*Daphne E. Pedersen, UNIVERSITY OF NORTH DAKOTA, daphne.pedersen@und.edu*
*Alena Kubátová, UNIVERSITY OF NORTH DAKOTA, alena.kubatova@und.edu*
*Rebecca B. Simmons, UNIVERSITY OF NORTH DAKOTA, rebecca.simmons@und.edu*

# Authenticity and Psychological Safety: Building and Encouraging Talent Among Underrepresented Students in STEM

## ABSTRACT

The Undergraduate Scholarships with Mathematics and Science Training, Exploration, and Research Program (US MASTER) is a STEM scholarship program funded by the United States National Science Foundation. It was implemented at an upper-Midwest institution to target and provide structured support to low-income, academically talented undergraduates in biology, chemistry, geography and geographic information science (GISc), environmental sciences, and physics and astrophysics. In addition to providing financial support, the program features an integrated approach to mentorship and advising consisting of an ongoing seminar course in which students engage in collaborative projects, research experiences with a faculty mentor, and targeted academic advising. As part of our assessment efforts, we interviewed student participants regarding their experiences. A consistent theme emerged regarding mentorship: in addition to providing access to professional socialization experiences and the facilitation of competency and performance, students reported that it was the ability to form close relationships based on personal authenticity and feelings of psychological safety and trust that provided the best scaffolding for success in a challenging STEM environment.

## KEYWORDS

first-generation students, mentoring, psychological safety, STEM, underrepresented students

## INTRODUCTION

Low retention of STEM students, particularly those who are women, underrepresented minorities (URM), first generation, and from rural backgrounds, is well documented (President's Council of Advisors on Science and Technology [PCAST] 2012). To combat the social and academic inequalities that shape students' efficacy in STEM, the use of high-impact educational practices has been lauded (American Association of University Women [AAUW] 2010; National Academy of Sciences 2011). These techniques serve as a means of increasing student engagement and retention (McDaniel and Van Jura 2020), particularly among underserved student populations (Conefrey 2018). High impact practices include activities such as first-year seminars, learning communities, writing intensive courses, collaborative projects, and undergraduate research (Kuh 2008). Those most involved in the conversation continue to call attention to the critical role that mentorship also plays in fostering student achievement and retention (Fifolt, Engler, and Abbott 2014). Mentorship is particularly influential when working with women and URM students (Chemers et al. 2011; Sadler et al. 2010) and others at risk of being lost in the STEM pipeline (Rosser and Taylor 2009).

High impact practices and concerted mentoring efforts can help foster student success, in part because they help provide the scaffolding necessary to support the development of students' science identity (Carlone and Johnson 2007). The significance of a strong science identity is important for shaping students' future behavior, including pursuit of a STEM career (Chang et al. 2011; Chemers et al. 2011). Science identity is composed of three overlapping components, including competence (having meaningful scientific knowledge), performance (having scientific skills, that is, the ability to use scientific tools and language in appropriate settings), and recognition (receiving validation from others in the field). Whereas traditional educational approaches focus on the development of scientific proficiency (in other words, competence and performance), a more holistic approach also includes attention to the personal needs of students and pointed efforts to support identity development through recognition (Kendricks, Nedunuri, and Arment 2013).

Bringing these two facets of best practices together—high impact educational experiences and close mentoring—in support of students' science identity development (Estrada, Hernandez, and Schultz 2018), the Undergraduate Scholarships with Mathematics and Science Training, Exploration, and Research Program (US MASTER) was implemented at the University of North Dakota, located in the Upper Midwest of the United States. The program targets and provides structured support to low-income, academically talented undergraduates in biology, chemistry, geography and geographic information science (GISc), environmental science, and physics and astrophysics. Special attention is given to recruiting women, first generation, and URM students. These opportunities are important given the student body of the institution, which has fewer URM students than the national average. The US MASTER program is funded by an NSF S-STEM grant, which provides scholarship support and funding for programming to increase recruitment and retention within STEM undergraduate studies.

As part of the project assessment efforts and social science research plan for the grant project, annual interviews are being conducted with student participants regarding their academic experiences and science identity development. In the first wave of interviews, a consistent theme emerged: in addition to providing access to professional socialization experiences and the facilitation of competency and performance—two of the three "legs" of science identity— students reported that the most powerful aspect of the US MASTER program is the ability to form close relationships based on personal authenticity and feelings of psychological safety and trust. Such relationships provide the scaffolding for success in a challenging STEM environment, and foster recognition—the third leg of science identity that is most elusive for URM students.

