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Don't be too Political: Depoliticization, Sexual Orientation, and Undergraduate STEM Major Persistence

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Abstract

Lesbian, gay, bisexual, and queer (LGBQ) students persist in STEM majors at a lower rate than their heterosexual peers. This study posits that heteronormativity, as an instance of depoliticization in STEM affecting LGBQ students, could be a primary contributing factor. Using national, longitudinal data from the Higher Education Research Institute (HERI) at UCLA, this study tested LGBQ-related college experiences to determine if they help explain the retention gap between LGBQ STEM students and their heterosexual peers. Through multilevel regression modeling, we found that LGBQ status is not a significant predictor of retention in STEM after controlling for LGBQ-related experiences. The results suggest that LGBQ-related and other politicized experiences predict lower retention in STEM for heterosexual students, meaning a culture of depoliticization in STEM may be detrimental to more students than those in minoritized social identity groups.

Keywords: academic persistence, STEM education, sexual minority groups, college students, college environment, student research, women's studies, gay-straight alliances, campus climate, depoliticization

Introduction

National reports express concern regarding the adequacy of the STEM workforce to sustain innovation enterprise, global competitiveness, and national security in the United States (National Research Council, 2010; Xue & Larson, 2015). The President's Council of Advisors on Science and Technology (2012) indicated that over the next decade, given current trends, the United States will need to produce more than 1 million additional college graduates in STEM above current levels of productivity. The report indicates that the quickest path to this goal involves addressing inequities in retention among students from groups most underserved by STEM fields. As a robust STEM workforce is critical to maintaining the nation's economically competitive position in the world, graduating more students in STEM has become a national concern.

Researchers and policy experts have long established the structural factors impeding the full participation of women and racially minoritized people in STEM fields (Chang, Sharkness, Hurtado, & Newman, 2014; Ong, Wright, Espinosa, & Orfield, 2011). An emerging body of literature focused on the experiences of LGBQ (lesbian, gay, bisexual, and queer) individuals, as well as people who identify as trans, gender non-conforming, and nonbinary (often abbreviated as TGNC), also face inequitable conditions hindering their full participation in STEM. This research shows that LGBQ people face discrimination in STEM workplaces (Barthelemy, 2020; Cech & Rothwell, 2019; Yoder & Mattheis, 2016), and within their undergraduate programs (Cech & Waidzunas, 2011; Cooper & Brownell, 2016). These conditions have led to a marked disparity between heterosexual students and their sexual minority peers in terms of persisting within STEM undergraduate degree programs (Hughes, 2018), despite prior academic preparation, interest in STEM as a career, and participation in programs like undergraduate research shown to promote retention in STEM.

The purpose of this study is to identify differences between heterosexual and sexual minority students with respect to factors that predict retention in STEM. In particular, this study builds on that by Hughes (2018) by focusing on experiences that reveal the effects of depoliticization and heterosexism on LGBQ STEM student retention. Previous results showed that prior academic preparation and taking advantage of STEM-related opportunities did not influence the inequity in persistence between these groups of students; this study hypothesizes a separate set of experiences may reveal the more pernicious effects of a separate set of influences.

This paper is focused on sexual orientation, and the initialism LGBQ, referring to lesbian, gay, bisexual, and queer, is generally used throughout. That said, other forms of the initialism are used throughout the paper in reference to other work that defined study participants differently. References to other work will use the initialism used by the authors of those studies. Transgender, gender non-conforming, and gender nonbinary (TGNC) students are likely included in this study, but the dataset does not include a full accounting of gender identity for us to adequately disaggregate students who hold these identities. Further, studies that conflate gender identity with sexual identity tend to dilute TGNC student voices as they are typically a much smaller proportion of the overall LGBTQ community. TGNC students who may be part of this sample would be categorized with their sexual identity group.

Theoretical Framework

STEM fields are replete with heterosexism and heteronormativity in a manner that would likely cause LGBQ people to reconsider their position within these fields. On the surface, these fields appear to be separate from personal experiences such as sexual orientation given their commitment to ideals of objectivity and meritocracy in the process by which science and engineering is carried out (Cech & Sherick, 2015). In other words, it should not matter who performs the science or solves the engineering problem as long as appropriate procedures are carried out thoroughly, carefully, and precisely. Yet when markers of difference, such as the disclosure of a nonheterosexual identity, are unveiled, the response is not uniformly benign (Riley, 2013). Assumptions of heterosexism and heteronormativity are deeply embedded within the culture of STEM that most members of these fields could not readily identify how these influences operate.

First, STEM fields are not separate from the broader sociopolitical forces that shape power and privilege around issues of sexual identity. LGBQ people and experiences have become increasingly affirmed by society (Pew Research Center, 2019), but anti-LGBQ stigma is not universally condemned (Pew Research Center, 2020), in spite of the recent ruling from the United States Supreme Court on application of the Civil Rights Act to discrimination on the basis of sexual orientation and gender identity. LGBQ people will continue to monitor how they behave in various social settings due to the fear of being stigmatized (Herek, 2007). LGBQ people in STEM are especially likely to alter their behavior to conceal their sexual identities because, in an environment where personal experiences are perceived to be irrelevant, it can be difficult to discern whether revealing one's sexual identity either directly or inadvertently would expose one to some level of stigma (Mattheis, De Arellano, & Yoder, 2019).

