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Developing Communities of Practice to Serve Hispanic Students: Supporting Identity, Community, and Professional Networks

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Work in Progress: Developing Communities of Practice to Serve Hispanic Students: Supporting Identity, Community, and Professional Networks

Underrepresentation of women and students of color in science, technology, engineering, and math is a national epidemic. The lack of socioeconomic, gender, and racial/ethnic diversity in computer science is particularly pronounced—only 11% of recent computing graduates were women, while Hispanics comprised only 7% of all Bachelor degree earners [1]. Ethnic minorities who are also the first in their families to attend college are less likely to graduate than their peers, especially when they experience a lack of peer support to achieve in higher education [2]. Co-curricular and informal learning opportunities can provide students access to expert thinking in their disciplines, and can improve retention in the sciences [3]. S-STEM scholarship programs were designed to provide curricular, co-curricular, and financial support to students with financial need who are underrepresented in STEM fields. Results from S-STEM program indicate scholars experience greater retention and higher achievement than their peers, [4,5,6] yet little is known about how S-STEM scholarship programs shape students' professional identities in their fields.

The Cybersecurity National Science Foundation S-STEM scholarship project is a joint effort between two- year and four-year schools in two western regions of the country—EL Paso Community College and the University of Texas at El Paso in southwest Texas, and Merced College and California State University, Stanislaus in the northcentral valley of California. All departments engaged in the project belong to Hispanic-Serving institutions, of which at least 25% of enrolled students are Hispanic. The geographic regions influenced by the project have average median incomes far below the national average. In this context, we study the effects of a scholarship program aimed to boost transfer to four-year computing degrees, reduce students' time to graduation, and develop a network of professionals tackling cybersecurity as an area of emphasis. The research questions that drive this project are:

1. What evidence suggests the Cybersecurity S-STEM program supports minority students' development of science identities through access to ***performance, competence,*** *and* ***recognition*** [7]?
2. How does the design of the Cybersecurity S-STEM program support elements of learning through a **community of practice** [8,9]?

In this social science research project, we use Carlone and Johnson's science identity framework [7] as well as use community of practice theory to understand the experiences of computer science undergraduate students as they become more expert computer scientists and engineers. We use *both* frameworks in this paper to shed light on how faculty considered the design of the program as supportive of collective identity development (or being part of a select group of students and faculty who *do* computer science) in computer science, and how students individually identify as computing people. We view both elements are vital to understanding how S-STEM scholars may benefit from scholarship program participation and *become* computer scientists and engineers.

Conceptual framework

Research on STEM identity indicates positive interactions with more knowledgeable others are vital to developing strong affiliation for the field [10,11]. We view "STEM identities" as a valuable analytical tool for considering how students gain information about their place in STEM fields, and gain access to more expert practice in STEM. Perhaps more importantly, when undergraduate STEM students receive information indicating they are *not* right for STEM from those in their network with power, they are more likely to leave the field [12,13]. Research in computing has shown how bias can influence whom identifies with computing careers and academic pathways—indicating those who resemble the majority in the STEM fields (e.g., Caucasian and Asian males) are more likely to receive feedback that they are right for the field, while others have interactions that indicate they may be more suited for another field.

We view identities as fluid, and developed in interaction with others. Lave and Wenger's [8] concept of communities of practice is also useful for considering how individuals who are part of collective practice can shape one another's experience in becoming more expert in a field. For example, Lave and Wenger discuss how a community of practice can shepherd new members towards more competent activity through providing access to the practices of more capable others. The sense of the joint enterprise, or how S-STEM staff and students learn together in the domain of computer science, can add to an understanding of how S-STEM can support underrepresented students in computing.

Methods

Research on the S-STEM grant has involved mixed methods, including participant observation at national and local events (e.g., HENAAC conference participation, course observation, student research group observation, regional training observation, including undergraduate research training as well as content-specific training, e.g., cybersecurity workshops. Observation allows the research team to develop interview protocols and focus group questions that are tailored to the local community and practices of the departments under study. Data that inform the work include: faculty interviews, activity observation, student surveys and interviews, and student transcript analysis to determine the influence of a scholarship program on student outcomes. The program has just begun its second year, and so student course transcript data and student outcome data are not yet available. This paper suggests a theoretical basis for the program's design and the initial qualitative evidence from stakeholders regarding its benefits for students in developing positive computing identities.