## LITERATURE REVIEW

### Science identity

The concept "science identity" was developed by Carlone and Johnson (2007) who interviewed 15 women of color during their undergraduate and graduate studies in science and followed them into science-related careers. They found that among the women, though all were ultimately successful, those who attempted but were unable to achieve recognition from others within the field experienced more difficult trajectories within science. As noted by Carlone and Johnson (2007), sometimes "bids for recognition" were ineffective because of personal identities —race, ethnicity, and gender may serve as barriers when interacting with gatekeepers in the field. Thus, recognition may be difficult to achieve because these visible statuses lead some gatekeepers to question students' competence and performance. Ultimately, they may fail to distinguish women and URM students as legitimate scientists and thereby withhold recognition. The work of Carlone and Johnson (2007) is consistent with a body of scholarship identifying the limited social capital and restricted networks of women and URM students in STEM and the impact this has on persistence and retention (see for example Skvoretz et al. 2020)—despite achievement in the areas of competence and performance.

The theory of science identity has been quickly and widely adopted. There is already a rich literature emerging that utilizes both quantitative and qualitative approaches. The perspective itself is appealing because it recognizes the importance of more traditional aspects of scientific competence and performance while also acknowledging that success within STEM depends heavily upon interaction with gatekeepers and one's experiences with privilege and inequality. Recent work by Avraamidou (2020), for instance, argues that science identity development is inherently intersectional and political in nature given the power of educational inequalities—sexism, racism, classism, etc.—that shape student opportunities, experiences, and learning. Furthermore, Avraamidou argues that because recognition is so critical to the formation of science identity, emotion is also a central aspect of the process. Similarly, Le et al. (2019) acknowledge that identities operate at the individual level but are constructed through interaction within organizational and institutional settings shaped by inequalities. As they note, "Differences matter, because they affect how we view ourselves as science people and how easily we can form authentic science identities" (2). Distillation of this developing body of work indicates that as faculty, our willingness to provide both opportunity and recognition to a diverse body of students is critical to their success and advancement within STEM. In order to do so most effectively, we must move beyond deficit models of thinking (Smit 2012) and create safe learning spaces in which we can authentically engage with students, and where they feel a sense of psychological safety and freedom to take educational risks.

### Science identity and mentoring

The work of building students' science identity and encouraging students to see themselves as emerging scholars and scientists relies on both the form and quality of relationships with faculty, including mentoring relationships. Along these lines, guidance on productive mentoring relationships includes recognition that attention should be paid to the psychosocial needs of a mentee, whether instrumental help or career support is provided—as in the apprenticeship model of mentoring (Arora and Rangnekar 2015). Indeed, mentoring has frequently been confused with "good teaching" and reduced to the functional aspects of mentoring relationships while excluding other possible functions (McKinsey 2016). Through the provision of social and emotional support, a mentor can help the student develop a sense of identity (Chemers et al. 2011). This is done by facilitating personal and emotional development (Nakkula and Harris 2013); building feelings of competency and self-efficacy; boosting self-esteem; and helping students see themselves as scholars (Robnett et al. 2019) through expressions of acceptance and affirmation (Liang, Bogat, and Duffy 2014; Tenenbaum, Crosby, and Gliner 2001). In turn, this support promotes outcomes closely aligned with the competence and recognition dimensions of science identity (Carlone and Johnson 2007). This growth is also critical for students' ability to successfully develop performance skills.

Yet, while instrumental and socioemotional mentoring have complementary functions that are both critical to student success, research indicates that many mentoring relationships tend to follow more conventional models of imitation and grooming (Allan 2011; Dahlberg and Byars-Winston 2019). Furthermore, mentoring relationships remain more elusive for women and underrepresented minorities (Saffie-Robertson 2020; Thomas 2001). Research indicates that across academic and occupational contexts, women and underrepresented minorities in STEM face both sociodemographic and structural challenges; there are fewer potential mentors with similar sociodemographic traits for women and underrepresented minorities to connect with, and potential mentoring relationships may not develop due to a variety of structural barriers. These include "lack of access to information networks, tokenism, stereotyping, socialization practices, norms regarding cross-gender relationships, and reliance on inappropriate power bases" (Saffie-Robertson 2020, 568). Thus, educators must be mindful but also incredibly intentional to effect equitable access to mentoring opportunities for students, and to ensure that these efforts include attention to socioemotional wellness and growth.