Further, social norms operate uniquely within STEM in ways that set these fields apart, especially fields within STEM that are more gender imbalanced than others (e.g., engineering, computer science). Hegemonic masculine norms are deeply embedded within STEM due both to the historic exclusion of women and people of other genders from STEM and to the construction of masculinity in STEM to compensate for ways engagement with STEM work did not conform to broader social norms around masculinity (Frehill, 2004). Historically, masculinity has been associated with athleticism, manual labor, and physical aggression, qualities that are not associated with people who do scientific or engineering work. As such, especially as men who work in STEM have become characterized as "nerds," men within STEM have developed norms to "reclaim" the power and prestige that society affords to men by associating masculinity with discipline and technical expertise (Faulkner, 2007). The result is that STEM fields become viewed as "men's fields," and participation by people who are not men experienced as a gender transgression. Further, reinforcement of heterosexual norms further "legitimizes" the claims to masculinity by men who do not conform to broader masculine ideals (again, athleticism, aggression, etc.); the rejection of nonheterosexuality becomes part of how masculinity is performed by men in STEM fields (Murray, 1997). People who are not men and/or are not heterosexual thus are viewed potentially as illegitimate members of STEM, as interlopers or transgressors who threaten the fragile nature by which masculinity affords STEM culture its status in society.

LGBQ identities are also viewed as incompatible with STEM because these identities are also politicized, especially within today's sociopolitical context. STEM fields conform to an underlying ideology of depoliticization (Cech & Sherick, 2015), which emerges from a concern that social aspects of STEM work undermine objectivity and threatens its legitimacy (Faulkner, 2007). LGBQ people are politically visible, and in particular, trans identities are hyper political given the amount of legislation targeting trans people's access to public facilities. Advocacy for diversity in STEM is also viewed as a political activity, thus hearing the concerns LGBQ people raise about their working conditions would not be welcome in a STEM workplace (Cech &

Sherick, 2015). Altogether, between the pervasiveness of heteronormativity and the operation of depoliticization in STEM, it's no wonder LGBQ people may question their commitments to their interest in STEM fields.

Literature Review

LGBQ students in STEM navigate the heterosexism and heteronormativity that pervades these fields and that which permeates throughout the overall campus environment. They encounter these forces within opportunities that, on the surface, are designed to promote their persistence in STEM fields. Our review of the literature starts with an overview of the climate LGBQ students face within STEM fields, followed by discussion of resources available to help ameliorate this climate. Then we will examine factors that are generally recognized to promote retention in STEM, focusing on ways they might promote LGBQ participation in STEM as well as unintended consequences due to masked heterosexism.

LGBQ Climate in STEM

Overall, LGBQ students continue to report a poorer climate than their heterosexual peers (Ramirez & Zimmerman, 2016). In STEM fields specifically, research on the LGBQ climate is nascent but has grown steadily over the past decade. Three studies depicting the climate for students in engineering point to a chilly, and at times hostile, environment that leads students to compartmentalize sexual identity while in academic spaces (Cech & Waidzunas, 2011; Hughes, 2017; Trenshaw, Hetrick, Oswald, Vostral, & Loui, 2013). Congruent with these findings, a report commissioned by the American Physical Society determined that LGBT+ physicists felt compelled to hide or cover their sexual orientations and gender identities, resulting in feeling isolated and considering leaving their workplaces (Atherton et al., 2016). In a follow-up study, Barthelemy (2020) found gender harassment in physics especially common for LGBT+

physicists, particularly among women. Linley, Renn, and Woodford (2018) also found students reported STEM classrooms to be less safe than those in the social sciences and humanities. Taken together, this climate demonstrates the pernicious effects of widespread heterosexism and heteronormativity across STEM—though Yoder and Mattheis (2016) showed how this climate varies across STEM fields: LGBTQ people were more open with their colleagues in STEM fields with higher representation of women (see also Sansone & Carpenter, 2020).

LGBQ-supportive Co-curricular and Curricular Resources

LGBQ students facing an adverse campus climate are less likely to persist in college, which has led to the provision of resources intended to counter this hostile climate. One resource that has made a difference for LGBQ inclusion on college campuses nationwide is LGBT student organizations (Revilla, 2010). These organizations provide a sense of belonging and opportunities for leadership for LGBTQ students (Renn, 2007), and several operate at the intersections of minoritized experiences to address the unique needs of, for instance, queer Latinx women (Revilla, 2010). Participation in LGBT student organizations enhances the salience of sexual orientation identity for LGB students (Hughes & Hurtado, 2018), and promotes pro-LGBT activism among heterosexual students (Goldstein & Davis, 2010). LGBQ STEM students have begun to form chapters of the national organization oSTEM (Out in Science, Technology, Engineering, and Mathematics) on their campuses to provide an LGBT student organization that encompasses their professional commitments to STEM careers (oSTEM, n.d.).

