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Queer and Engineer? Exploring Science and Engineering Identity among LGBTQ People

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Abstract

The purpose of this research paper is to test to see if science and engineering identity differ between students along the basis of minoritized sexual and gender identities. LGBTQ (lesbian, gay, bisexual, transgender, and queer or questioning) students are more likely to leave engineering and other STEM majors before the end of their fourth year of college, much of which is due to the hetero- and cisnormative climate they experience in STEM departments. The climate may undermine students' identification with science and engineering, affecting their motivation, belonging, and persistence in these fields.

The data for this study was collected from student surveys at four research universities nationally, with 548 students forming the analytic sample. About 56% of the sample are LGBQ (lesbian, gay, bisexual, or queer), 16% TGNC (transgender, gender nonconforming, or nonbinary), and 65% are in a STEM major. Students completed a two-part survey which encompassed data about their social networks and their college experiences. The data for this analysis were drawn from the section on students' college experiences, which included an adaptation of Godwin's engineering identity measures to assess students' interest in their chosen field of study, students' assessment of their competence and performance in their courses, and students' perceptions of being recognized as a science person and as an engineering person. Demographic data on sexual identity, gender identity, and major were used to test comparisons. ANOVA and regression modeling were used to test group differences.

For the most part, few differences were observed between groups regarding measures of science and engineering identity. Interest in their field of study only differed marginally by LGBQ status, with LGBQ students scoring slightly higher than heterosexual students. Perceptions of competence and performance in their field of study differed only by STEM major, with STEM students scoring slightly lower, suggesting some potential degree of insecurity among STEM students regarding their academic performance. Recognition as a science person only differed by STEM major as STEM students reported much higher recognition than their non-STEM peers. Recognition as an engineering person also differed by STEM major similar to recognition as a science person, but to a somewhat lesser degree; however, LGBQ students also reported being less likely to be recognized as an engineering person as well.

Taken together, if engineering and other STEM fields look to broaden participation among people from groups historically excluded from full, authentic participation, one factor is the extent to which LGBTQ people see themselves as part of these fields. The data presented here suggest to some extent that LGBTQ people score similarly to their peers on indicators of science and engineering identity, but that attention to their experiences is still warranted. As LGBTQ issues become politicized across the nation, LGBTQ individuals need safe environments in STEM fields to nurture their intrinsic motivation and pursue fulfilling careers.

1.0 Introduction

The purpose of this research paper is to test differences in science and engineering identity among students based on minoritized sexual and gender identities. LGBTQ (lesbian, gay, bisexual, transgender, and queer or questioning) students are estimated to be underrepresented by about 20% in Science, Technology, Engineering, and Mathematics (STEM) fields compared to statistical expectations [1]. They are also less likely than their heterosexual, cisgender peers to persist in STEM majors and obtain STEM degrees [2, 3]. Bias, harassment, and unsupportive environments in STEM departments contribute to these challenges, as LGBTQ students encounter more systemic hetero- and cisnormative learning and career climates than their peers [4, 5]. These climates have the potential to diminish students' identification with science and engineering, which would then inhibit their motivation, sense of belonging, and persistence in these fields [6, 7]. Even though diversity initiatives in STEM fields have been slower to tend to the inclusion of LGBTQ people [1], there are continued efforts to broaden participation in STEM, with researchers emphasizing the inclusion of LGBTQ people in these initiatives. In line with this, the White House recently released a report on the need to sample data on LGBTQ disparities, as highlighted in the Federal Evidence Agenda on LGBTQI+ Equity [8]. We align with this imperative, viewing it as a mandate to address LGBTQ equity within STEM. This commitment to data collection is important, providing a foundation for making well-informed policy decisions aimed at inclusivity.

Our study addresses the issue of potential disparities in science and engineering identity among LGBTQ students, disaggregating along the lines of sexual orientation and gender identity, especially as those experiences compare to their cisgender, heterosexual peers. We draw insights from studies that emphasize the value of acknowledging and addressing the specific needs of LGBQ and TGNC groups in STEM [9, 10]. We wonder whether the unique ways LGBTQ people navigate STEM careers and negotiate identity would lead to discernible differences in science or engineering identity that may point to a need for developing targeted interventions to enhance inclusivity and support within the learning environment. We do acknowledge that such a comparative analysis risks positioning LGBTQ students at a “deficit” relative to their peers, so we focus on our interpretations of group differences to posit systemic, rather than individual, explanations for these differences. Further, there is great within-group diversity among LGBTQ students—none of these analyses should be interpreted as uniform across student experiences; rather, the only potential “constant” in these students’ lives is the systemic heterosexism and cissexism they face in pursuing a STEM career.

2.0 Literature review

The body of research on LGBTQ students in STEM is relatively new but growing at an accelerating pace. The current research highlights many factors that contribute to disparate retention rates between LGBTQ students and their peers, as well as some insight into how LGBTQ students do or might experience science and engineering identity. The literature is also diffuse in terms of how samples of students with minoritized gender and sexual identities are constructed, and as such, our terminology may appear inconsistent throughout this section, yet it’s important to demonstrate when studies might focus on sexual orientation or gender identity specifically, especially for studies focusing on TGNC students.

2.1 LGBTQ students in STEM

LGBTQ students are more likely to leave a STEM major than their cisgender, heterosexual peers [2, 3]. From some of the earliest research on queer and trans students in STEM [11, 12] to now [9, 13], research has consistently documented the heterosexist and cissexist conditions facing LGBTQ students in STEM departments [5, 10]. LGBTQ students encounter these conditions as persistent microaggressions and discriminatory practices which lead them to conclude that the climate, while improving, remains hostile to their participation in STEM [14, 15]. Even when faculty employ practices to improve the learning environment, such as through active learning, LGBTQ students, and transgender students in particular, feel a need to surveil their environment to avoid interacting with peers who are hostile to them [16]. These experiences often spark a sense of isolation, hindering their sense of belonging in learning endeavors [17, 18]. Transgender students in engineering have even described their decision to leave engineering as a self-protection mechanism [19].

