academic progress for SEISMIC Scholars with that of a control group of students who do not participate in the program activities, 2) utilized annual surveys of Scholars to assess changes in capitals over time, 3) utilized pre/post surveys for students engaging in service learning to assess changes in self-efficacy and skill development, and 4) conducted interviews of graduating Scholars to assess their understanding of the program's impact on them.

The control group was composed of students who were eligible to apply to be a SEISMIC Scholar, according to Table 1, but were not selected. All members of the control group qualified as Low Income (eligible for Pell Aid) in their year of selection. In this paper, we report on the academic progress of Year 1 and Year 2 groups, as these Scholars and control group students have completed at least two years of studies after the award was granted. In Year 1, there were 11 students selected to be SEISMIC Scholars and 17 students were selected for the control group. In Year 2, eight Scholars were selected, and there were 37 students in the control group.

SEISMIC Scholars were surveyed annually through an instrument which included questions on students' academic progress as well as their development of social and cultural capitals and other aspects of their academic experience. The capitals module portion of the annual SEISMIC survey is adapted from sociologist Allison Hurst's School to Work survey module (Hurst, 2018, 2020). For SEISMIC, the full annual surveys included questions about outside-of-class meetings with faculty, the size and diversity of student's social networks, involvement in extracurricular activities, and questions which probed for indications of their sense of belonging on campus and breakaway guilt from their families.

To determine the impact of the service-learning experience, SEISMIC Scholars in the Psychology 230 class were surveyed to assess impact on self-efficacy, outcome expectations, and skills development at the beginning of class and again after their participation in STEM service-learning activities. The survey contained modified statements from the American Association for the Advancement of Science (AAAS) Self-efficacy for Public Engagement with Science Scale for Scientists and the AAAS Outcome Expectations for Public Engagement with Science surveys (Peterman et al., 2017; Robertson et al., 2018), and questions designed to assess the impact on attitudes and beliefs towards science and the impact on skills, such as communicating verbally, managing time, and taking responsibility as a scientist. Surveys asked respondents to rate their level of agreement with statements related to their ability to achieve specific goals connected to STEM communication and outreach (self-efficacy); their belief that their STEM outreach work would achieve the intended outcomes (outcome expectations); and statements related to attitudes and beliefs towards science, and skills development. A Likert scale (1-5) was used, where a score of 1 indicated strong agreement, and a score of 5 indicated strong disagreement. Four questions, which convey negative statements, were reverse scored.

Additionally, exit interviews were conducted with the first graduating cohort of the project to collect qualitative data about participants' experiences with the program. Interview questions were designed to understand how the program was related to growth in participants' knowledge, skills, social and cultural capital, and future plans. The questions included:

- What did you learn about science and society as a result of your participation in the program?
- What knowledge have you gained about STEM through the program?
- What specific knowledge have you acquired through your participation in (a) Open Lab Nights; (b) After School STEM Program; (c) Summer Research Program and (d) Science Courses?
- What set of science skills have you developed during your time in the program?
- What specific skills have you acquired through your participation in (a) Open Lab Nights; (b) After School STEM Program; (c) Summer Research Program and (d) Science Courses?
- Can you describe some personal growth experiences you have had during your time in the program?
- Could you describe how your social network has changed during your time in the program?
- Can you identify some important relationships and connections you have made that contributed to your development as a science student in your time in the program?
- What specific aspects of your support network, both on

and off campus, have changed the most during your time in the program?

- Can you share some reflections on your work with mentors, faculty, peers, and other program associates during your time in the project?
- In what ways has your participation in this project affected your preparation and aspiration for a future science career?
- How might you use your network, during your time in the program, in the future?
- What are some of your future plans in the science field?

Each interview lasted about one hour and gave participants the option to not answer any question or to end at any point. Eight out of the ten graduates of cohort one fully participated in the interview sessions.

