Differences in How STEM Students Define Themselves as a "STEM Person": Implications for College STEM Instructors

Valentina Espinosa Suarez, Heidi Cian, and Remy Dou
Florida International University, Miami, FL

Subject/Problem

STEM education researchers are interested in how individuals think of themselves as STEM people (i.e., their STEM identity) due to associations between identity and STEM career pursuits and persistence (e.g., Carlone & Johnson, 2007; Hazari et al., 2010). Much of this research points to the powerful role that recognition by significant persons in the STEM community plays in STEM identity construction. In college contexts, STEM instructors are especially positioned to convey recognition of STEM students as STEM persons through evaluation of performance, invitation to participate in research opportunities, and recommendations for specialized programs. Therefore, receiving recognition from these instructors in ways that allow college students to see themselves as a STEM person is important to their persistence in STEM. Carlone and Johnson's (2007) research with career scientists suggests that individuals may require different forms of identity-supportive experiences depending on how they engage with STEM—particularly noting a difference for research and health scientists. They described scientists in health careers as "altruistic" scientists whose identities were supported by experiences that allowed them to help others. "Research" scientists, on the other hand, needed formative experiences that supported their identity as someone who discovered new ideas and carried out scientific investigations.

Premed students are stereotyped as hyper-focused on grades at the expense of understanding (Lin et al. 2013), are often excluded from STEM research opportunities, and often are not able to access the medical colleges for which they spend their undergraduate careers preparing for (e.g., 41% in 2019; Association of American Medical Colleges, 2020). As such, in their college experiences they encounter unique challenges to their STEM identities. While Carlone and Johnson's (2007) work identified differences in identity-supportive experiences recalled by *career* research and health scientists, research is needed to understand in what ways college STEM students with different aspirations may identify with STEM in unique ways. Knowing this would help instructors differentiate their construction of classroom experiences in ways that are most supportive of the STEM identities to which their students aspire. Understanding how to differentiate particularly based on easily identifiable characteristics that are relevant to the subject matter (i.e., premed status) could be especially informative, as it provides recommendations based on easily recognized factors and could clearly integrate with biology instruction and curriculum (e.g., design of laboratory experiences).

In this proposal, we present our study exploring how and to what extent premed students compare in their self-perception as a "STEM person" to peers not on a premed track. Our purpose is to provide guidance to college biology instructors as to how students may be best supported in their STEM pursuits, and particularly how this support can be differentiated to accommodate the unique ways that students may see themselves as a STEM person. To explore STEM identity, we draw from the identity framework of Hazari et al. (2010), which postulates recognition, interest, and performance-competence as contributors to physics identity among physics students. This is an extension of Carlone and Johnson's (2007) science identity framework, which defines identity as composed of recognition, performance, and competence.

Hazari et al.'s revision has shown to be more reflective of the identity factors of STEM students (compared to career scientists in Carlone and Johnson's work) and has been validated for studying identity in college biology (Hazari et al., 2013) and STEM students (Author, 2019).

Research Design

This research is a sequential explanatory mixed-methods study (Creswell & Plano Clark, 2017) that took place at a Hispanic-Serving Institution in the Southeastern United States. For our quantitative study, we developed a survey to measure STEM identity which consisted of Likert scale items assessing STEM interest, STEM recognition, STEM performance-competence, and STEM identity (details in Author, 2019). Given the university population of our study, we focused on items that assessed STEM identity in an academic context: measuring recognition through the degree to which they felt their teacher saw them as a STEM person, interest through desire to learn more about STEM topics, and performance-competence through perception of performance on STEM assessments. We adopted Hazari et al's approach to measure identity, using an item that asked participants to rate the degree to which they saw themselves as a STEM person. We distributed the survey to students enrolled in introductory STEM courses via email invitations. Roughly 10% of students completed the survey (N = 522). Since the purpose of this research was to explore the STEM identity differences between STEM premed students and STEM students not on the premed track, we isolated the responses to only those who indicated that they were STEM majors (n = 440). We analyzed the survey through four linear regression models assessing the relationship between pre-med status and STEM identity, performance-competence, recognition, and interest. We controlled for gender, perception of home support around science, and biology major, drawing from literature that indicates these variables contribute to STEM identity (e.g., Cotner et al., 2017; Gokpinar & Reiss, 2016; Sadler et al., 2012).