On the other hand, evidence points to the benefits of being able to be openly LGBTQ within a STEM department, such as enjoying similar research productivity rates as one's peers [20], as well as building more visible LGBTQ communities in STEM to help all LGBTQ people find a greater sense of belonging [21]. Thus, efforts to address LGBTQ issues are becoming more popular today, with researchers calling for increased visibility, inclusive policies, and allyship within STEM departments [22, 23]. The American Society for Engineering Education has in many ways led these efforts through the development of its Safe Zone program and LGBT+ Virtual Community of Practice [24]. This initiative in particular has demonstrated positive outcomes in promoting engineering educators' awareness of the needs of LGBTQ students and methods for constructing LGBTQ-inclusive learning environments. That said, little research has explored how LGBTQ students in STEM experience science and engineering identity.

2.2 Engineering and science identity

The construct of engineering or science identity was developed as a way of understanding student motivation to pursue and persist in STEM fields [25, 26]. The extent to which a student sees themselves, and is seen by others, as someone who does science or engineering, the more likely they are to identify with these fields. A stronger sense of identity with science and engineering leads to greater motivation [27], increases belonging within STEM [28], and is associated with the pursuit of a STEM career [29]. LGBTQ students unfortunately tend to experience a separation between their LGBTQ identities and their pursuit of science and engineering courses of study [9], often due to pressures to compartmentalize being queer or trans in STEM from the STEM environments in which they spend much of their days [10, 11, 30]. In other words, one would expect that LGBTQ students may feel a diminished sense of science or engineering identity relative to their peers due to these pressures to prevent integrating their multiple identities into a coherent sense of self.

Fostering science and engineering identity, particularly among underrepresented groups, is important for understanding students' experiences and pathways through STEM fields [31, 32]. Carlone and Johnson first framed science identity, from which the leading model for conceptualizing engineering identity was derived, as comprising three elements: perceived recognition by others as a scientist, belief in one’s ability to perform scientific tasks, and belief in one's competence in scientific concepts [25]. Their work emphasized the need to cultivate inclusive identity within STEM. Although the literature on engineering identity has built in a diffuse manner, encompassing sense of belonging, motivation, and the amalgamation of one's self-perception relative to the field of engineering [33], Godwin and her colleagues developed a model of engineering identity that cohered with Carlone and Johnson’s model through research on the role math and physics identities played in students’ ultimate selection of an engineering major [34, 35].

In situating LGBTQ students’ science and engineering identities, the added layers of sexual orientation and gender identity may unearth new insights into how engineering or science identity forms. The scholarly work sums up that how LGBTQ students experience science and engineering identity is influenced not only by these students’ academic aspirations, professional interests, beliefs in their abilities, and influences from those around them, but also how they maneuver through heteronormative and cisnormative cultures within STEM departments [10, 30]. Though, LGBTQ students’ successful negotiation of their science and engineering identities can foster a positive sense of self-awareness within STEM, they continually face societal discrimination and systemic barriers in this process hindering their full participation into the scientific and engineering workforce.

2.3 Theoretical framework: Engineering identity

The theoretical framework guiding this study is Godwin’s model of engineering identity [36], which was developed from a model of science identity [25], adapted to assess identity across many academic contexts. Identity represents an indication of the degree to which students recognize themselves as fitting with science and/or engineering fields. In the field of STEM education research, identity has appeared to be a widely utilized construct, providing insights on students' inherent psychological motivations to commit to degrees in these fields [26]. It has become an important framework for analyzing how individuals' multiple social identities influence their journey into, through, and out of STEM. In theorizing identity among science professionals, Carlone and Johnson conceptualized three key dimensions: recognition, performance, and competence [25]. According to these conceptualizations, science identity was characterized by the ability of a scientist to demonstrate knowledge and understanding of science content, fluency in discussing these subjects, and a belief in her ability to succeed in such subjects. Furthermore, this scientist recognized herself and was acknowledged by others as a science person.

Building on this research, Hazari et al. added interest to the constructs [37], defining interest as students’ appeal to engage in science activities and finding science to be an enjoyable activity. After quantitatively measuring these four constructs (i.e., interest, performance, competence, and recognition beliefs) through factor analysis, the four constructs reduced into three underlying constructs consisting of interest, recognition, and a combined factor of performance and competence. Because students did not respond differently to types of questions intended to measure how they believed they could perform in class and how well they could understand class content, Hazari et al. hypothesized the overlap of performance and competence beliefs into one dimension [37]. Godwin then applied and quantitatively tested an engineering identity model that measures students engineering identity in three dimensions: performance/competence in engineering subject matter, interest in engineering as a career, and recognition as an engineering person [36]. In this study, we adopt the use of these three dimensions, though adapted to encompass a variety of fields students might choose in college.

3.0 Methods

The purpose of this study is to test whether science and engineering identity differ among students along the basis of sexual orientation or gender identity. To achieve this purpose, we administered a survey at four universities nationally from spring semester 2022 through spring semester 2023 which captured data on student demographics, students' social networks, college experiences, and Godwin's measure of engineering identity, adapted for the purposes of this study. The analytic sample for this study is 548 students, of which 56% are LGBQ (lesbian, gay, bisexual, or queer) and 16% are TGNC (transgender, gender nonconforming, or nonbinary). About 65% of the sample indicated a college major in a STEM field. LGBTQ students were oversampled for this study given the focus of the overall research project on LGBTQ student participation in STEM majors.

3.1 Survey instrument

The survey itself was developed through a multi-phase process encompassing two major sections. The first section focuses on capturing information about students' social networks, and the second section collects data on students' college experiences and individual characteristics. The second part of the survey, data from which was used in this study, captured three psychological constructs known to predict retention in engineering and/or other STEM fields, a host of college experiences, and demographics about the participants themselves. The set of experiences simply asked if students had ever participated in each activity. The three constructs were taken from preexisting measures and adapted to the purposes of this study, one of which was used in this study, Godwin's measure of engineering identity [36].