Data Analysis Strategies

Our purpose in this paper is to illustrate the broad effectiveness of the combined program. Given the small number of supported students to date and the lack of a randomized control trial, we do not attempt to identify causality between retention and either the curricular or financial support in this paper. Rather, we aim to document an association between participation in SEISMIC and student success, as well as SEISMIC Scholars' self-reported growth as students and scientists. Our analyses are organized into four areas:

1. We compared the retention and graduation rates of supported SEISMIC Scholars and a control group of students qualified to apply but not selected for the program. Retention and graduation rate data were drawn from official student records for both SEISMIC Scholars and members of the control group. Differences in rates of retention were analyzed using a chi-square analysis assuming significant differences at $p<0.05$.
2. We examined annual surveys to assess SEISMIC Scholars' self-reported growth in capital. Due to the relatively low number of participants to date, survey questions on annual surveys related to growth in Capitals will be reported as numbers of Scholars, or percentages, who report changes on important measures.
3. We examined pre/post surveys for the service-learning experience to assess changes in SEISMIC Scholars' self-efficacy, attitudes, and skills. We calculated mean scores for each participant from a battery of questions related to Self-efficacy, Outcomes Expectations, and Attitudes and Beliefs about Science. For each combined measure, we test for significant pre-/post-course differences using a Wilcoxon signed-rank test. Descriptive statistics were examined to assess self-reported change in skill development.
4. We looked for common themes within Graduating Scholar Exit Interviews which tie SEISMIC learning objectives to curriculum. After Graduating Scholar Exit interviews were transcribed, we utilized a keyword analysis to identify common themes and selected quotes from individual Scholars that epitomize each theme.

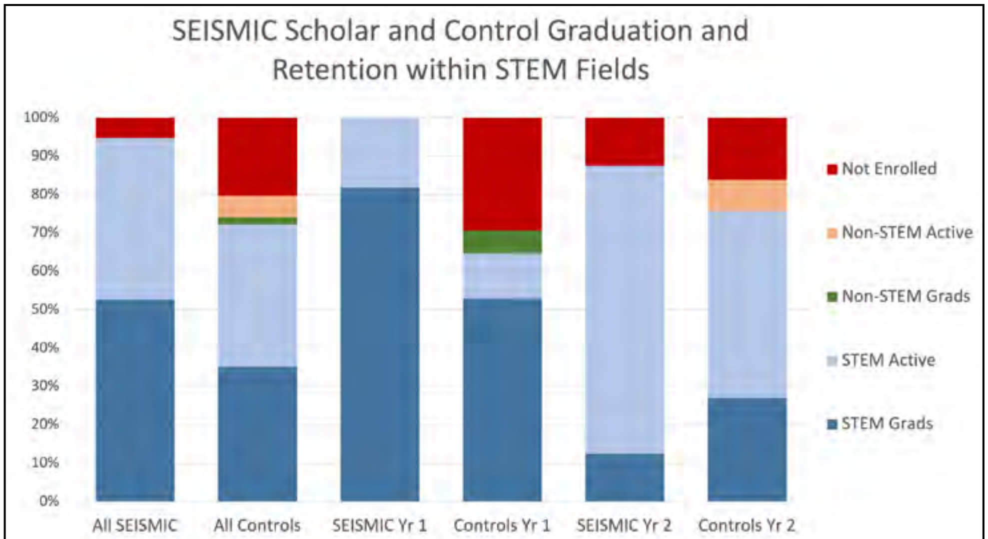

Figure 1. The academic status of SEISMIC Scholars compared with control group students. Both Scholars and control group students are eligible for Pell Aid and earned strong grades early in their academic careers. However, a larger percentage of students in the comparison group failed to complete or remain active in their STEM studies.

Results: STEM Retention and Graduation

The principal goal of the SEISMIC program is to help retain and graduate Scholars in STEM fields at BSU. As a marker of successful retention, we first considered whether a Scholar or control group student

1. Has graduated with a STEM degree,
2. Remains active in a STEM program at BSU,
3. Has graduated with a non-STEM degree,
4. Remains active in a non-STEM program at BSU, or
5. Has left BSU and is not an active student.