While the purpose of the survey analysis was to give us a sense of the degree to which premed students identified as STEM people relative to their peers, we wanted to further understand the reasons premed students felt they were STEM people and examine how those reasons compared to that of their peers. Individuals were purposefully selected to participate in a 60-minute interview (N = 20; nine of whom were premed). Selections were made to diversify participation based on self-reported demographics, STEM identity, and items assessing perceived family support in STEM. We selected individuals to invite to interviews in clusters, with analysis occurring concurrently so that the next cluster of individuals could be identified, and interview questions adapted to test emerging themes (Miles et al., 2018). We developed descriptive codes (Miles et al., 2018) grounded in the participants' reflections on why they felt themselves or others to be a STEM person (or not). Theme development began by looking at these codes to determine patterns in how individuals describe themselves as STEM people and how they compare themselves to others, particularly focusing on comparison to others in STEM fields. We engaged in peer debriefing with members of the study population (i.e., undergraduate STEM majors, including premeds) to test the durability of our themes (Miles et al., 2018).

Analyses and Findings

The regression model for STEM identity was significant, $F(4,483) = 2.56$, $p < 0.05$, $R^2 = 0.02$, with premed students more likely to see themselves as a STEM person than those not on a premed track ($\beta = -0.10$; $p < 0.05$). The model for recognition in STEM was significant, $F(4, 483) = 5.39$, $p < 0.001$, $R^2 = 0.04$, with students on the premed track, were more likely to

perceive that their STEM teachers saw them as a STEM person than those not on a premed track ($\beta = -0.12$; $p = 0.01$). Pre-med status was not significant in the performance-competence model, indicating that premed students did not differ from peers in their sense of ability to do well on STEM tests and exams. The performance-competence model was significant, however, $F(4,483) = 4.56$, $p = 0.001$, $R^2 = 0.04$, with lower self-evaluation of performance-competence for women compared to men ($\beta = -0.10$; $p < 0.05$). The interest regression model was not significant for premed category or any other variable, $F(4, 483) = 0.88$, $p = 0.48$, $R^2 = 0.01$, suggesting that our variables were not associated with a difference in interest in learning more about STEM topics.

Interview data suggested that STEM students—regardless of major or premed status—felt themselves to be a "STEM person" due to perceived interest in STEM and intelligence in STEM—aligning with our identity framework and research showing significant contributions of interest and performance-competence on identity (Author, 2019). We looked at interview codes related to how participants described themselves "doing" science to see if differences existed in what activities they associated with feeling like a STEM person. Premed students often described a STEM person as someone who helps others through the work that they would be doing in their careers, stating that their aspiration to help others in this way was a reason they felt themselves to be a STEM person. This was especially apparent for the students who identified as female (seven of the nine premed students we interviewed). For instance, Mary reflected that she felt drawn to a career as a doctor because she "liked the idea of a job that involves helping others." Students who did not intend medical careers did talk about helping others through their work, but they described helping through innovation, by making scientific contributions to mankind broadly, rather than through care-oriented activities that helped individuals. These findings map onto the categories of "altruistic" and "research" scientists identified by Carlone and Johnson (2007).

The groups of students also differed in the way that they described feeling like a STEM person through hands-on activities. Students who were premed described feeling like a STEM person when doing activities in the university science lab, whereas students not considering medical careers more often discussed unstructured activities, such as construction or tinkering hobbies, as formative to their self-perception in STEM. This association between STEM and tinkering was especially true for men, consistent with research on gender differences in the structure of STEM activities (Archer et al., 2010). This finding also complicates the division between research and altruistic scientists observed in Carlone and Johnson's work, by suggesting that in the college context laboratory research experiences may be meaningful for sustaining STEM identities of students who aspire to medical careers, especially for women. Several premed participants discussed not truly feeling like a "STEM person" until they had laboratory experiences in their college biology classes, while students who associated "doing" STEM more with engineering-type tasks experienced unstructured recreational activities outside of school. These findings indicate an important role of the university laboratory experience for students who may not have access (materially or otherwise) to free-choice STEM opportunities.