The survey was then tested through cognitive interviewing and expert review [41, 42]. Cognitive interviewing consisted of meeting with people who met the study's criteria for inclusion and having them complete the survey about 2-3 items at a time, discussing their understanding of the questions and how they decided on their responses as they progressed. Cognitive interviews were performed with three college students to assess how they responded to the items. The survey was then distributed to several survey design, engineering identity, and social network analysis experts for review. A rubric was developed for them to assess each item, and their feedback was used to make further edits and refinements to the instrument. After validation was completed, the survey was entered into Qualtrics for distribution. Participants were offered a $10 gift card for completing the survey.

3.2 Variables

The primary dependent variable for this study is a measure of science and engineering identity based on Godwin's measure for engineering identity [36]. Godwin measured engineering identity across three dimensions: interest in engineering, recognition as an engineer/engineering person, and perceived performance/competence in engineering. Each of these dimensions are measured as latent variables comprising multiple indicators provided on the survey instrument. Interest encompasses three items that capture the extent to which students are interested in learning about engineering, enjoy learning about engineering, and find fulfillment in doing engineering; however, we adapted these items by replacing “engineering” with “my field” for broader applicability.

Recognition focuses on the extent to which the participant perceives that their parents (or guardian), instructors, and peers see them as an engineering person. This set of questions was asked twice—once with the phrase “engineering person” and once with “science person.” We initially wanted to adapt these items for “person in my field,” but after expert review it was determined that the items would not capture what we were hoping they would capture.

Performance/competence reflects the extent to which students perceive their own knowledge and abilities in engineering. This dimension comprises five items that capture students’ confidence in their understanding of engineering in class and out of class, that they can do well on exams, that they understand concepts in engineering, and that others ask them for help. These items were adapted from engineering to “my field” for greater applicability.

Missing data were handled using listwise deletion as, after removing cases missing much data and cases Qualtrics flagged as potentially fraudulent, only a very small number of cases were missing any data. However, this meant that there are slightly different n’s for different analyses, varying by about 2-4 cases.

Exploratory factor analysis was used to test the performance of the measures with the sample as well as develop scores for each dimension of science/engineering identity for regression analysis. All three dimensions—interest, recognition, competence/performance—were tested using EFA and a reliability coefficient to determine that the measures performed well with the sample, and all analyses confirmed the measures performed well. The factor loadings were then used to develop weighted sums for each identity dimension so that those variables with higher factor loadings contribute more to the score than items with lower factor loadings. EFA results are reported in the following table. Bear in mind that recognition was measured twice, so our results show four factors even though the model comprises three dimensions.

Table 1: Exploratory Factor Analysis for Identity construct

Survey Item	Factor Loading 1	2	3	4
Factor 1: Performance/competence (α=.86)				
I am confident that I can understand my field outside of class.	**0.75**	0.05	-0.03	-0.02
I am confident I can understand my field's subject matter in class.	**0.83**	0.00	-0.02	0.01
I can do well on exams in my field.	**0.79**	-0.02	-0.04	0.02
I understand concepts I have studied in my field.	**0.77**	0.06	0.04	0.00
Others ask me for help in my field.	**0.57**	-0.03	0.07	0.00
Factor 2: Interest (α=.91)				
I am interested in learning more about my field.	-0.04	**0.90**	-0.01	0.01
I enjoy learning my field.	0.06	**0.87**	0.00	0.00
I find fulfillment in doing work in my field.	0.05	**0.80**	0.03	-0.02
Factor 3: Recognition as a science person (α=.93)				
My parent(s) or guardian see me as a science person.	-0.06	0.05	**0.85**	0.02
My instructors see me as a science person.	0.03	-0.01	**0.89**	0.00
My peers see me as a science person.	0.01	-0.03	**0.92**	0.00
Factor 4: Recognition as an engineering person (α=.95)				
My parent(s) or guardian see me as an engineering person.	-0.02	0.02	0.03	**0.88**
My instructors see me as an engineering person.	0.00	0.01	-0.01	**0.95**
My peers see me as an engineering person.	0.02	-0.03	0.00	**0.92**

Note: N=544; method was principal axis factoring with promax (oblique) rotation

4.0 Results

The purpose of this study was to test whether science and engineering identity differ between students on the basis of sexual orientation and gender identity. We first ran bivariate tests (t-tests) to see if the values of our four dependent variables differed by LGBQ status, TGNC status, and STEM major. We then ran a multivariate regression to test all of these three independent variables together, controlling for a set of college experiences known to relate to science and engineering identity.

The first four t-tests compared the four dependent variables—interest, recognition as a scientist, recognition as an engineer, and performance/competence—by whether students are STEM majors. T-test results are presented in the following table. Keep in mind that interest and performance/competence were adapted to accommodate any field. Of the four variables, only one was not significant. Interest in one's field did not differ significantly between the two groups. The largest significant difference was recognition as a science person, with STEM students reporting a nearly 4-point higher average on this variable than non-STEM students. The difference for average recognition as an engineering person was about 2.5 points. Performance/competence also differed significantly, by about a half a point, though it was non-STEM students reporting higher performance/competence in their fields than STEM students.

