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CAREER: Exploring LGBTQ Student Trajectories and Belonging in STEM Through Social Network Analysis

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Introduction

Engineering, among other STEM fields, faces an intractable diversity problem. Progress to reverse the historic exclusion of people from groups minoritized in STEM has been slow and incremental, and national calls to broaden participation in STEM have only increased [1]. This situation is a problem because people from minoritized backgrounds face barriers to their participation in STEM that are unrelated to their interest in or talent for STEM work, and the STEM workforce benefits from diversity by broadening the array of perspectives working on the most pressing, complex problems facing society [2]. Past research has documented the ways participation in STEM is shaped by race and gender, and newer threads of research are exploring other forms of minoritization, including sexual orientation and different gender identities.

Project Overview

The purpose of this NSF CAREER-funded project is to examine the participation of LGBTQ students in STEM fields. In this paper, we document progress toward meeting the first research aim of the project, to examine the social networks of LGBTQ students in STEM, compare their networks to those of their peers, and test the relationships between network characteristics and student outcomes in STEM. Research has shown that the LGBTQ climate in STEM undergraduate degree programs is rife with heteronormativity and cissexism [3, 4], leading LGBTQ students to leave STEM majors and careers at higher rates than their heterosexual, cisgender peers [5, 6]. LGBTQ students who remain in engineering and other STEM fields report implicit and explicit pressures to manage their peers' discomfort with sexual and gender diversity through either downplaying, or covering, these identities, or even outright passing as heterosexual [7, 8]. LGBTQ students compartmentalize their sexual and gender identities when navigating academic spaces, which may be reflected in how they manage their social networks within and outside of academic settings—particularly STEM. This first phase of our project is aimed at collecting data to test this hypothesis.

Social Network Theory

Social network theory provides the foundation for social network analysis, the primary method employed to reach the first research aim of this project. Social network theory helps explain the influence of a person's social context on their growth and development, particularly through the examination of the influence of strong and weak social ties [9]. Social network analysis comprises the methods used to study social context though collecting information on the patterns of relationships among people in a particular network [10]. We use an egocentric approach that focuses on the set of relationships that compose an individual's (ego) social network. An egocentric approach allows us to measure network homophily specifically, or the extent to which an individual shares characteristics and experiences with significant people in their social networks [11]. When individuals' networks are made up of people who are similar to themselves, their access to new information and experiences become limited.

Instrument Development

The primary work accomplished in the first year of the project was development of a survey that would capture data on students' social networks as well as the student outcomes hypothesized to be affected by network characteristics. We developed a survey that achieves two primary purposes: generating an ego-centric social network to capture characteristics of the set of people students rely on most for support, and measuring a set of student outcomes expected to relate to network characteristics. These outcomes include sense of belonging, science or engineering identity, and commitment to field of study.

One important aspect of this survey is the set of items capturing demographic characteristics. Historically, surveys have excluded items that prompt respondents to report their sexual orientations or gender identities beyond the typical binary construction of gender. As we include sexual orientation and gender identity as important demographic variables on this survey, a consensus on best practices for doing so is still emerging within the social sciences. We followed an approach that included an expansive list of sexual orientations to ensure representation of a broad array of the ways students may identify, and we also included an expansive list for gender identity. To reflect the fact that the term transgender on its own does not reflect a gender identity itself, but rather how a person's gender identity relates to the sex they were assigned at birth, we provided a separate item to prompt respondents to indicate if they identify as transgender. This two-step process for gathering data on gender identity aligns with recommendations from experts in the field. These demographic items, as well as students' major in college, also help screen participants to ensure we welcome adequate participation across different social identity groups.

Social Network Analysis

An egocentric network represents a single person's social network, and the social network analysis (SNA) section of the survey aims for this goal without overburdening participants by attempting to model an important subset of an individual's complete network [10]. Egocentric social network instruments start with a name generator, or a prompt that asks students to identify a set of people they consider most influential in their networks. Our survey starts by asking students to identify six people, or the three people most important to them across two domains of support: sources of personal support and sources of academic support. Participants then identify qualities of their relationships with each of these identified network members, also known as "alters." These qualities include the closeness of the relationship, the frequency of interaction within the relationship, and several demographic variables about each alter. For LGBTQ participants, we prompt whether this alter is aware of their LGBTQ identity. Participant networks will then be characterized through aggregate statistics across the six identified alters, such as the proportion of alters who share social identities with the participant (homophily) or the proportion of alters who belong to different social identity groups (e.g., LGBTQ alters).

Student Outcomes

Sense of Belonging: The survey then measures three affective outcomes that previous research has shown relate to persistence in engineering and other STEM majors and that we hypothesize will be influenced by the composition of students' social networks. The first of these outcomes is

sense of belonging. A sense of belonging is the extent to which students see themselves as part of a particular group or community, especially the degree to which they experience cohesion with that group [12]. We adapted Hurtado and Carter's [13] measure of sense of belonging to measure students' perceptions of belonging within their field of study.