A second resource is the inclusion of LGBQ material in the curriculum. Incorporating LGBTQ-related material into the curriculum provides a more supportive learning environment for students (Furrow, 2012), and engaging with diversity through coursework improves heterosexual college students’ attitudes toward LGBT peers (Engberg, Hurtado, & Smith, 2007). Incorporating LGBQ topics into the classroom can pose challenges to faculty in terms of teaching on LGBQ topics with integrity, handling one’s own lack of preparation to teach LGBQ issues, and addressing student resistance to these topics in the classroom (Fletcher & Russell, 2001; Kuvalanka, Goldberg, & Oswald, 2013). In STEM, faculty also face the perception that LGBQ issues are irrelevant in terms of the technical knowledge students need to master (Cech & Sherick, 2015; Hughes, 2017), or are even perceived as unprofessional to address (Cooper & Brownell, 2016). As a result, LGBQ students may seek these resources in other departments, like women’s studies programs.

STEM Experiences

LGBQ students in STEM also encounter several opportunities and practices that research has shown promote student persistence in STEM, especially for minoritized students. These experiences include undergraduate research, student-faculty interactions, and interactions with peers. Although the literature base regarding the efficacy of these experiences for LGBQ students specifically is nearly nonexistent, to some extent these experiences should support LGBQ persistence in STEM and to some extent these experiences likely reinforce or even augment the climate described earlier. One major reason these experiences may affect the trajectories of LGBQ STEM students in such a conflicting fashion is, at their core, participating in these activities increases interactions with STEM peers, faculty, graduate assistants, and other key figures who hold differing levels of comfort with LGBQ people.

Undergraduate research. One of the single most-studied experiences that tend to have one of the strongest effects of retention in STEM is participation in undergraduate research (Chang et al., 2014; Jones, Barlow, & Villarejo, 2010). Engaging students in research early in college can improve their academic performance (Jones et al., 2010), contributing to their persistence in the major. Research experiences are a powerful learning tool, engaging students and stimulating curiosity; at their core, they encourage the development of science identity through engaging undergraduates in scientific practice (Graham, Frederick, Byars-Winston, Hunter, & Handelsman, 2013).

Undergraduate research appears to be influential for LGBQ students as well, though it has not been shown to increase LGBQ student retention in STEM (Hughes, 2016). LGBQ students are more likely to participate in undergraduate research than heterosexual students (Hughes, 2018), and participation in undergraduate research significantly enhances LGBQ students' academic development (Kilgo, Linley, Renn, & Woodford, 2019). Kilgo et al. show that LGBQ students appear to be more likely to participate in high-impact practices overall, which includes undergraduate research, but high participation may serve more as a buffer to prevent poor academic outcomes rather than serving as an instigator of better academic outcomes. Where other researchers have begun to turn to undergraduate research as a panacea for broadening participation in STEM among students from groups most underrepresented in STEM, perhaps undergraduate research is less ameliorative for addressing systemic heterosexism in STEM.

Student-faculty interactions. Undergraduate research is typically recommended to support student persistence in STEM because it provides an opportunity to engage authentically with science, but it also provides an opportunity to interact with and be mentored by STEM faculty (Chang et al., 2014; Hurtado, Eagan, Figueroa, & Hughes, 2014). Faculty play an outsized role in the experiences of students, whether they be in STEM or not (Mayhew et al., 2016), mostly due to how central academic experiences are for students. That said, faculty-student interactions significantly, and more often negatively, affect students' persistence in STEM (Christe, 2013). STEM faculty can positively influence student persistence through more student-centered teaching approaches and signaling accessibility to students in the classroom (Cotten & Wilson, 2006; Maltese & Tai, 2011), as well as through demonstrating individual concern for students and setting high expectations for student success in out-of-class interactions (Cox & Orehovec, 2007; Sullins, Hernandez, Fuller, & Tashiro, 1995).

However, interactions with faculty can be quite different for LGBQ students than for their heterosexual peers. Science and engineering faculty are less likely to demonstrate concern for LGBT issues or participate in LGBT workshops than their counterparts in the social sciences (Brown, Clarke, Gortmaker, & Robinson-Keilig, 2004). Further, more than one-third of engineering deans reported they are aware of potential anti-LGBT bias among faculty and staff within their colleges/schools (Cech, Waidzunas, & Farrell, 2016). LGBQ students also report greater comfort with faculty who are LGBTQIA (Cooper & Brownell, 2016), though may be less likely to find "out" faculty in STEM than outside of STEM. To start, LGBQ faculty generally face penalties in their course evaluations because of coming out as LGBQ in the classroom (Russ, Simonds, & Hunt, 2002). Further, LGBQ STEM faculty who are out are less comfortable in their departments than those who are not (Patridge, Barthelemy, & Rankin, 2014), and biology faculty are more likely to disclose to their colleagues than students out of concern for losing student respect in a manner that could hamper teaching evaluations and career progress (Cooper, Brownell, & Gormally, 2019). Overall, LGBQ students' interactions with STEM faculty are far more likely with heterosexual faculty than faculty with shared experiences, which may cause LGBQ students to question their place in STEM.