Table 2: T-test comparison by STEM Major

Parameter	M	SD	M	SD	t	p
	STEM major		Non-STEM			
Interest	11.690	0.093	11.429	0.179	1.43	0.15
Performance/competence	15.769	0.132	16.324	0.182	-2.49	0.01
Recognition as science person	11.244	0.104	7.498	0.246	16.26	<.001
Recognition as engineering person	7.302	0.207	4.834	0.195	7.84	<.001
	LGBQ student		Heterosexual			
Interest	11.751	0.108	11.404	0.148	1.94	0.05
Performance/competence	16.033	0.133	15.936	0.178	1.14	0.65
Recognition as science person	10.034	0.179	9.721	0.210	0.45	0.26
Recognition as engineering person	6.114	0.204	6.826	0.256	-2.20	0.03
	TGNC student		Cisgender			
Interest	11.723	0.193	11.575	0.098	0.63	0.53
Performance/competence	15.879	0.281	15.986	0.116	-0.37	0.71
Recognition as science person	9.782	0.325	9.942	0.147	-0.44	0.66
Recognition as engineering person	5.941	0.378	6.542	0.175	-1.41	0.16

When disaggregated by LGBQ status, one difference was significant and one was incredibly close to being significant (p=.053) that we'll comment on it here. The one difference that was significant was recognition as an engineering person—heterosexual students were about 0.7 points, on average, more likely to report being seen as an engineering person. On the other hand, LGBQ students were about 0.4 points, on average, more likely to report interest in their chosen field of study—though a marginally significant difference. The other two variables were not significant. None of the four variables differed significantly for TGNC students.

These patterns generally held up in our multivariate models as well, as seen in the next table. Overall, the models for recognition as a scientist or engineer were a better fit to the data than interest or performance/competence, and much of the reason was the two former variables differed a great deal between STEM and non-STEM students whereas the other two did not. We first ran a multivariate model predicting the four dependent variables with just STEM, LGBQ status, and TGNC status as predictors. LGBQ status was marginally related to interest and significantly predicted recognition as an engineering person, and STEM major significantly predicted all of the dependent variables except interest. This model provides a baseline for interpreting the results of the full model, Model 2.

Table 3: Multivariate Analysis

	Interest			Rec as Sci Person			Rec as Eng Pers			Perf/ Comp		
Model 1	B	SE	sig	B	SE	sig	B	SE	sig	B	SE	sig
Constant	11.265	0.178	***	7.444	0.225	***	5.209	0.303	***	16.294	0.214	***
STEM major	0.212	0.188		3.731	0.237	***	2.635	0.318	***	-0.626	0.225	**
LGBQ status	0.346	0.192	+	0.134	0.243		-0.751	0.327	*	0.189	0.231	
TGNC status	0.015	0.258		-0.160	0.325		-0.274	0.438		-0.115	0.310	
Model 2												
Constant	10.633	0.624	***	5.054	0.772	***	5.999	1.020	***	15.108	0.739	***
STEM major	0.205	0.205		3.511	0.253	***	2.821	0.334	***	-0.655	0.242	**
LGBQ status	0.344	0.206	+	0.048	0.255		-0.988	0.337	**	0.263	0.244	
TGNC status	0.031	0.272		-0.211	0.336		-0.200	0.444		0.013	0.322	
Undergraduate Research	0.132	0.200		0.416	0.248	+	-0.329	0.327		0.003	0.237	
Conference	0.158	0.220		-0.006	0.273		0.798	0.360	*	0.160	0.261	
oSTEM membership	-0.195	0.335		0.163	0.414		0.045	0.547		-0.369	0.396	
LGBTQ organication	0.111	0.283		0.156	0.350		0.033	0.462		-0.247	0.335	
Major-related club	-0.027	0.202		0.232	0.249		0.911	0.330	**	0.131	0.239	
Other club or organization	-0.004	0.204		0.056	0.252		0.035	0.333		0.263	0.242	
Premedical major	0.203	0.239		0.719	0.295	*	-1.862	0.390	***	0.325	0.283	
Second-year student (ref: first-year)	0.107	0.276		0.582	0.341	+	-0.557	0.451		0.578	0.327	+
Third-year	0.050	0.273		0.019	0.338		-0.810	0.446	+	0.554	0.323	+
Fourth-year	0.409	0.299		0.894	0.370	*	-1.018	0.489	*	1.212	0.354	**
Fifth-year or more	0.213	0.483		0.697	0.597		-1.323	0.789	+	0.993	0.572	+

Note: *** p<.001, ** p<.01, * p<.05, + p<.1

We then ran a model with all our control variables as well. The model predicting recognition as a science person was the best fit for the data, with an r-squared of .3488 and a significant F-test (p<.001), followed by recognition as an engineering person (r-squared=.187, p<.001), and performance/competence (r-squared=.0489, p<.05). The model predicting interest was a poor fit (r-squared=.019, p=.77). No variable in the interest model was significant, with LGBQ status as the only marginally significant predictor (b=0.344, p<.1).

STEM major significantly predicted recognition as a science person (b=3.51, p<.001) and as an engineering person (b=2.82, p<.001) as well as performance/competence (b=-0.65, p<.01). Another variable with similar consistency was year in school: specifically, relative to first-year students, being in the fourth year of school predicted recognition as a science person (b=0.89, p<.05), recognition as an engineering person (b=-1.02, p<.05), and performance/competence (b=1.21, p<.01). One variable was significant in both the recognition models; being a premed major significantly predicted being recognized as a science person (b=0.72, p<.05) and an engineering person (b=-1.86, p<.001).

One variable long connected to science identity was only marginally significant in the recognition as a science person model; having participated in undergraduate research marginally predicted being recognized as a science person (b=0.42, p<.1). Three variables were only significant in the recognition as an engineering person model. LGBQ status (b=-0.99, p<.01), having attended a conference (b=0.80, p<.05), and membership in a major-related club or organization (b=0.91, p<.01) all significantly predicted being recognized by others as an engineering person. Year in school had several marginal effects across the four models, generally reflecting differences between first-year students and students in other years of school.

5.0 Discussion

The purpose of this study was to test differences in science and engineering identity by sexual orientation and gender identity. No differences were observed based on LGBQ or TGNC status in any of the four dependent variables, except for perceived recognition as an engineering person. In both models, LGBQ students on average reported perceiving less recognition as an engineering person than their heterosexual peers. For the most part, we interpret this as reflecting a higher likelihood that LGBQ students in STEM tend to be in the biological sciences rather than in engineering [43, 44]. STEM fields that tend to enroll more women seem to be more open to diversity than other STEM fields, and the aforementioned studies show enrollment of LGBTQ students can mirror that of women in STEM as a result. We are also heartened by the general lack of significant differences along the lines of LGBQ and TGNC status in how these reflect intrinsic factors predicting selection of and persistence in a STEM career. Disparate experiences between students with minoritized gender and sexual identities and their cisgender, heterosexual peers led us to anticipate that LGBTQ students would also experience "less" science and engineering identity [45, 46], but that hypothesis did not hold with this sample.