### Authenticity and psychological safety

Fostering growth among STEM students, particularly those who may face additional barriers within the academy, is best achieved within open, respectful environments in which they feel valued and safe. As reported by Webb and Barrett (2014), attentiveness, courtesy, information sharing, and a balance of authority with connection helps build student-faculty rapport, which in turn translates into effective learning. Personal authenticity can be an effective foundation for rapport and relationship building, as it allows students to see faculty mentors as relatable, approachable models within STEM (Fries-Britt and Snider 2015). When early interactions build and develop into authentic mentoring relationships, the work of recognition takes place, but as well, both students and faculty can be more open sharing concerns and constructive criticism. Thus, in addition to building trust (Fletcher and Ragins 2007), this honesty and transparency allows for better problem solving and strategizing about how to move forward (Fries-Britt and Snider 2015). Focusing on students of color, Leudke (2017) noted that "meaningful and honest dialogue… facilitated a space where [the student] felt comfortable discussing flaws" and the faculty could in turn help the student strategize ways to overcome barriers and transform them into successes (46). Students can feel comfortable with vulnerability when they know they are in a safe and supportive environment.

The ability to share personal vulnerability within academic environments is known as psychological safety. Psychological safety is an interpersonal construct that emerged within organizational studies, describing a state in which members of a team feel they can take interpersonal risks and openly share ideas without fear of criticism or other repercussions (Edmondson 1999). In an educational setting, students describe psychological safety as a feeling of not being judged by others (Tsuei et al. 2019). This absence of judgment affords students a safe learning environment in which they can focus on learning and share comments and questions or perform tasks while abandoning concern for how they appear in others' eyes (Tsuei et al. 2019). In short, students lose the psychological work of constant self-monitoring and benefit from the psychological gains of trust and safety. This sense of safety leads to the authentic expression of ideas and emotions by students (Tsuei et al. 2019), and because they let their guard down, students are no longer afraid to show their mistakes and can learn from them (Carmeli 2007). Kark and Carmeli's (2009) work showed that when feelings of psychological safety are present, students feel greater vitality and higher levels of involvement in the work environment. In contrast, when students do not feel a sense of psychological safety, they may limit participation in classes and be reticent to engage: they may speak out less, be unwilling to ask questions, and choose not to interact with their peers. This withdrawal allows them to minimize the possibility of failure in front of others and limit potential consequences for poor performance or mistakes (Tsuei et al. 2019). By sitting back, they hope to project a quiet image of competency within the classroom—speaking up only when they know they have "the right answer" or have a clear grasp of the material.

Pulling together what we have learned, the development of student science identity— including competence, performance, and recognition—is best fostered within mentoring relationships that are marked by authenticity and psychological safety. Interacting as one's authentic self allows for rapport building and encourages students to feel safe taking risks. These risks may include opening up to faculty members about personal difficulties or knowledge gaps or expressing vulnerability within the lab or classroom. These expressions of vulnerability help students engage more actively within STEM and move to higher levels of achievement. We contend that these expressions of vulnerability, when met with authenticity and psychological safety, help promote student success within STEM by fostering recognition but also encouraging students to build their competence and performance abilities.

## METHOD

### Program objectives and structure

The US MASTER program at the University of North Dakota is funded by an NSF S-STEM grant[1], and provides financial support via academic scholarships to talented students with demonstrated financial need. Although common conceptual elements, theories, and/or pedagogical approaches may underscore S-STEM projects at various universities, each S-STEM program is fundamentally unique as it is created to meet the needs of the specific student body and set of STEM programs for which the program is built. In addition to critical financial support, the US MASTER program features a scaffolding of supportive and integrative programming to students in all stages of degree progress: a unified approach to mentorship and advising consisting of an ongoing seminar course in which students regularly engage with each other and the faculty in collaborative readings and research projects, research experience with a faculty mentor, and targeted academic advising with both a professional advisor and faculty advisor. The program is now in its $10^{th}$ year and second phase of grant funding on our campus, the first phase of the grant project serving over 50 undergraduates. Many of these students have gone on to successfully pursue graduate studies and careers in STEM. In this paper, we focus on research findings from the second phase/funding period of the grant project, which builds programmatically upon the successes of the first funded program. The second phase of the program differs in two key aspects: we have included mentorship training for faculty and now have a social science research plan to investigate students' science identity development.