Some participants also talked about premed students or medical workers abstractly, reflecting on their perception of members of this population as "STEM people." While our inquiry focuses on how students define themselves as STEM people, this was a relevant finding given the importance of peer recognition in individual perception of STEM performances and STEM identity (Hughes et al., 2020). Premed students recognized medical professionals, or those who aspired to be medical professionals, as STEM people, but students not aspiring to careers as doctors were more reluctant to make that association. Jake, a biomedical engineering major, distinguished himself from doctors whose work he felt was "more fact-based" rather than

innovative, remarking that a doctor would only be “in STEM" if they “develop new things for whatever use in the body...like what I would do in prosthetics.” Carla, a biology major and aspiring teacher, did not generally see her premed peers as STEM people because, as she saw it, they were more focused on getting good grades than learning content and skills in their science courses. While research has documented the consequences of faculty stereotypes of premed students on the premed student experience (Lin et al., 2013; Sade, 1984), more research is needed to understand the implications of the stereotypes students may have of their peers, for instance in how and to what extent premed students are invited to participate in group work.

Collective Analyses, Contribution & General Interest

At many universities, large, introductory biology courses are attended by students with a large range of postbaccalaureate STEM intentions. Retention of these students in STEM majors is important, especially for premed students given the challenges many of these students face in pursuing their chosen careers due to low acceptance rates to medical schools. Identity theory suggests that experiences that support interest, performance-competence, and recognition in STEM help to positively develop STEM identity, which is related to career pursuits. While recognizing these contributors is valuable, our research suggests that it is important to also consider differences between the types of experiences that contribute to senses of interest, recognition, and performance-competence, especially for students on premed tracks. Collective examination of our quantitative and qualitative findings offers some important insights in understanding the STEM identity of college students, with implications for research and practice.

While quantitative findings indicated no differences in how premed students compared to their peers in terms of STEM performance-competence, interview data suggested that the types of activities each group of students associated with “doing STEM” differed. This implies that survey research assessing STEM identity using performance-competence and indicators should consider diversifying what types of activities are assessed to capture differences that may not be realized in narrowly defined assessments of these constructs. In practice, findings suggest that instructors with students with an array of career aspirations, such as in an introductory biology class, will want to provide a diversity of performance opportunities to support the various ways students may find personal resonance with doing STEM. Similarly, while the interest regression model did not indicate differences in students’ willingness to learn more about STEM, the interview findings regarding helping others indicates that the type of information students will want to learn more about—and the utility they expect of that extra knowledge—will likely differ, with students on the premed track being especially interested in learning more about science in a way that can be applied to help others. Thus, explicit associations between curriculum and these interests could support students’ sense of belonging in STEM.

Our research also offers some important implications of the intersection of gender and STEM identity. The performance-competence model showed a significant difference in gender, with women rating themselves lower than men, aligning with other research suggesting that women perceive their abilities in STEM less favorably than do men (e.g., Sadler et al., 2012). Assessment-based performances, like those measured in our survey, tend to be a stronger contributor to self-efficacy in men than in women, who may be more affected by interpersonal, relational experiences (Zeldin et al., 2008). Given this suggestion and our results, it may be important for biology instructors to communicate positive performance-based feedback to women in their classrooms beyond exam scores, for instance through personal dialog. Our interview data further suggested some tendency among non-premed students to dichotomize

caregiving and STEM personhood among students not pursuing medicine. These findings resonate with critical feminist scholarship that problematizes the rejection of empathy and care in STEM (Harding, 1986). Given that many of our premed participants associated their self-perception in STEM with their desire to provide care, it may behoove biology instructors to demonstrate the relevance of their curriculum to caregiving. In doing so, instructors may additionally model for other students the value of care work in STEM. These efforts could be consequential given that peer recognition is also an important contributor to STEM identity, and that instructor recognition has a strong influence on how students see their peers as STEM persons (Hughes et al., 2020).

Survey data indicated that premed students felt more so than their peers that their instructors recognized them as STEM people. While our work did not study the perceptions of faculty, rather looking at how our students perceived their instructors to think of them as STEM people, previous research suggests that premeds are perceived by university faculty as excessively competitive, and these impressions may influence both undergraduate curriculum and student major choices (Sade et al., 1984). However, little research exists on this point, and what is available is likely outdated. Our findings imply that further research is needed that assesses the perspectives of STEM instructors directly to better understand how these stereotypes manifest in the modern classroom and affect the differential recognition that instructors may convey to premed students. Research on faculty reflective practice of attitudes and behaviors towards premed students may be especially valuable.

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