The most consistent predictor across the models is being a STEM major. In terms of being recognized as both a science and an engineering person, this difference makes absolute sense. It was surprising to see that STEM students' perceived competence and performance with their subject matter was lower than that of their non-STEM peers, but given students often perceive STEM topics to be more difficult, this difference may reflect a difference in confidence between STEM and non-STEM students. These effects for STEM majors were consistent across both models for the three dependent variables for which this coefficient was significant. Another consistent predictor was fourth-year status, using first-year status as a reference category. Fourth-year students reported a higher perception of their performance and competence in their field, higher perceived recognition as a science person, and lower perceived recognition as an engineering person. The performance/competence difference makes sense in that students with a stronger sense of science and engineering identity are more likely to persist in their majors [6, 47, 48]. The lower perceived recognition as an engineer is interesting; there are somewhat fewer fourth-year engineering students compared to first-year students (14 of 113 compared to 19 of 111), but this difference could also reflect some change in confidence in becoming an engineer as well.

Students who indicated being premedical students reported a difference in their perceived recognition as a science or engineering person. On the one hand, they perceive being more likely than their peers to be recognized as a science person, and, on the other hand, they perceive being less likely to be recognized as an engineering person. Although there are engineering fields that are associated with the health sciences, such as biomedical engineering, it doesn't seem surprising that many premedical students would not perceive themselves to be engineering students. Two variables were significant in predicting being recognized as an engineering person that were not significant in other models. Students who were members of a major-related club or organization and students who had attended a conference during college both perceived being more likely to be recognized as an engineering person. The former makes a lot of sense as student chapters of engineering professional societies abound for engineering students to network and learn more about their planned profession [49]. The latter is likely tied to these organizations in that students often travel with their campus chapters to conferences. We were a little surprised that this variable was not also significant for recognition as a science person, but undergraduate research was also in the model and was a marginally significant predictor. Presenting undergraduate research would be the primary reason many STEM students attend conferences [50-52].

5.1 Limitations

These data are limited in important ways that a reader should take into account when interpreting the study results and transferring findings to other settings. First, the survey dataset itself is a cross-sectional dataset, meaning that all data were captured at one point in time. Relationships among variables are only guaranteed to be correlational and not causal in nature, though prior research and theory may provide some evidence for cautiously interpreting some correlations as causal in nature. Second, we wanted to acknowledge our decision not to disaggregate engineering majors from other STEM majors given this audience; given our focus on LGBTQ communities, we were concerned disaggregating further than STEM/non-STEM may lead to smaller subsample sizes that would limit our statistical analyses. We will explore statistical power when we have fully completed data collection. That said, the item regarding premedical students is separate from major and helps offer insight into the competitiveness in STEM learning environments. Third, even though the data were collected from a group of institutions that were geographically diverse, each institution is not representative of the region in which it is located and all four are large, research universities. We have a diverse array of students represented in the dataset, but there will be other ways our sample is not representative of the broader universe of college students. These results may reflect broader patterns in higher education nationally, but the construction of our sample does not allow us to definitively conclude so. Finally, these data are only as accurate as our participants were able to, or willing to, be in completing the survey. Sure, social desirability bias is a minor looming threat to this study just like most social science research, but generally speaking we anticipate that any desirability bias or inaccuracies should not threaten the kinds of statistical tests we are running as we are not making claims based on the actual magnitudes of the parameters but rather the relative direction of the results from 0 or within-sample comparisons.

5.2 Implications for research

The results of this study open several avenues for future research to further explore how LGBTQ students experience science and engineering identity relative to their cisgender, heterosexual peers. First, as prior research has shown that LGBTQ students are more likely to select a non-STEM major [44], and, within STEM, more likely to select majors in the biological sciences [43], what implications does this have for how they experience science and/or engineering identity? How do they experience these before college and how do those experiences influence their decision about which major to enter in college? This study was unable to test for differences in interest in science and engineering specifically, as the variables were adapted for applicability across multiple fields; future research could examine how LGBTQ students make decisions about their majors and how minoritization may play a role in that process.

Second, with few significant differences between LGBTQ students and their peers on all four dependent variables, we are led to wonder if the differences then are more qualitative in nature than quantitative. If LGBTQ students experience a very different climate in STEM fields than their peers [14, 53], those experiences must shape their science and engineering identities. If we can't detect these differences quantitatively, perhaps the true differences are in how they make meaning of their experiences. Perhaps they have different reasons for choosing STEM than their peers, which would be like women and racial minorities [47], and their experiences of minoritization in STEM spaces may also shape their trajectories through STEM in terms of their eventual career aspirations upon graduation. Further, many LGBTQ students in STEM are also women and/or students of color, and qualitative inquiry could explore how these identities intersect with each other as well as what factors are more, or less, salient in making sense of their place in STEM. Qualitative research on how LGBTQ students experience science and engineering identities could unveil many of these differences and explore how they influence students' pathways into (or out of) STEM careers.

5.3 Implications for practice

In terms of what these results may mean for engineering educators, one fortunate result is that we observed few differences between LGBTQ students and their peers on science and engineering identity. Engineering educators thus should not presume that LGBTQ students are less interested in STEM subjects, nor do they perceive their ability to understand and engage with content in their fields to be lower than their peers. Any differences in their outcomes in STEM are more likely a result of an unwelcoming learning or laboratory environment, and resources are available to educators to help make these spaces more inclusive [24]. Availing oneself of these resources will provide additional tools to create a learning environment in which all students are enabled to succeed.