Data analysis

Data were analyzed using the constant comparative method, and beginning with the concepts posited by Carlone and Johnson—competence, performance, and recognition—serving as the a priori codes of interest. As hypotheses were made, all data were examined for confirming and disconfirming evidence. For example, the hypothesis that students receive recognition through the S-STEM scholarship designation, was interrogated across data types (observation, interviews) and data sources (staff, faculty, and student participants). As program design elements were described by faculty and staff, the analysis focused on drawing preliminary

conclusions that relate to student experiences and design elements that relate to supporting students' computing identities.

Results, part 1: Developing identities as computer scientists

Using an identity lens for engineering identity development is valuable, as it adds complexity to one-dimensional studies of engineering persistence like self-confidence, self-efficacy, career interest, or ability. The analyzed data is presented related to Carlone and Johnson's of "competence" or the opportunities students have to develop their understanding of computing, "performance," or opportunities students have for demonstrating knowledge of computing expertise, and "recognition," or the acknowledgement they receive for their efforts in computing.

A.) Competence

S-STEM students described ways their participation in the scholarship program influenced their development of computing competence by providing co-curricular, applied research opportunities in their field, creating additional study time by alleviating the need to work for pay. In addition, conference participation improved competence by assisting students in understanding how they might apply their skills to career opportunities following completion of the four year degree.

Research as opportunities for developing new *competencies*

Students described how the research opportunities they received because of their inclusion in the S-STEM program led to opportunities to develop computational competencies- in particular, the student in the quote below describes how the research focus allows students to develop hands-on understanding of different elements of research. The quote indicates initial discomfort with the hands-on elements of the research experience, yet the eventual success was gratifying.

> "Well the thing is with each and every single one, it's kind of different. …with [professor], I really enjoyed how we kind of, we're actually able to do it sort of hands-on, sort of do it ourselves, when most classes are kind of just sitting down, taking notes, etc., etc.. I also kind of didn't like how we were kind of thrown in there, literally thrown in there with very little experience with any of the materials that we were working with. We were able to ... I mean eventually, we were able to get to it, but at the beginning it was very tough."

Carving out more time to study to develop *competence*

Three faculty spoke at length regarding how the S-STEM scholarships had the potential to improve the lives of their students and put them in a different position from which to develop competence. Students in this study all received S-STEM scholarships. A requirement for S-STEM scholarship is eligibility for Pell Grants, which are based solely on economic need. Given the economic standing of the S-STEM scholars, many typically work to support themselves or to contribute to the household income. Long work hours off campus are correlated with lower GPAs and lower retention [13]. By providing student funding to financially underresourced students who perform well academically, S-STEM creates greater opportunity or student

competence development. Faculty speak of the ability of students to concentrate on their studies, as their need to contribute financially is lessened. S-STEM increased the time they could devote to academics, and the relief of not needing to worry about financial burdens in the coming years because of the longevity of the scholarship for eligible students.

The financial aspect of S-STEM is particularly useful in shrinking time to degree for the Hispanic population because they, as a demographic group, are more loan-averse than other academic stakeholders [11]. The motivation to complete in four years with scholarship funds is an incentive to complete in a timely manner, particularly important in institutions where the latest available four-year graduation rates are between 12% and 16% [12].

A faculty member put it this way regarding how the monetary gains for S-STEM students influences development of computer science competence:

> "Of course, they need the money to afford college, so they can pay for things but it's not just money. It's like a sense of relief, like ... In their unconscious thought when they are learning in class, if they're too worried about how they're going to pay rent it's very hard for them to learn. So, I think having that money and having not to worry so much I think that's helped."

Another faculty member noted that the S-STEM leadership try to ensure the scholarship will make an impact in the students' lives outside of school by providing scholarships to students who will then have more time to focus on their studies:

> "I interview the applicants before they get the scholarship and I say, 'I want to make sure that the scholarship is going to make a difference,' It's mostly the students who are working 30 hours I do want to see that this scholarship is going to make you work 20 instead of 30 hours. Again, it seems from the five that we've funded so far (in spring 2017) I think that has been the case."