Student recruitment for the US MASTER program occurs through outreach initiatives conducted by participating STEM departments as well as in collaboration with various university services including TRIO and enrollment services. TRIO is a federal program funded by the US Department of Education to ensure equal educational opportunities for all Americans, regardless of race, ethnic background, or economic circumstances. It works to enable student progression through the academic pipeline from middle school to post baccalaureate studies and includes three primary programs from which it gets its name: Upward Bound, Educational Talent Search, and Student Support Services. TRIO staff regularly reach out to local high school administrators and counselors and provide direct counseling for students during site visits. During these visits, information about university scholarship programs and other development opportunities on campus is provided. With a focus on first-generation and URM students, two groups of students were recruited: 1) entering first year students, and 2) students currently enrolled at or transferring to the university. Many of these students go on to work as tutors within the TRIO program.

Among current program participants, 39% are URM, 67% are female, and 67% are first generation students. About two-thirds (67%) are biology majors; followed by chemistry (17%) and mathematics (11%) majors. The remaining students are enrolled in physics, environmental sciences, and geography. A large majority (82%) of participants have been engaged in research projects with faculty mentors.

### Campus context

The University of North Dakota is one of two public doctoral-granting universities within a 300-mile radius that provides impactful research experiences along with a strong educational foundation to the broader rural community in the Upper Midwest region of the United States. There are approximately 14,000 students attending the university, roughly 10,000 of whom are undergraduates. The campus is primarily residential and has a student body that is fairly traditional in age, with 65% of students being under the age of 24. The student population primarily consists of residents from the state and nearby Minnesota; 85% of the students in participating departments are from these two states. Thus, for many of the students engaged in the US MASTER Program, access to experiences with STEM may have been limited by their URM and first-generation status but also geographic location—which is often rural and/or non-metropolitan. Almost half (40%) of the population in North Dakota is rural, and although only 8% of the population is considered rural in Minnesota, 60 counties within the state are classified as non-metropolitan (Asche 2018). Supporting diverse students on the campus is also important given the student body profile of the institution. Institutional data suggest that there is a smaller percentage of URM students enrolled at the University of North Dakota than the national average; approximately 75% of the undergraduate student body identifies as White/Non-Hispanic. In contrast, 39% of students enrolled in the US MASTER program at the time of data collection identified as URM. The program also works with a higher proportion of first-generation students than the campus at large.

### Method and participants

Data for the current study were taken from interviews with undergraduate students participating in the US MASTER program at the University of North Dakota. IRB approval was obtained prior to the initiation of data collection efforts. An attempt was made to interview all students participating in the first year of the current grant project and in sum, 18 interviews were conducted late in the spring semester. All but two students involved in the program participated; these two students were away (e.g., studying abroad) and unable to be reached. Each in-person interview was conducted by the social science researcher and graduate research assistant on the grant project and took place in a conference room on campus. Interviews were approximately one hour in length. With participants' permission, interviews were audio taped and then later transcribed. The interview protocol (see Appendix) focused on students' interest in and trajectories into STEM fields; supportive and challenging experiences within STEM majors; relationships developed within the context of STEM studies; and access to and quality of mentorship. The primary questions driving the design of the instrument were: (a) What factors shape a student's decision to major in STEM? (b) What factors shape persistence in STEM? and (c) (How) does mentorship contribute to student outcomes, including science identity?

It is important to note that those who were interviewed were at different stages of degree progress and had spent a varied length of time in the US MASTER program. Whereas some students were freshmen and completing their first year in the program, others were further along in their academic careers and had been participants in the first phase of the grant project (for two or more years). The data collected during the interviews presented here makes up the first wave of interviews; follow-up interviews are planned for each of the following years of the project to generate a longitudinal portrait of student experiences. Because participants in the US MASTER program come from a variety of STEM majors, the experiences they reported took place within similar but also varied contexts. Students' scientific interests were diverse and while they may have taken the same courses or had contact with the same instructors or research mentors over time, each student had a unique study experience. Thus, our findings represent shared experiences within STEM that transcend the academic discipline. Due to the small number of cases, we were not able to group data by degree progress or major. Socio-demographic information about program participations is found in Table 1.

**Table 1. Socio-demographic characteristics of US MASTER students (N = 18)**

| **Major**[a] | *n* |
|---|---|
| Biology | 12 |
| Chemistry | 3 |
| Environmental studies | 1 |
| Mathematics | 2 |
| Physics | 1 |
| **Class Level** | |
| Freshman (first year) | 1 |
| Sophomore (second year) | 4 |
| Junior (third year) | 8 |
| Senior (final year) | 5 |
| **First-Generation** | |
| Yes | 12 |
| No | 6 |
| **Underrepresented Minority** | |
| Yes | 7 |
| No | 11 |
| **Financial-Aid Eligible** | |
| Yes | 18 |
| No | 0 |
| **Gender** | |
| Female | 12 |
| Male | 5 |
| Non-binary | 1 |

[a] Totals do not add to 18 due to double majors.