We also noted the two significant findings for engineering identity specifically for conference attendance and major-related clubs and organizations. Although the sample was broader than engineering students, these two experiences are common within engineering departments as essential components of the professional formation process. Although our data more or less indicate only that people who participate in these experiences are, on average, more likely to perceive that their instructors, parents, and peers perceive them as engineering people, this perception is essential to forming an engineering identity that we expect would motivate a student to persist in their studies and continue into an engineering career [6, 54]. Engaging in these activities provides the anticipatory socialization that would enable professional formation as engineers that engineering departments strive to achieve. And, although we did not engage in the series of interaction term testing that would offer more insight into whether LGBTQ students' access to these experiences relate to science and engineering identity, engineering educators should remain observant to whether all students have full, equitable access to opportunities that will aid them in reaching their STEM professional goals.

6.0 Conclusion

LGBTQ students are less likely to persist in STEM majors than their peers [2, 3], yet their contributions are needed to meet national calls to broaden participation in STEM fields. In this study, we tested whether differences in science and engineering identity may be contributing to this problem, hypothesizing that LGBTQ students may be less likely to persist in STEM due to a hostile climate and experiences of bias that might erode their science and engineering identities. In general, we found few differences between LGBTQ students and their peers on several measures of dimensions of science and engineering identity, leading us to conclude that their decision to leave rests far more on looking for supportive environments and not that these experiences have diminished their deeper interest in and motivation to learn STEM concepts. Perhaps these students never lose their identification with these fields, but rather find other productive and beneficial ways to put their talents to use in society.

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References

[1] J. B. Freeman, "Measuring and resolving LGBTQ disparities in STEM," *Policy Insights from the Behavioral and Brain Sciences,* vol. 7, no. 2, pp. 141-148, 2020, doi: 10.1177/2372732220943232.

[2] J. Maloy, M. B. Kwapisz, and B. E. Hughes, "Factors influencing retention of transgender and gender nonconforming students in undergraduate STEM majors," *CBE—Life Sciences Education,* vol. 21, no. 1, 2022, doi: 10.1187/cbe.21-05-0136.

[3] B. E. Hughes, "Coming out in STEM: Factors affecting retention of sexual minority STEM students," *Science Advances,* vol. 4, no. 3, 2018, doi: 10.1126/sciadv.aao6373.

[4] A. M. A. Casper, R. A. Atadero, and L. C. Fuselier, "Revealing the queer-spectrum in STEM through robust demographic data collection in undergraduate engineering and computer science courses at four institutions," *Plos One,* vol. 17, no. 3, 2022, doi: 10.1371/journal.pone.0264267.

[5] E. A. Cech and T. J. Waidzunas, "Systemic inequalities for LGBTQ professionals in STEM," *Science Advances,* vol. 7, no. 3, 2021, doi: 10.1126/sciadv.abe0933.

[6] B. E. Hughes, W. J. Schell, B. Tallman, R. Beigel, E. Annand, and M. Kwapisz, "Do I Think I'm an Engineer? Understanding the Impact of Engineering Identity on Retention," in *ASEE Annual Conference and Exposition*, Tampa, Florida, 2019/06/15 2019: ASEE Conferences. [Online]. Available: https://peer.asee.org/32674. [Online]. Available: https://peer.asee.org/32674

[7] B. E. Hughes and S. Kothari, "Don't be too political: Depoliticization, sexual orientation, and undergraduate STEM major persistence," *J. Homosex.,* vol. 70, no. 4, pp. 632-659, 2023, doi: 10.1080/00918369.2021.1996101.

[8] Executive Office of the President. (2023). *Federal evidence agenda on LGBTQI+ equity*. [Online] Available: https://www.whitehouse.gov/wp-content/uploads/2023/01/Federal-Evidence-Agenda-on-LGBTQI-Equity.pdf

[9] E. Kersey and M. Voigt, "Finding community and overcoming barriers: Experiences of queer and transgender postsecondary students in mathematics and other STEM fields," *Mathematics Education Research Journal,* 2020, doi: 10.1007/s13394-020-00356-5.

[10] A. Mattheis, D. C.-R. De Arellano, and J. B. Yoder, "A model of queer STEM identity in the workplace," *J. Homosex.,* pp. 1-25, 2019, doi: 10.1080/00918369.2019.1610632.

[11] E. A. Cech and T. J. Waidzunas, "Navigating the heteronormativity of engineering: The experiences of lesbian, gay, and bisexual students," *Eng. Studies,* vol. 3, no. 1, pp. 1-24, 2011/04// 2011, doi: 10.1080/19378629.2010.545065.

[12] D. Bilimoria and A. J. Stewart, ""Don't Ask, Don't Tell": The academic climate for lesbian, gay, bisexual, and transgender faculty in science and engineering," *NWSA Journal,* vol. 21, no. 2, pp. 85-103, 2009 2009. [Online]. Available: http://muse.jhu.edu/journals/nwsa_journal/v021/21.2.bilimoria.html.

[13] M. Jennings, R. Roscoe, N. Kellam, and S. Jayasuriya, "A Review of the State of LGBTQIA+ Student Research in STEM and Engineering Education," presented at the 2020 ASEE Virtual Annual Conference Content Access Proceedings, 2020.

[14] T. J. Atherton *et al.*, "LGBT climate in physics: Building an inclusive community," American Physical Society website, 2016. [Online]. Available: https://www.aps.org/programs/lgbt/upload/LGBTClimateinPhysicsReport.pdf

[15] T. D. Forbes, "Queer-free majors?: LGBTQ + college students' accounts of chilly and warm academic disciplines," *Journal of LGBT Youth,* pp. 1-20, 2020, doi: 10.1080/19361653.2020.1813673.

[16] K. M. Cooper and S. E. Brownell, "Coming out in class: Challenges and benefits of active learning in a biology classroom for LGBTQIA students," *CBE—Life Sciences Education,* vol. 15, no. 3, 2016, doi: 10.1187/cbe.16-01-0074.