Interactions with peers. LGBQ students' interactions with their peers in STEM may be even more detrimental to their decision to persist in STEM than their interactions with faculty. On the surface, interactions with peers, and especially out-of-class academic interactions with peers, such as study groups, are promoted to overcome much of the impersonal environment students encounter in introductory-level STEM courses (Brewe, Kramer, & Sawtelle, 2012; Koenig, 2009). Incorporating active learning in classroom teaching practices especially helps ameliorate attrition from STEM (Haak, HilleRisLambers, Pitre, & Freeman, 2011). Outside the classroom, studying with peers, such as through learning communities, or providing an online environment for discussion to promote intellectual growth can also support student persistence in STEM (Graham et al., 2013).

Increasing interactions among students, either in class or out of the class, can lead to unintended consequences for LGBQ students. Cooper and Brownell (2016) studied how LGBTQIA students experience active learning in an introductory biology classroom. By increasing the number of interactions students have with each other, and the number of students with whom an individual student will interact, active learning increases the likelihood that LGBTQIA students disclose their identities to their peers. In response, participants reported in many instances their peers were not welcoming or accepting of their LGBTQIA identities, especially when their peers made it apparent they felt disclosure of LGBTQIA identity was inappropriate or unprofessional. These types of interactions likely bleed over into other subjects and out-of-class interactions, which may mean time spent studying with peers is less helpful for LGBQ students than their heterosexual peers.

Methods

The purpose of this study is to identify experiences that affect persistence in STEM fields for LGBQ college students and compare those experiences to their heterosexual peers. The research questions guiding this study are:

1. Do LGBQ-related experiences reveal the influence of heterosexism and depoliticization on the difference in retention between LGBQ students and their heterosexual peers?
2. What factors significantly predict four-year retention of a STEM major for LGBQ students, and how do they compare with heterosexual students?

Data Source and Sample

The data for this study were taken from the 2015 College Senior Survey (CSS) and the 2011 Freshman Survey (TFS), both administered by the Cooperative Institutional Research Program with the Higher Education Research Institute (HERI) at UCLA. HERI first added items pertaining to sexual orientation to their surveys in 2015, presenting the first opportunity to study LGBQ student STEM retention with these widely used datasets. The TFS is administered to first-time, full-time students at four-year colleges and universities at the very start of their college experience to capture information about students' background characteristics and pre-college academic and social experiences, and then the CSS is then administered to students at the end of their fourth year and focuses on the experiences students had during their four years in college. To examine four-year college outcomes, student responses on the CSS are matched with their responses to the TFS to produce a longitudinal dataset. The overall longitudinal sample consisted of 13,325 students, of whom 4388 expressed an aspiration to a STEM major at the start of their first year. After accounting for missing data, as discussed below, the final analytic sample consisted of 4162 students, including 318 who identified as LGBQ. The list of majors classified as STEM is provided in Appendix A.

Variables

Dependent Variable. A full list of variables included in the analysis, and their coding, is provided in Appendix B. The dependent variable in this study was a dichotomous variable indicating whether participants had persisted in a STEM major after four years. As the analytic sample was narrowed down to those students who indicated an aspiration or decision to major in STEM when they entered college, students' fourth-year major, as reported on the CSS, was recoded into a dichotomous variable indicating whether participants were still enrolled in a STEM major at the end of their fourth year.

Independent Variables. The primary independent variables of interest were a set of experiences pertaining to how LGBQ students navigate heterosexism and homophobia on campus. These items, from the CSS, included participation in an LGBT student organization, having taken a women's studies course, sense of belonging, and frequency of seeking counseling. Working off campus and being a commuter student are included in this set as they have been shown to predict retention as well. Participation in an LGBT organization and taking a women's studies course were dichotomous variables indicating whether students had engaged in these experiences at any time during college. Sense of belonging is a latent, multi-item construct developed by HERI using item response theory (Sharkness, DeAngelo, & Pryor, 2010). The frequency by which students sought counseling was measured in three levels (never, sometimes, frequently). Time spent commuting and working off campus were both initially measured ordinally, but due to heavily skewed distributions as most students did not commute or work off campus these variables were recoded to be dichotomous.

A secondary independent variable of interest was student sexual orientation. This variable was taken from the CSS for two reasons, the first being that 2015 was the first year this variable was available. Second, although in most research using CIRP data the demographic items used are those measured on the TFS, and an increasing number of students are entering college having disclosed their sexual orientations prior to college, many students still come out during college. This variable was then recoded to aggregate students who identified as lesbian, gay, bisexual, or queer into a single category labeled LGBQ. Although one reason aggregation was performed was due to sample size concerns within each category after initial reduction of the initial sample to just STEM aspirants, the most important reason was to ensure that the analysis reflected how heterosexism systematically affects participation in STEM. Aggregation should not be interpreted to mean that individual experiences across the four sexual identity categories can be assumed uniform, nor that experiences within each category are uniform either. This variable was also used to disaggregate the sample into two subsamples for analysis for RQ2.