### Analytic strategy

Thematic analysis of the interview transcripts was performed to find common threads emerging from the data that related to mentoring relationships. An inductive approach was adopted, allowing the content of the data to dictate the coding and thematic development. This process follows the method outlined by Braun and Clark (2006) which moves from familiarization with the data to identification of important features (coding), searching for and then again reviewing themes across the data (reviewing and organizing codes to create broader constructs of meaning), and naming themes. Our analysis of the data uncovered two primary, latent themes in the student interview data related to "good" mentorship and encouragement to develop a strong science identity: psychological safety and authenticity were repeated patterns across the student interviews. These two themes were the strongest pertaining to successful mentorship as characterized by the students and were found to be shared regardless of stage of degree progress or major. Furthermore, the strength of these two themes is indicated by their ubiquity across the interviews. These two themes emerged in response to different questions in the student interview; they were discussed relative to trajectories into STEM, challenges the students faced, and when reporting experiences within mentoring relationships.

## RESULTS AND DISCUSSION

In the interviews focusing on academic experiences and science identity development, two consistent themes emerged: in addition to providing access to professional socialization experiences and the facilitation of competency and performance, students reported that it was the ability to form close relationships based on personal authenticity and feelings of psychological safety and trust that provided the best scaffolding for success in a challenging STEM environment. While one-on-one mentoring and daily interactions with faculty were essential for retention and graduation, students mentored by more "nurturing" faculty reported more positive experiences overall. These findings are consistent with scholarship highlighting the importance of psychosocial mentoring and the work of recognizing low-income women and URM students as scholars and members of the STEM academic community (Daniels et al. 2019; Dawson, Bernstein, and Bekki 2015).

In order for successful academic and mentoring relationships to develop, students noted that a sense of mutual authenticity was important. The perception that faculty communication was honest and genuine inspired a sense of trust in students, who then felt comfortable being more forthcoming in return. These conversations were more likely to occur when the faculty member adopted an informal conversational style with students, which led to them being viewed as "approachable" and "easy to talk to." Students described the transformational power of having impromptu conversations in the hallway with faculty members who remembered them, greeted them enthusiastically, and "were themselves instead of just fulfilling a professor role in front of the classroom." Relationships with authentic faculty were also described as more encouraging, motivating, and inspiring. As one student—Mark—noted, it is this ability to connect with a professor on an individual level that "makes the experience." Here, he describes the relationship shared with a faculty member who later became his research advisor and mentor:

> My senior year of high school I had a campus tour, and he [the professor] gave me a tour of the chemistry building. I really enjoyed it. He was a really nice professor, so I took a class with him. I started to get to know him. I talked to him after class if I needed help

> and took another class from him. That's when I'd really go to his office a lot and so I got to talk to him a lot more. That was very helpful because there was one point when it got really overbearing in my academic life. There was a lot of stuff that I had to do, and he was able to work with me and help figure out how to manage the load…I got to talk to him in a relaxed way. He told me what his research was about, what was going on in the department. It was just talking with him on that basis that was really neat. I saw him in a different sense; not like how you see them in the classroom. I feel that it's important to find that one professor you can connect with, because it's a lot easier when you have someone who cares about what you are doing. (Mark, biology major)

Mark struggled to settle on a STEM major since he enjoyed all the sciences. When Mark expressed concern that chemistry might not be the right major for him, the professor suggested that he work in his lab to get first-hand experience and see if it was a good fit. This evolved into a mentoring relationship supported by the US MASTER program. As noted by Fries-Britt and Kelly (2005), authenticity and trust enable mentoring relationships to grow stronger over time, as being one's authentic self requires a greater degree of vulnerability. Authenticity leads to trust, which can then inspire rapport and honest sharing. This foundation motivates students to work harder to build competence and performance skills, and it is critical to persistence and retention within STEM.

One female student, Therese, reported that as a first year chemistry major, she had difficulty transitioning into the college learning environment, but things changed when she was able to connect with a research advisor and mentor in whom she could trust. Therese was a first-generation student who grew up in a rural farming family. In high school she developed a strong math background and participated in a number of extracurricular STEM opportunities.