Student focus group data also convey the idea that students are better able to focus on their work because of the scholarship. One student describes how scholarship funds alleviates a worry regarding his parents' sacrificing for his academic advancement.

> "For me, personally, I'm a first-generation student. My parents came from Mexico, both of them, so we're kind of ... I don't want to say low income, 'cause we're not completely low income, but me going into college would have been financially hard for my dad or my parents, and considering I have an older brother too that he's going to college, too, and my dad's paying for that straight out of his pocket, so with the scholarship, I relieve so much stuff off his shoulders, so that kind of gives me a good feeling."

Another student indicates how he no longer needs to work off-campus to support school expenses and the cost of commuting to campus.

> "The scholarship's definitely changed my experience as well, 'cause my first year, I used to work a part time job at (discount store), and it was like just minimum wage, part time work. It wasn't the most enjoyable experience, but I still stayed there, 'cause I wanted to keep making money to help pay for my school. I still receive the federal program like the Pell Grant, but I would say I have at least 1000 to $1500 left over after my financial aid was

> disbursed, but with the scholarship, I'm receiving so much more income that I left my part time job this summer, and I've had much more time to focus on my classes and stuff, and I'm no longer financially struggling."

Understanding career options to shape *competence* development

As students develop their technical competence, they continually learn about the career field for which they are attempting to prepare. Professional conference attendance, as part of the S-STEM program, assists students who are underrepresented in computing by developing their career savvy, so students can better understand how to apply their technical knowledge to a variety of workplaces. As the student explains below, he was unaware of the breadth of careers available to computing professionals. The conference exposure shifted his understanding of career opportunities.

> "I never thought I would ever like have ... Just the fact that I was able to actually speak to people from that company, and learn what exactly it was like to work there, it was definitely amazing, 'cause there was also a lot of other companies there that I had never even heard of. Before that conference, I only just knew the popular companies like Google, Facebook, Intel, Microsoft, but I saw that there were all these other engineering and science companies over there, and it was like, 'Oh, these guys look for computer sciences, too?' I thought they would have just looked for engineers, but no, they look for people like us as well."

B) *Performing* computing identities

To a lesser degree, student data suggests those who attended a conference because of their S-STEM participation benefited from *performing* computing identities.Through the S-STEM scholars program, students traveled to a professional conference for Hispanics in engineering, which supports students through professional development, networking opportunities, competitions, and a career fair. At the conference, students circulate with professionals in engineering fields and *perform* their engineering identities. In other words, *they have opportunities to act as novice engineers among professional engineers in a supportive environment*. One student described how the job fair offered a chance to practice applying for technical positions.

> "I didn't know what to expect. So I was like, I was really afraid they're going to be all technical based questions and I was like, "Well, this is going to go great," but I was surprised. Most of my questions, because on my resume, I had customer service ones and they're like, "Well, since you're only second year. That's good that you have at least that, because it's so customer based. You're going to have to be talking to customers 24/7 and you have to have that good communication skill."

Recognition as "computing people"

Current data do not indicate that S-STEM students view the scholarship itself as providing recognition for them as computing people, or alternatively, as "good students" in the major, leaders in the department, or in any other way as supporting the ways they are viewed in the department. *S-STEM advocates could provide explicit recognition that is perceived as building student reputations in the department.* In related work at other HSIs, students' descriptions of

their place in the department has indicated how faculty provide recognition to students within the department, and that this recognition influences student commitment to the major [13].

Results Part 2: Understanding the benefits of S-STEM on student identity development based on programmatic design

The first results section provides initial evidence from this work-in-progress paper that suggests the S-STEM program is supporting students' development of engineering identities necessary for persisting and thriving in computing career pathways, particularly related to performing and building competence in their field. The second portion of the results section addresses how the program is designed to form a local community of computing practice. Communities of practice create roles for participants, offer opportunities to strengthen expertise, and create a sense of membership towards a common goal. Identity work is not only accomplished individually, but also in interaction with others. These interactions within the local community communicate to students about their potential in computing.