[17] J. B. Yoder and A. Mattheis, "Queer in STEM: Workplace experiences reported in a national survey of LGBTQA individuals in science, technology, engineering, and mathematics careers," *J. Homosex.,* vol. 63, no. 1, pp. 1-27, 2016, doi: 10.1080/00918369.2015.1078632.

[18] J. G. Stout and H. M. Wright, "Lesbian, Gay, Bisexual, Transgender, and Queer Students' Sense of Belonging in Computing: An Intersectional Approach," *Comp. Sci. Eng.,* vol. 18, no. 3, pp. 24-30, 2016, doi: 10.1109/mcse.2016.45.

[19] A. E. Haverkamp, A. Butler, N. S. Pelzl, M. K. Bothwell, D. Montfort, and Q.-L. Driskill, "Exploring transgender and gender nonconforming engineering undergraduate experiences through autoethnography," in *ASEE Annual Conference and Exposition*, Tampa, FL, June 2019.

[20] J. Nelson, A. Mattheis, and J. B. Yoder, "Nondisclosure of queer identities is associated with reduced scholarly publication rates," *Plos One,* vol. 17, no. 3, 2022, doi: 10.1371/journal.pone.0263728.

[21] M. C. Sinton, K. N. Baines, K. A. Thornalley, V. Ilangovan, and M. Kurt, "Increasing the visibility of LGBTQ+ researchers in STEM," *The Lancet,* vol. 397, no. 10269, pp. 77-79, 2021, doi: 10.1016/s0140-6736(20)32626-x.

[22] J. J. Coon *et al.*, "Best practices for LGBTQ+ inclusion during ecological fieldwork: Considering safety, cis/heteronormativity and structural barriers," *Journal of Applied Ecology,* vol. 60, no. 3, pp. 393-399, 2023, doi: 10.1111/1365-2664.14339.
[23] N. Alexander *et al.* (2022). Increasing inclusion & competency in STEM: Understanding LGBTQ+ history, barriers, and heteronormativity. Available: https://doi.org/10.32942/osf.io/d38va
[24] S. Farrell, R. C. C. Guerra, R. Chavela Guerra, R. Tsanov, E. A. Cech, and T. J. Waidzunas, "ASEE Safe Zone workshops and Virtual Community of Practice to promote LGBTQ equality in engineering," in *2017 ASEE Annual Conference & Exposition*, Columbus, OH, 2017.
[25] H. B. Carlone and A. C. Johnson, "Understanding the science experiences of successful women of color: Science identity as an analytic lens," *J. Res. Sci. Teach.,* vol. 44, no. 8, pp. 1187-1218, 2007, doi: 10.1002/tea.20237.
[26] K. L. Tonso, "Engineering Identity," in *Cambridge handbook of engineering education research*, A. Johri and B. M. Olds Eds., A. Johri and B. M. Olds, Eds.: Cambridge University Press, 2014, ch. 14, pp. 267-282.
[27] D. Oyserman, *Pathways to success through identity-based motivation*. New York: Oxford University Press, 2015, pp. xiv, 295 pages.
[28] R. Stevens, K. O'Connor, L. Garrison, A. Jocuns, and D. M. Amos, "Becoming an engineer: Toward a three dimensional view of engineering learning," *Journal of Engineering Education,* vol. 97, no. 3, pp. 355-368, 2008.
[29] K. L. Meyers, M. W. Ohland, and S. E. Silliman, "How self-identification and views of engineering change with time: A study of students and professionals," (in English), *International Journal of Engineering Education,* vol. 28, no. 1, pp. 103-112, 2012 2012.
[30] B. E. Hughes, ""Managing by not managing": How gay engineering students manage sexual orientation," *J. Coll. Stud. Dev.,* vol. 58, no. 3, pp. 385-401, 2017, doi: 10.1353/csd.2017.0029.
[31] K. Atkins, B. M. Dougan, M. S. Dromgold-Sermen, H. Potter, V. Sathy, and A. T. Panter, "“Looking at Myself in the Future”: how mentoring shapes scientific identity for STEM students from underrepresented groups," *International Journal of STEM Education,* vol. 7, no. 1, 2020, doi: 10.1186/s40594-020-00242-3.
[32] D. M. Sparks, "Navigating STEM-worlds," *Journal for Multicultural Education,* vol. 11, no. 3, pp. 162-175, 2017, doi: 10.1108/jme-12-2015-0049.
[33] J. R. Morelock, "A systematic literature review of engineering identity: definitions, factors, and interventions affecting development, and means of measurement," *European Journal of Engineering Education,* vol. 42, no. 6, pp. 1240-1262, 2017, doi: 10.1080/03043797.2017.1287664.
[34] A. Godwin, G. Potvin, Z. Hazari, and R. Lock, "Identity, critical agency, and engineering: An affective model for predicting engineering as a career choice," *Journal of Engineering Education,* vol. 105, no. 2, pp. 312-340, 2016, doi: 10.1002/jee.20118.
[35] A. Godwin, G. Potvin, Z. Hazari, and R. Lock, "Understanding engineering identity through structural equation modeling," presented at the 2013 IEEE Frontiers in Education Conference (FIE), 2013.
[36] A. Godwin, "The development of a measure of engineering identity," presented at the ASEE Annual Conference and Exposition, New Orleans, Louisiana, June 26, 2016. [Online]. Available: https://peer.asee.org/26122.

[37] Z. Hazari, G. Sonnert, P. M. Sadler, and M.-C. Shanahan, "Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study," *J. Res. Sci. Teach.,* pp. n/a-n/a, 2010, doi: 10.1002/tea.20363.

[38] C. McCarty, M. J. Lubbers, R. Vacca, and J. L. Molina, *Conducting personal network research: A practical guide* (Methodology in the social sciences). New York, NY: The Guilford Press, 2019, p. pages cm.

[39] S. Hurtado and D. F. Carter, "Effects of college transition and perceptions of the campus racial climate on Latino college students' sense of belonging," *Sociology of Education,* vol. 70, no. 4, pp. 324-345, 1997, doi: 10.2307/2673270.