A host of control variables like those used in Hughes (2018) were then selected from the TFS and CSS, informed by the literature, to control for other factors anticipated to affect retention in STEM. Among demographic predictors were sex, race, and socioeconomic status. Sex and race were measured using dichotomous variables which will be further addressed with data limitations. Socioeconomic status was measured across a set of independent variables including a set of dummy variables measuring family income, a dichotomous variable indicating whether a student's mother had attained a college degree, and a dichotomous variable indicating whether either of a student's parents were employed in a STEM field. Measures of pre-college academic performance included high school GPA and standardized test scores. SAT scores, and ACT scores converted to SAT-equivalent scores, were scaled by 100 for ease of interpretation of regression coefficients. An addition for this model was the inclusion of students' intended STEM fields; students majors, as reported on the TFS, were aggregated into biological sciences, engineering, physical sciences, health professions, and math or computer science, and modeled as a set of dummy variables (using biological sciences as the reference category).

A set of institution-level predictors were included to account for potential institutional differences in retention. Institutional selectivity, measured as the average SAT score of the incoming first-year class at a given university, institutional type (four-year college or research university), and institutional control (private or public) were included. No variable was available on the survey to measure the LGBQ campus climate, but the survey included an item that asked students their agreement with the issue of legal marriage equality on a four-point scale ranging from "strongly disagree" to "strongly agree". This item was aggregated to the institutional level to assess if average student attitudes on an LGBQ political issue influenced LGBQ student persistence in STEM.

Two sets of college experiences were included that would be expected to promote student persistence in STEM. The first set included measures of student self-concept pertaining to academics, social abilities, and science identity. These variables included two CIRP constructs measuring academic self-concept and social self-concept, as well as two items pertaining to science identity that indicate the importance to a student of being recognized for contributions to one's field and of making a theoretical contribution to science. The second set included STEM-related activities typically shown to influence persistence in STEM. These included participation in undergraduate research, the frequency of studying with peers, time invested in homework or studying, and a CIRP construct measuring student-faculty interaction.

Analysis

Missing Data. Missing data were handled in two steps. Cases missing data on the dependent variable and on sexual orientation were removed through listwise deletion, which accounted for less than 5% of all cases in the dataset. Missing values for other variables were estimated using multiple imputation (MI) as data was assumed to be missing at random. MI provides a robust method for estimating missing values through estimating multiple values for missing data, adding random draws from the distribution of residuals to introduce random error in estimates (Allison, 2002). Only one variable was missing values for more than 10% of cases, but fewer than 15%; the average missingness for remaining variables was about 5.3%. It's worth noting that estimated parameters may be a bit conservative in comparing between LGBQ and heterosexual samples as LGBQ students composed only 7.6% of the sample; this concern was attenuated through inclusion of LGBQ status as a predictor variable in the imputation model.

Descriptive statistics. Proportions for categorical variables and are provided in Table 1, broken into the three samples—the full sample, all LGBQ participants, and the heterosexual random sample drawn for the disaggregated analysis for RQ2. Descriptive statistics (means and standard deviations) were run for all continuous variables, provided in Table 2. Correlations among all variables were examined to identify possible issues with multicollinearity, though none were identified.

Multivariate analysis. Hierarchical generalized linear models (HGLM) were run to determine which experiences significantly predicted retention in STEM. HGLM was the most appropriate analysis technique for this study because of the dichotomous nature of the dependent variable and the clustered, multi-level nature of data—students clustered within schools (Raudenbush & Bryk, 2002). Continuous independent variables were grand-mean centered, so regression coefficients reflected average values on the independent variables, rather than zero. Delta-p statistics were then calculated for each significant regression coefficient to aid in the interpretation of the results; delta-p statistics provide an estimate of the change in the probability of the outcome per a one-unit change in an independent variable (Cruce, 2009).

Three models were run to address research question 1 and are displayed in Table 3. The first model tested LGBQ status alone, and the second model tested whether LGBQ status remained significant with the main set of independent variables included. The third model used the full set of control variables to assess the unique variance shared between each independent variable and the dependent variable. Two models, disaggregated by LGBQ status, were then run to address research question 2 and are presented in Table 4. For these subsamples, the entire sample of LGBQ students was included, but a random sample, stratified by institution, of heterosexual students equivalent in size to the LGBQ sample was utilized for more direct comparison.

Limitations

The results of this study are limited in important ways regarding the generalizability of the findings to broader populations. The most important limitations are those pertaining to the nature of this study as a secondary analysis of an existing dataset. For instance, race and gender are measured in very limited ways in this study. Student gender was still measured as sex and in a dichotomous manner (male/female) on this administration of the CIRP surveys. As mentioned earlier, this means that any TGNC students who completed the survey were categorized based on their sexual orientation. TGNC students who identify as heterosexual may enjoy some form or level of heterosexual privilege but being TGNC likely violates heteronormativity in and of itself as well. Race was collapsed into a dichotomous variable indicating Student of Color due to subsample size concerns within more specific racial/ethnic identity categories to avoid excluding participants in smaller categories. Changes in sexual orientation, especially sexual orientation identity, over time is also difficult to capture in survey research using two time points, so this variable should be interpreted as a snapshot that likely captures nearly all students who identify as LGBQ.