By using complementary social science concepts, we "zoom out" from the individual as the unit of analysis, in results section 1, to the department S-STEM teams themselves, which are made up of at least one faculty member and scholarship students. We also consider the relationships between two and four-year institutions in the same region, and the relationships that are mediated through the scholarship designed to remove barriers for transfer to four-year engineering programs. Table 1 below describes programmatic elements and shows how the program element fits within what is known about building a community of practice conducive to developing computer scientists. Following the table, we provide initial evidence from participants regarding the developing local communities of computing practice that *systematically* support student identity development in computing. Because this section focuses on programmatic design, the faculty and staff voices are privileged. The discussion hypothesizes relationships between the student computing identity findings and the programmatic design findings, and provides recommendations for expanding student computing identity development through greater programmatic attention to competence, performance, and recognition.

Program element	Educational research support of practice
Scholarship funds provide support to students with financial need tied to campus activity	Students' time on campus helps give students a sense of belonging on campus important for persistence in undergraduate studies [14]. Faculty are more expert participants in computer science, and so this access can enhance learning [6].
Scholars have additional access to faculty through scholarship activities	Students' access to faculty can influence persistence as well as student learning gains [15]. As students interact with faculty who share the career trajectories towards which they aspire, students have the added benefit of greater access to expert thinking in the domain [5].
Scholar development and implementation of conference workshop content	Students learn by facilitating the learning of others, in that they make new meaning of content as they seek to explain it, and represent their knowledge in new ways [16]. At the

	same time, the designation of presenter by more knowledgeable others *positions* scholars as more advanced members of the learning community—this designation can support computer science identity development [5, 8].
Scholars attend professional conference in cohorts with faculty, peers	Students attend a professional conference with other members of their local computer science community as well as with members of the global computer science community (e.g., professionals from industry, faculty from other institutions). Mutual engagement creates opportunities for interaction with more knowledgeable others in this setting. Their collective attendance allows for an opportunity to create *bonding social capital* [17] which may solidify student and faculty relationships and can develop a group into a *network* of supportive computer scientists.
Scholars participate in research poster sessions at a professional conference	Norms of participation in the local scholarship programs indicate scholars share knowledge of computing through presentation—this is a way perform computing identities [18]. Through this participation, they again have opportunities to act as more central participants in the field of computer science do [19].

Table 1:Program design elements that support computer science identity development

A) Community building locally around disciplinary ideas

Faculty interviews suggest the beginning stages of the development of local communities of practice that focus on computer science excellence in cybersecurity. Students who receive S-STEM funds are asked to participate in workshops to build cybersecurity skills, held locally on campus in collaboration with the Army Research Laboratory. Cybersecurity workshops are developed by upper classmen and graduate students with collaboration from the senior researcher at ARL and the S-STEM advisor.

> "Students who get S-STEM seem to be excited about the finances, the financial aid is obviously is addicting, but they also feel excited about being in a group. The way we label it, the way we market it is that you're going to be pioneers in the cybersecurity department and that seems to excite them. Whatever we tell them about, here's what we're going to involve you in cybersecurity workshops and all that, they seem to get excited. That's when they, in those presentations, that's when they start asking questions, that's when they wake up. They feel part of a community that is engaged in something they relate to."

> "In this case, because of the S-STEM program that we have right now with cyber security, now the students are focused to go directly to a cyber security component of the university. So now they have this idea of what to study and what to specialize once they graduate with their Associate's degree in Computer Science from community college, and

then go to the university. So this is good for the community college--it's a huge milestone that we have established."

Faculty indicate their students are becoming interested in the cybersecurity career trajectory, and their work in local research groups establishes that interest and sense of belonging in the field. The relevance they recognize in their daily lives may be driving that identification in the field.

B) Paving a path towards more expert practice in computing

A faculty member describes the process of scaffolding students towards roles as mentors and role models for their peers. In the description of interactions, he alludes to ways S-STEM scholars are becoming knowledgeable members of the academic community who are expected, as members of the local computer science community, to support their peers.