> When I first came to college, I couldn't figure out how to study. Once I got into the research lab, I started talking to [my research advisor] about it. I told him I was struggling with finding different ways to take notes and different ways to study, because I just was not absorbing the material. He shared that he is a very hands-on learner and that's how he got into research. And he showed me different ways to solve problems while still learning the material in the chapter. He helped me figure out my study habits and was really encouraging. It was really important as a freshman, during a kind of vulnerable time in my life, to be welcomed and taken in by the professors. Now I am leaning towards doing research [as a career] because of the experiences here. (Therese, chemistry)

During the interviews, students noted that they appreciated the opportunity to share their personal troubles and classroom struggles, and that they were more likely to do so with the faculty members they perceived as more forthright and authentic with students. Difficulty with course material and/or test taking, poor sleep or study habits, conflict within or difficult interpersonal relationships, family issues, and questionable choices were among the concerns students reported sharing with more authentic faculty, who were then better able to assist and counsel them in how to best master content. Thus, we saw that when faculty shared their authentic selves, students could also enact an authentic identity in a safe space and real learning and disciplinary commitment could occur because they felt the support to move forward—in other words, recognition fosters competence and performance building.

Another female student of color we interviewed not from North Dakota noted that it was difficult to open up to faculty in the beginning, but that once she did, she found a supportive network of people who were able to help her both personally and professionally:

> My advisor has been a huge part of my college experience. She has given me helpful advice on how to manage my stress and anxiety, such as making sure I build time into my schedule for "me time" where I'm not around anyone…and times when I'm not thinking about school and the next thing that has to be done. The faculty here also want to help me do the best that I can do, and they're willing to cheer me on. When they see that I'm starting to get stressed out, they reach out to me. And when I get critiques, they always make sure that there is a positive in there too. It's like, "you're doing really well, these are just a handful of things you should be thinking about while you're doing it." This is the kind of criticism I need because I'm a very self-critical person. So, if I get a mix of the two, then I think, "okay, I know where I need to grow but I'm also not on the wrong track. (Jess, fisheries and wildlife biology)

Along these lines, the ability for URM students to express vulnerability ultimately helps them build community and feel a sense of security within the academic institution (Núñez, Murakami, and Gonzales 2015). Relational qualities in mentoring such as authenticity and empathy are particularly important in the support work carried out with college-age women; these factors increase perceptions of self-efficacy and self-esteem as a foundation for learning (Liang et al. 2002).

Mark, the senior biology student, talked of having the freedom to share "bad ideas" with a second advisor, who gave him the flexibility in the lab to try out these ideas. In this way, the student had the freedom to experience the true process of scientific discovery and learn from his failures as well as his successes. He reported a better understanding of conceptual science because of this permission to explore, which developed out of an initial sense of psychological safety. The performance leg of science identity in this case preceded comprehension. This student laughed as he said, "Now she can tell me what's a good idea and what's a bad idea… she'll tell me, 'It's a bad idea, but if you want to try it go ahead!'"

Marcia is another student who had returned to her undergraduate studies after a long break. Older than the other students, Marcia noted that her poor test taking ability was a limiting factor, but that meeting a group of supportive advisors and mentors meant that she made the decision not to drop out of school a second time.

> If I hadn't gotten plugged into the US MASTER program and met my advisor, then I think there's a good chance I would have dropped the whole thing. But having people say, "hey, you can do this. You know, I think you really have something to offer," has really inspired me to keep going. It has a snowball effect that keeps you moving forward even though you're thinking that it's so much work. I think the overall confidence my advisor has in my ability is probably the biggest thing. She seems very sure that I am going to do just fine, which helps offset some of my own self-doubts. It's encouraging

> when she says, "even if you are a bad test taker it doesn't necessary mean you aren't smart, it just means you aren't good at multiple choice questions. Don't let that influence how you regard your other abilities." (Marcia, biology)

Leaving school would have been a justifiable choice for Marcia, as she had children and previous career experience to fall back on. Yet, she moved beyond her performance issues because she felt that she had adequate recognition and found this support enabling and motivating. In contrast, in mentoring relationships, a lack of psychological safety and recognition is potentially toxic, coloring a student's outlook about the advisor, the department, and the university. Shawna, a young woman with learning disabilities pursuing a major in fisheries and wildlife biology, was asked about things that have helped foster success in her coursework. She began her response by noting,

> I don't really care for my academic advisor at this point. She doesn't think I can do what I can actually do. She doesn't think I can handle the classes. She has favorites, and I'm not one of them. It feels like she is always looking down on me and doesn't take the time to help me. So now I don't rely on academic advisors in my program. I guess what gets me through is the fact that I want to be done; I want to do well, and I want to get into grad school. I am my own cheerleader. (Shawna, fisheries and wildlife biology)

Shawna believed that she had been stigmatized because of her diagnosis by this faculty member, but in contrast, had very positive experiences with her research advisor, whom she describes as

