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Transfer Students' Perception of STEM Faculty Dispositions Towards Gender Impacts Confidence and Success in STEM Career Pathways

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ABSTRACT

United States policy aims to bolster a declining interest in the STEM (science, technology, engineering and mathematics), professions. This disinterest is especially notable in women, Latinx, Black and Indigenous people who make up first-generation Americans attending college. Removing barriers for those under-represented in the STEM professions could sustain a pipeline of undergraduates, and challenge inequity in cultural diversity in the STEM workforce. This study examines one program and its impact on transfer students in their pursuit of STEM careers. This is a qualitative analysis from 57 interviews of transfer students from community colleges into biological studies at a four-year university. Data were transcribed and coded, with the codes presented as evidence for themes that repeated within and across interviews. Codes and themes were analyzed to detect patterns in student views over four years. Results confirm the importance of financial and structural support as necessary but not sufficient to contradict the societal biases that contribute to low interest. Data support the importance of student views of the gender and disposition of faculty in the retention of students under-represented in STEM studies. The results are discussed in the context of two theories *Stereotype Threat* and the *Imposter Syndrome*.

KEYWORDS

Transfer student; Undergraduate STEM education; Gender; Microaggression; Imposter syndrome; STEM retention

The persistent challenge to increase the number of individuals choosing STEM careers (Committee on Prospering in the Global Economy of the 21st Century, 2007; President's Council of Advisors on Science and Technology, 2010; Tanenbaum et al., 2016) has been met with initiatives from both the federal, state, local governments and the private industry, most recently the reauthorization of the America Competes Act, 2022. One approach has been to recruit talented individuals from populations who are under-represented in the STEM workforce by increasing access and removing barriers to their participation in the attainment of degrees and certifications. Included in these populations and the focus of this study are students who represent the first in their families to attend post-secondary schools and women (Collins et al., 2020).

The key aim of this study was to understand the experiences of biology students who transferred from a 2-year institution of higher education to earn a degree at a 4-year institution. The two-part research question is, (1) What barriers did the students experience in their transition process and, (2) What supports did they utilize to achieve successful outcomes?

The study was conducted in an NSF-funded S-STEM program, called Biology Transitions, that was implemented in a university with a student population of 7000 students, located in midwestern United States. The program aimed to increase student persistence in STEM degree programs and degree completion and retention in the biological fields and workforce for students transferring into the biology department's undergraduate degree programs from community colleges and other 4-year universities. The program was structured on research-based design elements (Duggan & Pickering, 2008), such as removing financial barriers and providing advising, academic and social supports intended to assist students' transfer from community-colleges. A notable feature of this program and one that emerged as important to the experience of participants in this study was that students, during their first year, were advised and instructed by women biologists.

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Gender remains a persistent factor limiting the participation of women in STEM fields, especially those in positions of leadership (McCullough, 2020). This inequity and subsequent under-representation of women, contributes to a phenomenon called the Imposter Syndrome (Clance & Imes, 1978); a condition which refers to individuals who have the qualifications and meet performance criteria of a profession, but lack feelings of belonging. Initially identified by Clance and Imes (1978), the Imposter Syndrome research describes the perceptions of inferiority expressed by highly successful women in predominantly male-defined professions. One factor contributing to this sense of not belonging as adults, are the experiences of young students who receive messages throughout their K-12 education, that they are underqualified to achieve high level positions in careers that make up the STEM pipeline (Lester et al., 2017).

Persistent negative messages and microaggressions were first studied as systemic factors impacting the academic success of students of color (Lee et al., 2020) and expanded later to include girls and women who experienced stereotyping and bias in school and the workplace (Boysen, 2012). Programs aimed at challenging gender-based bias and increasing the participation of those from under-represented groups, focused more on improving access to opportunities and less on the impact of microaggressions experienced by girls who might seek careers in STEM (Souza, 2018). Student comments in this study reveal some of the early experiences these women had in STEM classes in school. Additionally, they describe how the Biology Transitions program offered a counter narrative to the socio-psychological challenges that participants from under-represented groups often bring into higher educational study.