[40] W. B. Davidson, H. P. Beck, and M. Milligan, "The College Persistence Questionnaire: Development and validation of an instrument that predicts student attrition," *J. Coll. Stud. Dev.,* vol. 50, no. 4, pp. 373-390, 2009, doi: 10.1353/csd.0.0079.

[41] P. C. Beatty and G. B. Willis, "Research synthesis: The practice of cognitive interviewing," *Public Opinion Quarterly,* vol. 71, no. 2, pp. 287-311, 2007, doi: 10.1093/poq/nfm006.

[42] K. Olson, "An examination of questionnaire evaluation by expert reviewers," *Field Methods,* vol. 22, no. 4, pp. 295-318, 2010, doi: 10.1177/1525822x10379795.

[43] D. Sansone and C. S. Carpenter, "Turing's children: Representation of sexual minorities in STEM," *Plos One,* vol. 15, no. 11, 2020, doi: 10.1371/journal.pone.0241596.

[44] M. Greathouse, A. BrckaLorenz, M. Hoban, R. Huesman, S. Rankin, and E. B. Stolzenberg, "Queer-spectrum and trans-spectrum student experiences in American higher education: The analyses of national survey findings," Rutgers University, Newark, NJ, 2018.

[45] J. L. Linley, K. A. Renn, and M. R. Woodford, "Examining the ecological systems of LGBTQ STEM majors," *J. Women Minor. Sci. Eng.,* vol. 24, no. 1, pp. 1-16, 2018, doi: 10.1615/JWomenMinorScienEng.2017018836.

[46] E. A. Cech and W. R. Rothwell, "LGBTQ Inequality in Engineering Education," *Journal of Engineering Education,* vol. 107, no. 4, pp. 583-610, 2018, doi: 10.1002/jee.20239.

[47] S. Chen *et al.*, "Am I a science person? A strong science identity bolsters minority students' sense of belonging and performance in college," *Personality and Social Psychology Bulletin,* 2020, doi: 10.1177/0146167220936480.

[48] M. J. Chang, J. Sharkness, S. Hurtado, and C. B. Newman, "What matters in college for retaining aspiring scientists and engineers from underrepresented racial groups," (in en), *J. Res. Sci. Teach.,* vol. 51, no. 5, pp. 555-580, 2014 2014, doi: 10.1002/tea.21146.

[49] C. M. Hinkle and M. D. Koretsky, "Toward professional practice: student learning opportunities through participation in engineering clubs," *European Journal of Engineering Education,* vol. 44, no. 6, pp. 906-922, 2018, doi: 10.1080/03043797.2018.1477119.

[50] J. J. Thompson, D. Jensen-Ryan, and J. Schinske, "Becoming a "Science Person": Faculty Recognition and the Development of Cultural Capital in the Context of Undergraduate Biology Research," *CBE—Life Sciences Education,* vol. 17, no. 4, 2018, doi: 10.1187/cbe.17-11-0229.

[51] K. Boudreau, D. DiBiasio, and Z. Reidinger, "Vignette: Undergraduate research and the difference It makes for LGBTQ+ students," *C. Underg. Res. Quart.,* vol. 1, no. 4, pp. 46-46, 2018, doi: 10.18833/spur/1/4/1.

[52] E. National Academies of Sciences, and Medicine,, *Undergraduate research experiences for STEM students: Successes, challenges, and opportunities*. Washington, DC: The National Academies Press (in English), 2017, p. 278.

[53] R. A. Miller, A. Vaccaro, E. W. Kimball, and R. Forester, "“It’s dude culture”: Students with minoritized identities of sexuality and/or gender navigating STEM majors," *Journal of Diversity in Higher Education,* vol. Advance online publication, 2020, doi: 10.1037/dhe0000171.

[54] M. K. Eagan, S. Hurtado, T. Figueroa, and B. Hughes, "Examining STEM pathways among students who begin college at four-year institutions [Commissioned Paper]," National Academy of Sciences, Washington, DC, 2014.

Appendix

Variables and Coding

Construct/ Variable	Parameter	Items	Scale	Reliability (alpha)
Science /Engineering identity. (Godwin et.al, 2016)	Performance /competence	I am confident that i can understand my field outside of class	1 = strongly disagree; 2 = disagree; 3 = agree; 4 = strongly agree	.86
		I am confident I can understand my fields subject in class		
		I can do well on exams in my field		
		I understand concepts i have studied in my field		
		Others ask me for help in my field		
	Interest	I am interested in learning more about my field	1 = strongly disagree; 2 = disagree; 3 = agree; 4 = strongly agree	.91
		I enjoy learning my field		
		I find fulfilment in doing work in my field		
	Recognition as science person	My parent(s) or Guardian see me as a science person	1 = strongly disagree; 2 = disagree; 3 = agree; 4 = strongly agree	.93
		My instructors see me as a science person		
		My peers see me as a science person		
	Recognition as engineering person	My parent(s) or Guardian see me as an engineering person	1 = strongly disagree; 2 = disagree; 3 = agree; 4 = strongly agree	.95
		My instructors see me as an engineering person		
		My peers see me as an engineering person		

Major	STEM =1	Biological science Engineering Mathematics and computer science Health professions Physical science	
	Non-STEM = 0	Business Education Arts and humanities Communications Social science	
Sexual orientation	LGBQ = 1	Asexual or ace spectrum Bisexual or pansexual Gay or lesbian Queer Questioning	
	Heterosexual = 0		
Gender identity	TGNC = 1	Agender Nonbinary Genderqueer Gender nonconforming Man (transgender) Woman (transgender) Questioning Transgender	
	Cisgender = 0	Man (not transgender) Woman (not transgender)	
Undergraduate research	1= Yes 0= No		
Conference attendance			
OSTEM membership			
LGBTQ organization			

Major related club		
Other clubs and organization		
Premedical major		
Year in school	1= First year, 2= second year, 3= third year 4= fourth and 5=fifth year and more	