This dataset also excludes students who left college altogether as opposed to switching into a non-STEM major. Although this type of attrition is important and should be addressed in future research, this limitation means our sample does not include students who may have left college due to a lack of fit with their interests and goals as well as students who may have been underprepared for college, a common criticism raised by STEM faculty regarding the reasons students leave STEM. In spite of these limitations, secondary analysis of existing datasets is a powerful tool for research in being able to address important questions using data that would otherwise be incredibly resource-intensive to collect (Rutkowski, Gonzalez, Joncas, & Davier, 2010).

Results

The three models presented in Table 3 address research question 1. Goodness of fit parameters are provided with the table to show how well the model fit the data. In model 1, LGBQ status is a significant predictor of persistence in STEM. After adding the set of independent variables of interest in model 2, LGBQ status loses significance and remains nonsignificant in model 3. This result suggests that these factors, especially those that pertain to LGBQ inclusion, help explain the difference in retention between LGBQ students and their heterosexual peers. In model 3, taking a women’s studies course (-8.71%) and participation in an LGBT student organization (-7.92%) appear to predict persistence most strongly. Seeking counseling more frequently (-3.11%) also significantly predicts retention in STEM. All three variables appear to have a push-from or pull-away effect on persistence in STEM as all three coefficients are negatively related to persistence. One interesting difference between models 2 and 3 is that working off campus loses significance while participation in an LGBTQ student organization becomes significant. For working off campus, the variance shared between this variable and the dependent variable is likely shared with other independent variables in the full model, meaning other factors can account for the relationship between working off campus and persistence. The relationship between participation in an LGBTQ organization and persistence appears to indicate the presence of a mediating, moderating, or confounding variable (suppressor effect) in model 3, beyond the scope of this particular analysis but an important hypothesis to explore in future research.

The control variables included in model 3 appear similar in many ways to the findings presented in Hughes (2018). Having a parent employed in a STEM field (+3.87%), earning a higher high school GPA (+5.51%), scoring higher on standardized college entrance exams (+3.85%), and valuing making a theoretical contribution to science (+13.45%) all promote retention in STEM. Studying with other students (+6.03%), spending more time studying (+4.36%), and participating in undergraduate research (+13.61%) also promote retention. Students with a higher social self-concept are less likely to be retained (-6.94%), as are students who attend a more selective university (-5.47%) and who are more highly value being recognized for contributions to their field (-5.80%). Not included in the model presented in Hughes (2018) are comparisons by major—engineering majors (+14.93%) and math/computer science majors (+10.24%) are more likely to persist than biological sciences majors.

To parse out the potentially complex interactions between these push-and-pull factors and sexual orientation in predicting retention in STEM, disaggregated models were run to identify which factors matter to heterosexual and LGBQ students. These two models are presented in

Table 4 and provide more nuanced insight into factors that may have contributed to the difference between LGBQ and heterosexual students in terms of STEM retention. Goodness of fit parameters are also provided for these disaggregated models; the set of push and pull factors did not improve the fit for the LGBQ model significantly at $p<0.05$ but only marginally ($p=0.056$). The factor that appears most to explain why LGBQ status lost significance in previous modeling is participation in an LGBTQ student organization. Heterosexual students who participate in LGBTQ organizations are more than 40 points more likely to leave STEM than their heterosexual peers who do not, whereas this experience is not significant for LGBQ students. Taking a women's studies course negatively predicts retention in STEM for both heterosexual (-20.52%) and LGBQ students (-13.73%). Seeking counseling is not significant for either group, which may be an artifact of the smaller samples in the disaggregated models.

One important factor that differs between the two models is sense of belonging. Where sense of belonging is not significant for heterosexual students, each 10-point increase in the CIRP sense of belonging construct score predicts a nearly 7-point increase in sexual minority student likelihood of persisting in STEM. This difference seems to be important given another interesting difference between the models with respect to the set of STEM retention activities. These experiences are only significant for heterosexual students. Most strikingly, undergraduate research participation is not a significant predictor of retention in STEM for LGBQ students in this sample, whereas it predicts a nearly 24-point increase in heterosexual student likelihood of persisting in STEM. Heterosexual students who study more often with peers are also more likely to persist in STEM (+6.20%). It appears that experiencing a sense of belonging is more important for LGBQ students in STEM to persist in STEM than the host of experiences intended to promote their persistence in STEM. Student-faculty interactions are also negatively related to retention in STEM for heterosexual students, but this finding is consistent with other research using CIRP data (and the review of literature by Christe, 2013) and is typically interpreted as interactions outside the research setting given the inclusion of that variable in the model (Chang et al., 2014). For instance, students who are academically struggling in STEM may be more likely to interact with faculty in seeking assistance.

Discussion

The purpose of this study was to test whether experiences that relate to how LGBQ students navigate campus heterosexism and homophobia accounted for a significant difference in persistence in a STEM major between LGBQ students and their heterosexual peers. LGBQ status was no longer a significant predictor of retention in STEM controlling for the primary set of independent variables, suggesting these factors help explain why LGBQ students leave STEM at higher rates. Disaggregated models were then run to identify which factors differed between the groups: heterosexual students who participated in LGBTQ student organizations were less likely to persist in STEM, whereas sexual minority students who experienced a higher sense of belonging were more likely to persist. In this section of the paper, we will discuss what these results mean in light of our conceptual framework and the extant literature.