Figure 1 compares the academic progress of Year 1 and Year 2 Scholars and control group students by cohort and overall. Overall, 95% of SEISMIC Scholars from the first two cohorts either graduated with a STEM degree (10 of 19 students) or remain active in a STEM program at BSU (8 of 19), with only 1 student who has left the institution. Within the comparison group, 72% have graduated (19 of 54) or remain active (20 of 54) in STEM. For the comparison group, 11 of 54 students, or 20%, are no longer enrolled at BSU, with the remainder enrolled in non-STEM disciplines.

Table 4 shows that the majority of each SEISMIC Scholar Cohort and each control group cohort remains active in STEM or have graduated two years after being eligible to apply for the program. A key difference is that in both years under review, the control group, which did not receive financial or programmatic support, has significantly higher rates of students who have left BSU or STEM studies. Of the 19 students in the BSU program, only 1 left STEM, whereas of the 54 students in the control group, 15 left STEM. A chi-square analysis revealed a significant difference, χ^2 (1, N= 73) = 4.16, p=.04, such that the SEISMIC program had a significantly higher retention rate than the control group.

	SEISMIC Cohort 1	SEISMIC Cohort 2	All SEISMIC	Control Group 1	Control Group 2	All Controls
Total Number	11	8	19	17	37	54
Number of STEM Graduates or Active Students	11	7	18	11	28	39
Number no longer in STEM	0	1	1	6	9	15

Table 4. Retention and Graduation in STEM of Scholars and Control Group Students

Results: Capitals Development of Scholars

A goal of the SEISMIC program is to support SEISMIC Scholars in developing their social and cultural capitals. Although all aspects of the program can reasonably be expected to contribute to the development of these capitals, one aspect of the SEISMIC program's curriculum that was designed to specifically focus on students' capitals is the 1-credit course in which all SEISMIC Scholars enroll during their first year in the program. Because only the first cohort has completed the program, data on impact on capitals through the whole program is somewhat limited, but we can highlight some preliminary evidence of student capital development. Scholars came into the program with some evidence of social and cultural capital relevant to college success. In their responses to the annual program survey in their first year in the program, 10 of the 11 Scholars in cohort 1 reported having taken a test prep course before applying to college, as did 5 of the 8 in both the second and third cohorts. Across all three cohorts, the mean number of schools each student applied to was above 4, and the mean number of campuses the student had visited before going to college was above 2.

Preliminary evidence also shows that Scholars progressed in developing their capitals over time in the program and that Scholars are connecting with BSU faculty. After their first year in the program, 7 of 11 students in the first cohort reported having talked to a professor outside of the classroom three or more times in the previous month. That number rose to 8 of the 9 first cohort Scholars who responded to the survey in their second year. In their third year, still two-thirds of the cohort reported talking with professors outside of the classroom three or more times in the previous month. In their first year, 5 of 8 of the second cohort Scholars who responded to the survey reported meeting with professors outside of class frequently, and in the second year the ratio increased to 6 of the 7 Scholars. Of the eight respondents among the third cohort, 5 similarly reported meeting with professors frequently. Two members of this cohort did report not meeting with a professor outside of class at all in the previous month, but we anticipate this will change for these cohort members in future years.

	Pre-course responses	Post-course responses
Average of responses to questions regarding self-efficacy*	2.08 +/-0.07	1.88 +/- 0.06
Average of responses to questions regarding outcome expectations	1.80 +/- 0.09	1.73 +/- 0.09
Average of responses to questions regarding attitudes and beliefs towards science**	1.73 +/- 0.07	1.52 +/- 0.06

*p=.009, **p=.012. A decrease in the average score (pre to post) reflects improved self-efficacy, outcome expectation, and attitudes and beliefs towards science.