> [S]uper helpful and really understanding. He talks me through what we are doing and what he expects from me, and what I should expect from him. If I ever need help he's there; the door is open. He doesn't tell me what to do but leads me in the right direction. He's like, "you can either go this route and accomplish this or take that route." Kind of like showing me all the ways I can go but not telling me which way I have to [choose]. He thinks I can succeed, but she doesn't. He thinks I can take on hard classes and knows I can do it, and she doesn't. So, around him I feel like I'm smart and know what I am doing, and around her… she's like, "I don't think you can do it." It's really down-putting. (Shawna, fisheries and wildlife biology)

Within mentoring relationships, the ability to have a frank conversation about difficulties and potential barriers while also providing constructive support is an important skill for mentors to master; the fluctuating levels of performance and confidence expressed by students may lead to some exasperation among faculty that must be tempered with both transparency, but also positive and constructive criticism (Värlander 2008). Ultimately, this psychological safety results in collaborative engagement within the learning environment and facilitates better comprehension and performance (Chubin and DePass 2017).

> I used to be a very angry perfectionist. If I didn't get things right the first time I felt like, "what's the point? I'm useless. I cannot do this." Working with my research advisors, I was worried at first that I was going to be fired. I approached my advisor and had to tell

> him that I screwed up and put the wrong thing in the tube. He was like, "Oh, we have a cleanup kit for that… just run it through that." He has a very approachable and calm style. Learning that if it happens again, you can redo it, and science is 90 percent failure anyway… I learned how to ask questions, and how to make mistakes and screw up. I've been noticeably calmer since then. I will still be very meticulous about things, but I'm a lot better at combatting the initial wave of horrible dread and self-loathing if I make a mistake. I did have an important moment. When I started working on a new project in the lab, my advisor was like, "you're basically a microbiologist now." And I was like, "I'm what?!" I just stood there for a moment taking it in, and I thought, "wait! I'm doing science!" (Andie, fisheries and wildlife biology major)

## CONCLUSION

The Undergraduate Scholarships with Mathematics and Science Training, Exploration, and Research Program (US MASTER) was implemented at the University of North Dakota to target and provide structured support to low-income, academically talented undergraduates in biology, chemistry, geography and geographic information science (GISc), environmental sciences, and physics and astrophysics. In this paper, we described findings from student interviews conducted as part of our assessment efforts. A consistent theme emerged regarding mentorship: in addition to providing access to professional socialization experiences and the facilitation of competency and performance, two important aspects of science identity, students reported that it was the ability to form close relationships based on personal authenticity and feelings of psychological safety and trust that provided the best scaffolding for success in a challenging STEM environment and fostered students' recognition as emerging scientists.

These findings are consistent with a rich history of research on socio-emotional mentoring. Multi-institutional work by Schreiner and colleagues (2011) with high-risk students indicated that students benefitted most from relationships with faculty and staff who knew them by name, took the time to talk with them, and openly expressed their care and concern. Like others, we found the sense of trust that emerges when fear about displaying ignorance or poor performance is removed helps facilitate relationship building between students and their teachers and mentors. Tsuei and colleagues (2019) noted that psychological safety within the educational setting calls for an educational alliance and authentic rapport between instructors and students. As we have described here, strong teacher-student relationships are built upon a foundation of mutuality and sense of trust. For psychological safety to develop, educators must be willing to interact authentically with their students and engage as real people. Both authenticity and psychological safety are consistent with the pedagogy for equity framework for teaching and learning. This approach requires that faculty and students acknowledge how individual histories and sociocultural contexts shape learning environments and seek to challenge traditional educational models to better promote equity and learning for all students (Núñez, Ramalho, and Cuero 2010).

Though we are enthusiastic about these findings, there are limitations to our work that should be acknowledged. The students interviewed for this project were participants in a single NSF S-STEM program, enrolled at one university. Located in the Upper Midwest of the United States, the campus primarily enrolls students from two adjacent states and has a fairly traditional student population in regard to age and residential status. In addition to the campus context and student population, there are methodological choices that shape how the data can be interpreted. For instance, the interviews included questions about experiences across time, but were conducted only once with each student; future interviews are planned but have not yet taken place. Also, the interview results did not always include sufficient detail to analyze mentoring relationships with greater depth. For instance, we did not consider the duration of mentoring experiences. Socioemotional mentoring relationships in which authenticity and psychological safety emerge often take longer to develop than those that are more instrumental in nature (Dahlberg and Byars-Winston 2019). Peer mentoring and support would also be useful to look at. Cooper (2011) and others (Ong et al. 2011; Phinney et al. 2011) have examined networks of support utilized by URM students, which often include peers and members of social networks.