Statistically, the most important finding was that participation in an LGBTQ student organization was significant (and negative) for heterosexual students but not LGBQ students. We hypothesized that these organizations, membership in which tends to be predominated by students in non-STEM majors (Toynton, 2007), to function as a “pull” factor in that they might offer a competing sense of belonging with STEM-related activities. Encouragingly, LGBQ STEM students who participate in these organizations are no less likely to leave STEM than their LGBQ peers who do not.

Rather, participation in these organizations appears to relate to heterosexual student decision-making regarding persistence in STEM. The most innocuous explanation is that heterosexual students who leave STEM have more time to explore a wider variety of interests and causes, but this negative relationship could demonstrate the pernicious effects of depoliticization within STEM: social concerns can be perceived as tangential at best, irrelevant at worst, to STEM (Cech & Sherick, 2015), which could also detrimentally affect an individual's interest in STEM if they are simultaneously deeply concerned about social inequities. What is most alarming about this finding is what research demonstrates to be a benefit for heterosexual students from participating in these organizations: heterosexual students who participate in LGBTQ organizations gain a deeper sense of empathy for their LGBTQ peers (Engberg et al., 2007) and experience heightened sexual orientation identity salience (Hughes & Hurtado, 2018). In other words, we may be observing an indirect "push" factor as heterosexual allies seem to be few and far in between in STEM.

A second important factor is the significant relationship between sense of belonging and retention in STEM for sexual minority students. Sense of belonging was hypothesized to serve as a factor that supports retention in STEM it is an important indicator of the climate experienced by minoritized students (Hurtado, Alvarez, Guillermo-Wann, Cuellar, & Arellano, 2012). Although the sense of belonging construct does not measure a sense of belonging in STEM specifically, which could indicate students who experience a lower sense of belonging in college may be more likely to change majors in general, that the variable was not significant for heterosexual students suggests that sense of belonging is one way in which sexual orientation is relevant in STEM. This finding also aligns with that of Thoman, Arizaga, Smith, Story, and

Soncuya (2014) which showed women's decreased sense of belonging led to a decrease in interest in STEM.

The most surprising finding is that the relationship between undergraduate research participation and STEM retention was not significant. Undergraduate research experiences are promoted as one of the most influential methods to encourage student persistence in STEM, especially for minoritized students (National Academies of Sciences, 2017). For LGBQ students specifically, these experiences enhance academic development (Kilgo et al., 2019), and LGBQ students are already more likely to participate in them Hughes (2018). Although this finding does not replicate prior research, we are hesitant to interpret this finding in a manner that suggests undergraduate research may not be effective for LGBQ students without more evidence. Further, Hughes found that the difference in STEM retention between LGBQ and heterosexual students grew from about 7% to over 9% in the regression model controlling for factors like undergraduate research—it is possible that these students would otherwise have been even more likely to leave STEM were it not for disproportionate participation in undergraduate research. Future research should assess reasons why LGBQ students' research experiences seem to be inconsistent compared to their peers.

Implications

The most pressing implications of this study then pertain to the climate in STEM for sexual minority students. Heterosexual STEM aspirants who participated in an LGBTQ student organization during college were more likely to leave STEM after four years of college, and LGBQ students with a higher sense of belonging are more likely to stay in STEM. Both of these results implicate the need for greater visibility of LGBQ people and their needs within STEM academic departments. Regarding students, LGBTQ resources like clubs and organizations can help provide a sense of community that increases belonging (Strayhorn, Blakewood, & DeVita, 2008), and the increasing proliferation of campus chapters of oSTEM (Out in Science, Technology, Engineering, and Mathematics) seems to be a step toward meeting this need. Future research should examine the efficacy of these organizations for increasing LGBQ student sense of belonging, especially relative to resources that are not specific to STEM fields.

The climate in STEM is not isolated to interactions with peers, however. The lack of significance for undergraduate research participation and for student-faculty interactions also raises an implication for STEM faculty. Cooper and Brownell (2016) found students indicated individual faculty willing to meet specific needs as they arose, such as concern for the use of correct pronouns and names in the classroom for transgender students, but that faculty were unprepared to provide systematic support across departments, colleges, and broader academic units. Faculty, staff, and administrators in STEM academic units have resources for professional development in becoming more effective LGBTQ allies; many campuses offer Safe Zone trainings that are intended to give these campus constituents the information and resources they need to better understand how to support LGBTQ students (Poynter & Tubbs, 2008). Many professional organizations, like the American Society for Engineering Education, also provide Safe Zone programming at their national and regional conferences (Farrell et al., 2017). Academic societies are a location that could broaden the impact of Safe Zone type trainings and offer them in a setting where these trainings are not competing with other faculty priorities, like teaching.