Table 5. Impact of Participation in Service-Learning on Self-efficacy, Outcome Expectations and Attitudes and Beliefs towards Science

Results: Self-Efficacy, Attitudes, and Skill Development for Service-Learning

Due to scheduling conflicts, only slightly more than half of SEISMIC Year 1 and Year 2 Scholars have enrolled in PSYC 230. A total of 10 SEISMIC Scholars completed pre- and post-course surveys to assess impact on self- efficacy, outcome expectations, and skills development. A Likert scale was used by students to rank their agreement with survey statements. A score of 1 indicates strong agreement; a score of 5 indicates strong disagreement. A decrease in the average score (pre to post) reflects improved self-efficacy, outcome expectation, and attitudes and beliefs towards science. To determine the significance of the overall impact of course participation on each of these measures, a Wilcoxon signed-rank test was performed on pre- and post- scores for all questions in each category. Analysis revealed a significant improvement (represented by a decrease in ranking) in self-efficacy and attitudes and beliefs towards science.

Additionally, students indicated that certain skills and perceptions of STEM improved, as a result of participating in the class, *Cultural Psychology: The Culture of STEM,*

Service Learning influenced improvement in my ability to	Quite a Lot	Somewhat	Not at All
Communicate Verbally	50%	50%	0%
Write Effectively	40%	50%	10%
Manage Time	20%	60%	20%
Provide Leadership to Others	20%	60%	20%
Feel a Sense of Community Responsibility	30%	60%	10%
Take Responsibility as a Scientist	40%	50%	10%
Understand Science Communication	5%	50%	0%
Appreciate the Importance of Attracting Diversity Among Scientists	90%	10%	0%

Percentages of students in PSYC 230: Cultural Psychology reporting improvement in each of 8 categories due to participation in the class and embedded STEM Service-Learning Requirements.

Table 6. Impact of Participation in Service Learning on Skills Development

and leading STEM outreach activities. The percentage of students indicating a particular skill improved "quite a lot," "somewhat," or "not at all" is indicated in Table 6. Highest gains were observed in student perception of their abilities to understand science communication, to communicate verbally and write effectively, to take responsibility as a scientist and to appreciate the importance of diversity among scientists. Research on the impact of STEM service learning will continue as additional SEISMIC Scholars enroll in PSYC 230.

Results: Exit Interviews connecting Curricular Elements and Scholars

We organize data from graduating Scholar exit interviews around three major themes: Knowledge, Skills, and Capital and Personal Skills related to participants' growth in their time in the project. Where possible, we draw direct connections by including a course number in parenthesis where the course directly connects to the exit interview finding.

Knowledge Gained: Scholars reported a wide variety of gains in knowledge as members of the program in a variety of directions beyond typical categories associated with disciplinary knowledge. For instance, Scholars said they understood, as far as the connection of science to society, the ethical norms and expectations of science application in society, i.e., using science for the greater good and to improve human life (PHIL 261). They also reported developing abilities to explain science to other people to demystify scientific misperceptions regarding its role in society, for example in describing how viruses like COVID-19 could infect people, including their family members (PHIL 261).

I think the thing that I learned the most is that scientists have a responsibility to serve the public and the world around them. I think it is our job to study the world around us, understand it and pass that information onto those who are not scientists who need the information. It is sort of like a public service we, as scientists, need to perform with our work. In this work, it is important for scientists to be honest because we should not do science for personal gain, money, or fame. We should serve as a bridge between those who study science and those who don't.

Furthermore, participants shared their awareness of the need for diversity and representation (i.e., different ethnic, racial, and economic groups) in science to offer diverse perspectives regarding the implications of science for different communities (PSYC 230). One student reported this interaction with school aged children this way:

It was interesting to notice and be aware of seeing the young kids associate with people like them in science, like the people who look like them. The black and brown kids would come to me more asking how I get to be in science, like as a brown person…you know…they would not say it directly, but you know what I mean. So that was very important how we can encourage them by just seeing us in science.