Methods

This qualitative study was based on a conceptual analysis of transfer student responses to interview questions about barriers and supports they experienced in their STEM education. Perceptions of the participants were used as indicators of the presence or absence of resources and support structures that impacted their success.

Participants

The participants in this study were students recruited by the university's NSF-funded Biology Transitions scholarship program, primarily from area community colleges. Those accepted into the program and included in this study were from populations who are under-represented in STEM careers, 92% female and 40% non-white. All participants had satisfied the requisite academic criteria and had expressed an interest in a STEM career emanating from the biological sciences.

Program Description

Transfer students in biology who fit the university's academic criteria and had unmet financial need were invited to apply to the Biology Transitions program. Eligible students were awarded scholarships to ease financial burden and were enrolled in a Scientific Inquiry seminar course for a minimum of two semesters. This course provided important academic structural and relational support to aid students in navigating the transition from community college into the Biology Department at this 4-year university. It also provided students with access to mentoring from peers and faculty and the development of connections with the greater university community. Throughout the duration of the study, 20 students completed degree programs and entered post-bac STEM careers (Table 1).

Timeline of the Study

The study spanned a four-year period from 2018 to 2022 and included multiple interviews from three cohorts of students. Audio recordings of interviews were transcribed and coded each year. The cumulative interviews were sorted into three categories for interpretations and discussion, (1) those conducted in the first month of the program, (2) those between the middle or end of year-2 and (3) those at the end of their program, prior to exiting.

Data Collection and Analytical Procedures

The data informing this research was derived from the perceptions of the students as they entered, engaged in coursework and exited the program. The research was framed by a qualitative methodological approach and bounded by the activity of the scholarship program. In accordance with a case study approach (Yin, 2011) the primary form of data

Table 1. Number of transfer students completing degree programs and inducted into STEM careers.

Cohort	Transfer Students Entering Cohort	Cohort Member STEM Degree Completion
2018–2019	5	4
2019–2020	9	6
2020–2021	14	10

collection was semi-structured interviews of participants ($N = 28$) conducted by the project's external evaluator and an educational researcher at multiple points across each student's two-year program, resulting in 57 total interviews. Seidman (1991), who studied the value of follow-up questions and the development of conversational partnerships, guided the interview approach. The interviews were audio recorded and transcribed with the cloud-based program, Trint. Transcriptions were manually corrected against the audio recording by the interviewer.

The transcripts were analyzed using qualitative methodology, Thematic Analysis (Hassan et al., 2011; Terry & Hayfield, 2020), with codes generated from the content of the interviews and applied, reflexively to interviews from the previous interviews in the study (Saldaña, 2014). Validity of the thematic interpretation of codes was established by inter-rater reliability between three researchers occupying various positions of proximity from the participants. The researcher closest to the project who acted also as the external evaluator, conducted the first two sets of interviews and identified the initial set of codes and themes. A subset of interviews, with names removed, was selected for coding and thematic analysis by an educational researcher who had no direct interaction with the participants outside of the interview and by a qualitative researcher from another university who did not know the project leaders or participants. Inter-rater reliability was established at an acceptable rate of 85% between evaluators, representing both internal and external researchers.

The themes that emerged from the responses of participants were analyzed by a hierarchical framing, with those addressing barriers of access to the university programs, first, and then, those addressing barriers to successful completion of the degree program. Additionally, the responses in each of the two levels were analyzed by participants' progress in the program when interviewed, beginning, middle, and end (Table 2).

Results and Discussion

The results of this study are discussed relative to the two research questions: (1) What are the barriers experienced by students in the transition process? And, (2) What support did they experience? Responses by participants which were somewhat bounded by the interview questions, were coded and grouped to generate relevant themes. Themes were identified from the coded responses to questions and any emergent comments that were repeated by more than one student. Themes were ranked in importance by the frequency of coded responses at three time points in the program. Only themes represented by the coded responses of 80% or more of the interviewees were included in this analysis (Table 2).