> *"*One thing that (as they begin to lead workshops for their peers) we hope those students will be role models for others, to get engaged. That's our goal really, every student that we fund through a scholarship, we tell them we're giving you the money, we're giving you support but we're always going to be asking you to do things and things that are going to go on your resume, something that will make you look like a leader or show off these leadership skills."

S-STEM scholars, now participants in the cybersecurity hands-on workshops held as co-curricular activities on their campus, are expected to take on leadership in the workshops in the coming semesters. The practice of leading workshops is meant to signal students' "expert status" to others in the local computer science academic community. This recognition can influence the participants' sense of belonging and confidence in ability. Data indicate this is less strong to date in the S-STEM program, that is, students are not perceiving this recognition.

C) Gaining access to the global computer science community of practice

Engaging in S-STEM gives students access to the global community of computer science practitioners- through engagement in a professional conference, as well as through the Mentornet experience. Faculty from the rural western sites indicate how this access to computing beyond the local context has the potential to enrich student experiences.

> "I wasn't really aware of Mentornet, that there's this resource out there for engaging with mentors online because we're in a poor, underserved area, where there aren't a lot of companies around that we can get people to be mentors. So this really expands the opportunities for our students to get mentoring, and to be in contact with folks from other places, and be able to think about whether they might go on from here."

> "I think attending a professional conference together will allow them to feel like part of something bigger. So when they meet other people like them, I think it will give them a lot of confidence."

D) Smoothing transitions locally- connecting 2 and 4 year campuses

Another way S-STEM is building an equitable computing community is through incentivizing 4 year completion for transfer students as well as four year institution students. In the 2016-17 academic year and in anticipation of the S-STEM grant, a practice of securing a designated advisor specifically for transfer students was enacted in one of the participating computer science departments. This advisor, part of the S-STEM team, was a transfer student herself who successfully completed a bachelors and a masters' degree at the four year institution, giving her additional insight into students' struggles to integrate into the 4 year school. The program design developed the role of transfer advisor to alleviate transfer student issues and concerns, support integration into campus, and at the same time do individualized recruitment for the S-STEM scholarship.

> "For advising, I would have the students come in and select their courses and I will check their backgrounds. If they were coming from (partner two-year school) or were about to take CS1s or they were going to take CS2s. So those are the ones that we targeted for application to the scholarship. I would talk to them about S-STEM right there, when I was in their advising session. I found out is that they were eligible for it, then I would tell them about the application and to be on the lookout for the application deadlines for the next semester."

By providing a targeted transfer advisor, the recruitment aspect of S-STEM was streamlined, and the advice given to transfer students was standardized. Initial evidence suggests that four-year staff and faculty communicating the offering of the scholarship to students opens up a line of communication across institutions that extends beyond scholarship recipients. Faculty describe contact with potential transfer students following the scholarship announcement that serves to connect students to the transfer school.

> "The requirement is that after a year, they start (four-year institution). So that's going to be the obvious transfer of the students for us. But then, all of the other students who apply and don't get the scholarships, they still keep in contact. They come and ask questions and say, 'Okay, I didn't get the scholarship. How can I get involved?' So, it's like a way of the students to connect with us indirectly. They start having email communication with (professor at four year school). Some of them look for other opportunities. I had another student who had another scholarship. She didn't get the S-STEM, but she got another one. So in a way, it's like the scholarship is helping us connect more directly with them. They ask questions about the program, the cyber security focus and all of that, but then they start asking questions about their interests, like questions about the classes and ... It's a way for them to start connecting with the department, that's how I see it."

The S-STEM scholarship has become a communication point that begins discussions with faculty and students across campuses, breaking the ice and creating communication channels that did not exist for potential transfer students.

Discussion

Initial evidence suggests the S-STEM scholars experience additional supports that shepherd their trajectories within computer science, including access to mentors, clear pathways from two- to four-year schools, research opportunities, and conference participation that further professional

development. The design of the S-STEM project is congruent with best practices for building a community of computer scientists with strong, positive identities in the field. While participant data is abundant regarding students' opportunity to build competence because of the scholarships, there is opportunity for greater promotion of student performance and recognition as S-STEM scholars.

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