Interviewees recognized, in what they learned about science, the interdisciplinary nature of STEM in terms of how some disciplines are essential to the performance of others (i.e., math in computer science or physics application); and the differences that exist in various fields and career paths, i.e., biology versus chemistry, physics, etc. (CHEM 299, NSCI 360). As an example, one student directly drew this connection, saying

I would say the exposure to research and the different courses; and how interdisciplinary everything in science is, helped me the most connect all the different parts of sciences.

Specific to participants' experiences with the summer research projects in CHEM 299, they acknowledged learning how science works (i.e., the scientific method) compared to other disciplines and its interdisciplinary nature. They explained acquiring knowledge about laboratory research protocols and procedures, the application of scientific methods, programming, laboratory techniques, teamwork, and communication. They also suggested developing an understanding of research and the ways in which research is conducted in science (i.e., knowing the scientific methods and steps). Finally, interviewees discussed finding their personal passion and excitement about potential science endeavors in the world that might be interested in.

I definitely learned a lot as a scientist student in the lab experiences. When I started, I did not want to be a scientist who does research because I did not know anything about research and even thought it was boring, but now I am leaning towards being a scientist because I fell in love with research.

In the science courses, participants said they learned about scientific ethics, research, and different STEM content knowledge. They also realized the interdisciplinary nature of science fields. They became aware of the complexities of science in terms how social sciences (i.e., psychology) are different from STEM sciences (i.e., biology, computer science, and physics) especially in the ways they approach and interpret scientific knowledge and work (PHIL 261 and PSYC 230).

Participants said they developed a learning network of peers, professors, and mentors that allowed them to grow personally and academically (NSCI 160). For instance, they became more confident, resourceful, persistent, resilient, and successful due to the support of their learning network. They acknowledged how the science courses allowed them to be clearer and more focused on their science career paths and goals (NSCI 160, NSCI 360). Finally, they argued the coursework gave them opportunities to acquire new abilities for learning science like being precise and using research and methods that are scientific to discuss and approach science projects and assignments (NSCI 360, CHEM 299).

Skills Gained: For skills students gained during their participation in the program, interviewees identified problem-solving, communication, teamwork and collaboration, critical thinking, analytical, interpersonal, laboratory experimentation as well as reading and writing skills - all of which are key themes throughout the curriculum. Specific to the summer research projects (CHEM 299), participants highlighted learning research protocols, laboratory safety, time management, data collection and analysis, coding, programming, and microscopy skills as well as the confidence and abilities to do science research. For their science courses, they acknowledged developing skills in understanding the multidisciplinary nature of science, the connections between the different fields of science and the application of science in different ways to solve different problems in society (PHIL 261, NSCI 360).

I guess mostly one thing that surprised me was how different fields of science exist and work together to solve problems. I did not understand this at first but then through the classes I learned how they work like how math is used in computer science and physics to figure things out. How they all go hand in hand.

Capital and Personal Skills Gained: As far as personal growth related to students' experiences during their participation in the program, interviewees said they gained the ability to listen (NSCI 160), collaborate and work with others (CHEM 299, NSCI 360), and make and maintain important connections with their peers, especially with those from similar racial, ethnic, and economic backgrounds (PSYC 230). Culminating, participants recognized how instrumental the connections made with their peers were vital to their self-confidence, success, and their own personal growth because they felt less isolated in science, especially during times when they were struggling to succeed (NSCI 160). Participants also acknowledged how setting up the program using a cohort model and sequencing courses so they followed a clear schedule and path to degree completion helped them stay focused, on track, and personally grow into better students.

I have to say my first year (before SEISMIC) was hard as I worked alone with no connection with other students. The second year I made friends and better connections. So my second half in the program was better than my first half because I felt connected.