Barriers and Affordances of Transitions Student Access to STEM Programs

The interviews were structured to access student perceptions (Yin, 2011). The questions were derived, initially from predicted barriers identified in the research literature with adjustments made in the second and third interviews as topics emerged from the interviewees' interests. At the beginning of their time in the Biology Transitions program, student responses aligned with the published literature (Duggan & Pickering, 2008; Jabbar et al., 2022) on barriers encountered in the transfer from 2-year community college to 4-year universities (Table 3). For example, students who were the first in their families to go to college reported a need for assistance navigating the systems on campus from admissions, to financial aid, to the registrar (National Academies of Sciences, Engineering, and Medicine, 2018). Additionally, extra attention of advisors to assist in the scheduling of coursework can impact the early experiences of transfer students, and this was cited as important (Table 2). These barriers can be summarized as structural

Table 2. Framework for thematic analysis of student responses on barriers and affordances to the transition process.

Research Question	Themes Generated—Beginning	Themes Generated—Middle	Themes Generated—End
What barriers did students report in their transition process?	First generation college/knowledge of systems Financial impacts Navigating campus facilities/ resources Difficulty of coursework/ expectations Sense of isolation	Time on campus vs work Shift in understanding of course expectations Confidence Challenges, particularly gender/ 1st generation	Work inhibited access to full resources
What supports did they utilize to achieve successful outcomes?	Writing Center Inquiry Project—sense of belonging Biology Transitions leadership support	Connections with other Biology Transitions students Inquiry Project Faculty support, particularly female scientists	Career-driven Increased interest in graduate school and STEM research careers

Table 3. Frequency of coded responses by interviewees at the beginning ($N = 27$), mid-point ($N = 21$) and end ($N = 9$) of transfer students' STEM program.

Themes	Initial Interviews across cohorts (N = 27) Response Frequency	Mid-Point Interviews across cohorts (N = 21) Response Frequency	Final Interviews across cohorts (N = 9) Response Frequency	Total # of Coded Responses
Importance of financial support	25	11	3	39
Importance of Advisor Relationships	28	13	8	49
Importance of Faculty Relationships	20	27	4	51
Importance of Transitions Special Project	20	6	0	26
Importance of Academic/Writing Support	13	2	0	15
First Generation College/ Knowledge of Systems/ Time on Campus vs Work	11	9	0	20
Importance of Gender / Faculty Support, particularly female scientists	N/A	14	17	31
STEM experiences in early education (K-12)	4	18	12	34
Navigating Campus Facilities/ Resources	8	0	0	8
Difficulty of Coursework	7	5	0	12

and were remedied by the programmatic features put in place prior to the start of the program and adjusted as needed, throughout. When referencing coursework challenges, early in the program, student comments valued the academic writing center, and the Biology Transitions program faculty leaders who provided guidance during the weekly Scientific Inquiry seminar. These structural supports were tangible and necessary for these students to access and succeed in their first two semesters. It was, however, the intangible qualities of the program that students cited as important when reflecting on their experience mid-way through. These were categorized as relational and socio-emotional supports.

Intangible Barriers to Transfer Student Success in STEM Programs

Early in the program the students reported a sense of isolation from campus activities due to their out-of-school work responsibilities and unfamiliarity with the campus. This increased the importance of the common Scientific Inquiry course which provided space for connections with other Biology Transitions students. Additionally, they referenced the support they received from the Biology Transitions faculty mentors in everything from clarifying academic expectations to identifying campus assistance. Supportive, friendly, helpful, were all words used in reference to this course experience illustrating that this structural support functioned as intended (Table 3). During the mid-program interviews a high frequency of comments indicated that students had feelings of being welcome but not a sense of belonging. When asked to discuss this more, it became clear that 'not belonging' didn't imply a campus social condition (Interview Summary, 2020) and was not connected to academic performance. One student reflected more deeply and suggested that this feeling of belonging was more about fitting into a career in STEM (Interview 036, 2020). A second student responded with anxiety about making it in the STEM career (Interview 034, 2020). This finding led the interviewer to add a subset of follow-up questions about pre-college experiences in STEM classes in order to gain insight into the discomfort. When asked directly about their early experiences in STEM learning environments, descriptions of a number of negative experiences emerged. The following are representative responses (Table 4):