Science and Engineering Identity: To capture the extent to which students identify with STEM fields, we used Godwin's [14] measure of engineering identity which examines internal states and student self-perceptions of engineering role identities. The instrument measures identity across three related constructs, interest, recognition, and performance/competence. We modified these items to reflect experiences across STEM disciplines. Within interest and performance/competence, we prompted students to consider "their chosen field" rather than a specific major (like engineering), and within recognition, we included the items twice to ask about their perceptions of being an "engineering person" and a "science person." Each construct comprises three or more items where students are asked to rate their agreement with each statement on a five-point scale of Strongly Disagree to Strongly Agree.

Commitment to Major: To measure students' commitment to their major field of study, we adapted an existing measure of intent to persist in college for this measure [15]. Short of being able to directly observe commitment to their major, this item helps assess how likely a student is to change their major. The theory of planned behavior then asserts that actions are typically preceded by intentions to act [16], meaning an intent to change majors is a likely indicator of a later decision to follow through.

Other Measures: The survey includes other items to serve as covariates and control variables in later analyses. These items include a question as to the extent students perceive their network as influential in their decision to change their major, participant demographics, and experiences participants may have had in college.

Instrument Validation

Instrument validation took place through two procedures: cognitive interviews with undergraduate students and expert review by experts in survey design and the content areas of the survey. We conducted four cognitive interviews with undergraduate STEM students to help evaluate the effectiveness of our survey questions and form. The participants were diverse in terms of their field of study as well as their sexual and gender identities. The cognitive interviews followed a "think out loud" procedure where students were asked to explain their understanding of the item and reasoning through their answer to us [17]. The interviews helped reveal how students thought about their answers, what they found confusing or unclear, and what they thought the questions were asking, which led to important survey revisions to add clarity.

Expert Review

The second procedure for validating our survey was to provide the instrument to experts for feedback. Expert review has been found as an especially reliable method for identifying potential problems with survey data quality [18]. In order to aid the expert review process, we developed a rubric to guide the review process. This rubric was designed to focus the experts on survey issues

such as content validity, cognitive burden, and potential points of failure across participant comprehension, retrieval, judgment, and editing of items [19]. Experts then offered brief comments on their ratings to aid with our revision process. For example, one of our expert reviewers identified language in the adapted STEM identity measure as a likely point of failure due to content validity and/or participant comprehension. She pointed out that being recognized as "a person in my field" may be too distinct a construct from being recognized as an "engineering person" or a "science person" from the original instrument. Rather than adapting the measure to "field" broadly, we included the items twice, once worded specifically for engineering and the other for science. As non-STEM students will also complete this survey, participants who are not in STEM should score low on both items, as well as observing distinctions between students in engineering and science.

Data Collection and Analysis

To represent a range of undergraduate experiences in STEM, we have identified and contacted five institutions that are geographically diverse and represent several institutional types. The sample includes two R1 universities, two R2 universities, and one community college across the Pacific Northwest, Pacific Southwest, Mid-Atlantic, Southeast, and Mountain West regions. Data collection is nearly complete at two institutions, and administration with the other three will commence in Fall 2022. We plan to reach a target sample size of 1000 students nationally using random, targeted, and snowball sampling to ensure adequate representation across LGBTQ communities; currently over 400 students have accessed the survey and approximately 300 have completed. Following survey administration, we will clean the data as necessary and prepare it for analysis. Our primary analysis techniques will use statistical aggregation within each participant's network to identify percentages of people named who share characteristics with the participant (homophily) and use those variables to predict each of the three student outcomes through regression modeling. We will use ANOVA models for simple comparisons between groups by major and sexual or gender identity as well as regression models with interaction terms to test these group differences further.

Future Work

Our next work will focus on the data analysis phase. This summer we will clean and analyze the preliminary data, and we will identify venues for dissemination of our findings, including the 2023 ASEE national conference. This summer we will also commence work on the second research aim, testing whether LGBTQ students complete degrees in STEM, both as a whole and within particular STEM fields like engineering, after securing access to two national datasets which will be matched to enable longitudinal analysis. The third research aim, a qualitative phase to explore how LGBTQ students experience STEM discipline-based identity, is slated to commence in summer 2023 with the development of interview protocols. To date, the project has had national and international impact on STEM education, particularly with regard to LGBTQ inclusion in efforts to broaden participation in STEM. Both enabling LGBTQ people to fully participate in science and engineering and identifying problems facing LGBTQ communities that require the involvement of the STEM workforce to solve, will greatly expand the impact of efforts to improve LGBTQ participation in STEM.

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