For instance, interviewees noted that the program design created an important peer support learning network and a predictable pace to move through successfully. Scholars reported that the expectations and timeline for meeting the requirements and graduating were not confusing. In all, they emphasized the program design and implementation were important aspects in their success. Their social network, interviewees explained, had also changed during the program because of the community of support that was created around them. They described the community as faculty, staff, advisors, peers, and mentors who helped them build connections, friendships, and relationships with like-minded STEM people that they did not have before joining the program.

> *I would say one example would be that I have learned to be more social. I tend to be not very social in general, kind of a loner. So, I was very nervous when I joined SEISMIC and realize that I was going to have to engage with other students, mentors, and faculty on a regular basis. For example, the summer research program forced me to engage socially with other students, mentors, and faculty, and it turned out to be a very positive and important thing for my growth. I ended up making good friends and connections and being more socially open.*

For instance, participants argued that their on-campus STEM community informed and supported their success in science more than their off-campus community composed of family members and neighborhood friends. Specifically, they shared that some important relationships and connections, within the STEM community, that contributed to their success and development as science students in their time in the program included (a) peers because of the opportunity to study, partner, and share resources with cohort mates, and (b) faculty, mentors, advisors, and support staff because they offered places, people, and resources from which to get support when they were struggling. Participants found that these opportunities were not available in their off-campus networks.

When interviewees were asked to reflect on their work with faculty, mentors, peers, and other supports, they explained (a) the critical roles that faculty advisors, mentors, and peers played in their success in science program in terms of how each encouraged and supported them especially when the program became challenging and they wanted to consider other program of study; (b) how the caring nature of faculty, advisors, and mentors gave them a sense of belonging in the program, which increased their confidence and ability to persist and be resilient (i.e. the faculty and mentors make time to listen, advise, and help me problem solve); and (c) the significance of the financial support (i.e., scholarship) in their success.

For instance, participants argued that the scholarship was a vital aspect of the changes in their support network, in terms of their on- and off-campus connections. They explained that the availability of funds lifted the burdens of working too many hours off-campus and struggling to keep up with the academic work. They also emphasized how the aid minimized financial dependence and pressures on their families, which usually have difficulties raising the monies needed to continue with the program. Participants also discussed how the scholarship funds helped them focus more on school and learning, a critical aspect of their success, rather than being overwhelmed with the stress involved in balancing working excessive hours and managing school expectations. Interviewees said that the aid contributed to their ability to succeed in science because it gave them the "needed break" to reduce work hours, financial stress, and tensions in their lives and families.

> *The financial support coming from off campus was no longer a pressure I had to deal with . . . so I was able to be focused on my campus connections with my peers, the professors and mentors and my study groups, and projects. Like I was able to have more time to work on the science projects with my friends.*

When participants shared their thoughts on how the program affected their preparation for success in STEM careers or further studies, they repeated the critical role and caring nature of faculty, advisors, and mentors as vital. They also added the value of engaging in research early, through the summer research program, as critical to their preparation because the research projects helped them (a) understand the nature of science better; (b) know how science work in the real world; and (c) realize what they might be able to do with science in the future. They also shared that the experience helped them develop a stronger aspiration and excitement for science in the future as they consider graduate studies and science career pursuits.

> *It has allowed me to think about and work in science in an interdisciplinary way, which helped me better understand my science career options. Also, knowing the importance of science in society which helped me with my career focus.*
>
> *Helping us do research right in our freshman year was a great idea as it gave us an idea and a taste for science. I got excited and determined to know and learn more about science.*

Discussion and Conclusions:

SEISMIC Scholars have been supported by a set of curricular program requirements that emphasize a broad understanding of science and how science is impacting, and impacted by, diverse communities inside and outside the traditional scientific community. The purpose of this paper has been to describe the curricular program and indicate evidence from surveys and graduating senior interviews that the financial and curricular support of SEISMIC work together to help retain Scholars and provide them with a broad understanding of the societal relevance of science.