We also note that some evidence suggests psychosocial support is more often provided in the context of informal mentoring relationships that are spontaneous and develop organically (Saha 2019). Encouragingly, informal mentoring efforts are generally more widely available to students than formal programming efforts (James, Rayner, and Bruno 2015) and have important implications for student learning and development (McKinsey 2016). Whether provided via formal mentoring programs or support structures, or more informal and organically developed mentoring relationships, we caution that efforts should be made to recognize and reward the caring and compassionate faculty who take on this invisible labor (Goerisch et al. 2019) that facilitates student commitment, retention, and graduation (Crisp and Cruz 2009), but also generates costs to faculty (Lunsford et al. 2013).

While challenging and reframing existing educational structures to create more equitable outcomes, we should also take care to acknowledge that women have less frequent interaction with their faculty mentors than men do and URM students; in turn, limited interaction is associated with reductions in scholarly productivity, a weaker science identity, and limited intention to pursue a PhD (Aikens et al. 2017). In contrast, opportunities to interact with faculty foster learning and are transformational in students' thinking about the purpose of higher education (Spronken-Smith et al. 2015). Awareness of these trends is vital to the conscientious creation of an equitable mentoring environment that supports the development and success of all students in STEM.

In conclusion, high impact practices, particularly undergraduate research experiences, involvement in student organizations, and peer interaction, are critical to the success of women and URM students in STEM fields (Espinosa 2011). Our study confirms that the benefits of these efforts are magnified by close mentoring, particularly when provided by authentic faculty who foster relationships characterized by psychological safety and trust. These distinctive relationships foster honest sharing and academic growth while assuring and reminding students that they are capable of success within STEM fields (Tenenbaum, Crosby, and Gliner 2001).

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## AUTHOR BIOGRAPHIES

*Daphne E. Pedersen is Chester Fritz Distinguished Professor and department chair of sociology at the University of North Dakota. She currently serves as the co-investigator and social science researcher for the National Science Foundation S-STEM US MASTER project and is the immediate past-president of Alpha Kappa Delta International Sociology Honor Society.*

*Alena Kubátová is Chester Fritz Distinguished Professor and chair of chemistry at the University of North Dakota. She currently serves as the lead of the National Science Foundation S-STEM US MASTER award, providing scholarships to students. Her ongoing interest is in promoting students' interest in sciences through research and experiential learning.*

*Rebecca B. Simmons is a professor of biology at the University of North Dakota. She is the educational coordinator for the National Science Foundation S-STEM US MASTER program, which supports talented students from underrepresented groups in STEM fields and serves as an inclusion ambassador for UND's College of Arts and Sciences.*

## ETHICS

This project was approved by the Institutional Review Board of the University of North Dakota.

## NOTES

1. The United States National Science Foundation (NSF) S-STEM program was developed to facilitate academic and career development in the STEM fields among low-income, talented students by supporting scholarships and evidence-based curricular and co-curricular activities at supported institutions. https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5257.

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# APPENDIX

## Interview protocol

1. Please tell me a little bit about yourself, and how you got to where you are now.
    a. What aspects of <u>the STEM field you are in</u> (e.g., chemistry) drew you to the field?
    b. Was there anyone along the way who encouraged you to pursue <u>a STEM degree</u>? Who?
    c. Were there any events in your life that shaped your decision?

We are interested in what leads students to pursue a STEM degree, and the shape of their experiences in STEM.

2. Thinking about the experiences you've had in your major so far,
    a. What has helped you be successful (in courses, the major, at UND)?
        i. Have you had to change any of your habits or behaviors to succeed?
        ii. Have you gotten involved in any activities or groups? Found additional supports or learning opportunities?
    b. Have you faced any challenging situations?
3. Are there other important relationships you have had that helped you
    a. See yourself as a "science person" (e.g., a chemist, a biologist)
    b. Develop competency in <u>your field</u>
    c. Gain legitimacy as a scientist in <u>your field</u> (help others recognize you as a scientist)
4. Are there people you consider your mentors? Why?
    a. How important have these relationships been to
        i. Your connection to UND
        ii. How you feel about your program (or major)
        iii. How satisfied you are with your decision to pursue _____ (e.g., chemistry) as a major
        iv. Whether you think you might go on to graduate school
    b. Has it been easy or hard to develop these relationships? Why?
5. Is there anything else you can think of that might be helpful for us to know?