This probing beneath the surface led to multiple examples of everyday interactions that seemed insignificant in a moment but collectively suggested an environment that has been described by the literature on microaggressions in which early STEM interest was perceived by those not represented in STEM careers, as discouraging. Most of the respondents ($N = 8$), when asked follow-up questions, had a story they could recall in detail that could have turned them away from pursuing study in STEM (Table 4). When viewed as individual comments, and out of context, these could have been spoken with the best of or at least neutral intentions. They were received, however, as casting doubt on these young students' competence and consequently, challenging their confidence. Decades of research on Stereotype Threat (Steele & Aronson, 1998; Steele, 2011) have demonstrated the negative impact that drawing awareness to one's race, gender, socioeconomic class in the context of societal views of inferiority, can have on performance on standardized tests (Spencer et al., 1999). Whether students are the target of these statements or merely witnesses, interactions with adults in positions of authority that are perceived as negative, or suggest microaggressions, can become barriers to choices of young people especially those with limited role models in the STEM professions (Collins et al, 2020). In

Table 4. Representative responses from mid-program participants (Interviews 039-055), on early STEM experiences, K-12, (2021–2022).

Interviewer	Student
Did you experience discrimination due to your gender?	"Not really"
In middle or high school, were you encouraged to study math or science and/or enter a STEM career?	"Not really"
Were you discouraged?	"Sometimes"
In what ways?	1. "Teachers will say there are no bad questions but they don't mean it." 2. "I asked a question and he said, 'Didn't you do the reading?'." 3. "I asked a question and my teacher said, 'Who can help with that answer?' Like everybody knows but me." 4. "I asked a question and my teacher said, 'That's something you should have learned before now.'." 5. "I learned not to ask questions and just look stuff up." 6. One male interviewee said, "I noticed teachers making students feel like they shouldn't have some questions. One teacher seemed to pick on the girls more. I felt bad for them." 7. "My teacher asked, 'What do you want to do after high school?' When I said I wanted to be a veterinarian, she said it's really hard to get into vet school. Like I couldn't do it." 8. "My guidance counselor said I shouldn't take more science if I wanted to go to college. My grades weren't the greatest, I guess." 9. "I always liked science, but never thought it could be a job, until now."

addition to limiting choices, these comments discouraged some students from asking questions and engaging in discourse in STEM classrooms, which research suggests are two ways that enhance STEM learning and cognitive development.

Contradictions to STEM Microaggressions in K-14 Education

Positive Interactions

In this study, respondents remembered and repeated these early experiences when they were discouraged from STEM study, however, the data from the current study did not confirm these experiences. Further analysis of responses indicated that most (90%) of the participants in the program featured in this study experienced course instructors as those who presented contradictions to some of their early school STEM experiences (Table 2). They cited as a primary support to their success, professors and advisors who were available for questions (Interview 47, 2020), did not judge the quality of the questions they asked (Interview 49, 2020) and according to one student, "would answer questions on a social media platform any time" (Interview-45, 2021), which was particularly helpful to this students' non-traditional out of class schedule. It's unclear if the absence of these positive interactions with science course instructors would have deterred their success; in the least it is likely that the responses they received from their professors contributed to a counter-narrative to their negative experiences prior to this program and provided a platform for continuing interest in STEM study and careers.

Representative Role Models

When the female students were asked if they experienced gender discrimination, no one said yes. When asked if it mattered to them that their professors were scientists and women, without hesitation and with varying degrees of enthusiasm,100% of the respondents said yes. When asked if they saw themselves as role models for middle school students who might want to enter STEM careers,100%, to varying degrees, said yes, with several already intending to initiate contact with their middle and high schools.

Conclusion and Implications

This study expands our understanding of barriers and affordances that impact the confidence and success of women who seek STEM careers. It confirms the importance of financial aid and structural supports to the success of transfer students and suggests that creating a durable pipeline of under-represented students in the STEM fields could benefit from visible working role models of scientists who represent the populations of the students recruited. Additionally, a key finding indicated that the narrative built by microaggressions from early STEM educational experiences was contradicted by the faculty who encouraged the types of student behavior known to foster academic success such as asking questions and engaging in discourse with experts in the content of the STEM fields. The study suggests that providing access is necessary but to retain interest and impact the success of populations under-represented in STEM fields, the intentional shaping of a learning environment that challenges the societal biases could

contribute to more young women choosing to enter the STEM workforce.

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