Even though the program is continuing and our evidence here is preliminary, some conclusions are warranted regarding the design and function of the SEISMIC program support. For instance, statistically significant increases in STEM student retention and graduation are found for Scholars as compared with students of similar academic talent and income. We cannot separate the impact of financial support from curricular support in these gains in retention and graduation or determine causality, but we do identify real differences between Scholars and control group students. In addition, Scholars do report increases in technical and soft skills and measures of social and cultural capital through surveys, and in exit interviews, Scholars connect these growths with the academic program associated with SEISMIC.

While we note the small size of the sample and possible selection effects in our study of this program, the interview and survey results do show promising indications of the development of participants' knowledge, skills, social and cultural capital, self-efficacy, outcome expectations, and future plans. Overall, these findings directly map to the learning outcomes of the interdisciplinary, curricular program of student support, and Scholars directly attribute their personal growth to activities within these classes. Of note, participation in STEM service learning was associated with gains in self-efficacy, which has been shown to correlate with interest in and persistence in STEM careers. This finding aligns with a recent report demonstrating that STEM service learning and the opportunity to share science knowledge with local public-school students is associated with gains in self-efficacy (Schmidt et al., 2020).

Participants' knowledge grew specifically in understanding the role of science and the ethical obligation of scientists in society in general, the interdisciplinary nature of STEM, the protocols and procedures involved in the scientific methods and in research, and the value in having a science learning community network. These areas of growth are precisely the areas that the curriculum of the support program was designed to build over time, starting with the introduction of capitals in NSCI 160 (Building Capitals for STEM), writing assignments examining science and society in PHIL 261 (Science, Values and Society), and outreach and explicit examinations of the role of culture in science in PSYC 230 (Cultural Psychology).

Scholars indicated that soft skills like problem-solving, communication, teamwork, collaboration, critical thinking, time management, and interpersonal skills resulted from interdisciplinary work throughout the program. Introductory research (CHEM 299) helped develop hard skills such as laboratory experimentation, programming, coding, microscopy, data collection and analysis. Social and cultural capital increased in making connections with peers; developing long lasting relationships with faculty, advisors, and mentors; creating support networks within their peer groups and with faculty mentors; and belonging to an interdisciplinary science teaching and service-learning community support system they can count on in the future. Scholars particularly considered their membership in a scientific cultural community of advanced practitioners (i.e., faculty and mentors) and beginners (i.e., cohort mates) that provided encouragement, advice and guidance, and support both personally and financially (i.e., scholarships) as an instrumental aspect in their success in the program.

We note that the statistically significant differences in STEM retention between the control group and Scholars may be attributed to both the financial support of the program and the cohort nature of the support, as was indicated in exit interviews. The scholarship component certainly relieved Scholars of some financial burden, which we believe increased their receptiveness to learning about science from different perspectives. Scholars also report direct connections between curricular program elements and the direct goals of the grant program in terms of the outcomes sought for graduating STEM students (interdisciplinary thinking, understanding the cultural relevance of STEM, communication skills, and STEM motivation and confidence).

Because of the impact Scholars indicate that the curricular elements of this program had on their retention and growth, we recommend that these elements of the SEISMIC program be considered as a model at other universities. Based on exit interviews and surveys, we particularly recommend that other institutions consider collaborations with non-STEM departments that can contribute to a broader social and cultural understanding of the function and impact of STEM work. The ability to leverage an S-STEM scholarship program to develop outreach opportunities, and the connections made between STEM and non-STEM departments and faculty, are positive additional benefits that accrue from the nature of the program. In an era where academic training and knowledge can be siloed, but world problems are transdisciplinary and culturally complex, we believe that a program of studies supporting Scholars to approach science as inherently culturally relevant and interdisciplinary is of value and importance.

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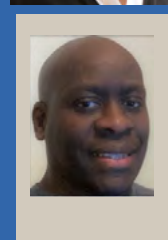

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