Conclusion

National reports have called for an increase in the number of STEM bachelor's degrees produced by American colleges and universities in the near-term future; addressing disparities in retention among groups most underrepresented or underserved in STEM could make a tremendous impact in achieving this large policy objective. LGBQ students are a group underserved in STEM fields who are leaving STEM fields at a higher rate than their heterosexual peers. The study sought to uncover potential reasons for this difference in retention and found that the climate in STEM is likely contributing most to sexual minority student decision-making around switching from a STEM major to a non-STEM major. The results of this study build on decades of research and intervention targeting gender and racial disparities in academic attainment in STEM, contributing to a broader narrative centering on patterns of exclusion and domination in STEM that have given shape to the inequities observed in these fields today. Policymakers should shift their attention away from compositional representation in STEM, which can lead to a fragmented approach that tries to address each type of exclusion as discrete and independent of others, to a more intersectional approach that acknowledges how each form of exclusion in STEM is interrelated and intertwined. Depoliticization in STEM upholds all forms of exclusion that prevent STEM fields from being able to truly transform some of the most pressing social problems of our day.

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Data Availability Statement: The data that support the findings of this study are available from the Higher Education Research Institute at UCLA. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the authors with the permission of HERI, and inquiries regarding data access can be handled by contacting HERI directly.

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Table 1
Frequencies for categorical variables

	Full Sample	Heterosexual	LGBQ
Retained in STEM	70.57%	71.60%	63.84%
Push/pull factors			
Taken a women's studies course	22.22%	22.84%	38.36%
Participated in LGBTQ student organization	7.29%	5.25%	42.14%
Work off campus	39.08%	36.73%	32.39%
Commuter student	49.84%	47.22%	46.23%
Demographics			
Sexual minority status	7.70%		
Sex: female	58.14%	59.26%	61.01%
Student of color	28.12%	32.10%	32.70%
Either parent employed in STEM	30.79%	32.41%	28.30%
Low income	7.06%	7.72%	8.49%
Middle-low income	11.94%	12.35%	15.72%
Middle income	30.01%	28.40%	31.45%
Middle-high income	31.22%	31.17%	29.56%
High income	19.76%	20.37%	14.78%
Mother has college degree	71.47%	72.53%	67.92%
STEM fields at college entry			
Biological sciences major	34.30%	37.35%	44.97%
Engineering major	20.76%	21.60%	13.84%
Physical science major	9.00%	13.58%	11.32%
Health profession major	30.54%	22.84%	23.90%
Math or computer science major	5.40%	4.63%	5.97%
STEM retention activities			
Participated in undergraduate research	41.70%	40.43%	49.69%
Institutional characteristics			
Attended four-year college	64.97%	66.05%	66.98%
Attended private institution	93.71%	91.36%	92.14%

Table 2
Descriptive statistics for continuous variables

	Full Sample		Heterosexual		LGBQ	
	Mean	SD	Mean	SD	Mean	SD
Push/pull factors						
Sense of belonging construct (scaled by 10)	50.94	9.18	50.98	9.26	49.14	9.49
Frequency sought counseling	1.38	0.61	1.38	0.59	1.64	0.72
High school academic performance						
HS GPA	7.18	1.00	7.18	1.10	7.19	1.01
SAT or ACT equivalent score	1266.08	174.91	1275.98	167.10	1309.20	168.40
Senior year self-concept						
Academic self-concept construct (scaled by 10)	52.40	9.82	52.26	10.24	50.96	10.44
Social self-concept construct (scaled by 10)	52.33	8.49	52.17	8.69	51.43	9.04
Importance of being recognized for contributions to one's field	2.56	0.84	2.55	0.83	2.62	0.90
Importance of making a theoretical contribution to science	2.31	0.98	2.25	0.99	2.27	1.07
STEM retention activities						
Frequency studied with other students	2.42	0.59	2.43	0.59	2.34	0.62
Hours per week homework or studying	3.99	1.39	4.10	1.39	3.89	1.42
Student-faculty interaction construct (scaled by 10)	51.63	5.60	51.33	6.16	51.23	5.69
Institutional characteristics						
Selectivity (avg. SAT score)	1243.49	143.95	1264.66	143.20	1264.66	143.20
Average student support for marriage equality	3.44	0.31	3.54	0.25	3.54	0.25

Table 3
HGLM predicting STEM retention, full sample

	Model 1			Model 2			Model 3			
	B	SE	sig.	B	SE	sig.	B	SE	sig	Delta-p
Constant	1.337	0.179	***	2.463	0.225	***	-0.969	1.115		
LGBQ status	-0.474	0.127	***	-0.277	0.148		-0.266	0.157		
Push/pull factors										
Taken a women's studies course				-0.507	0.105	***	-0.403	0.109	***	-8.71%
Participated in LGBTQ student organization				-0.236	0.127		-0.360	0.143	*	-7.92%
Sense of belonging construct (scaled by 10)				0.011	0.051		-0.028	0.037		
Work off campus				-0.345	0.089	***	-0.124	0.105		
Commuter student				0.037	0.107		0.052	0.109		
Frequency sought counseling				-0.162	0.064	*	-0.145	0.069	*	-3.11%
Demographics										
Sex: female							-0.036	0.088		
Student of color							0.082	0.126		
Either parent employed in STEM							0.189	0.087	*	3.87%
Low income (ref: middle income)							0.012	0.163		
Middle-low income							-0.040	0.154		
Middle-high income							0.129	0.095		
High income							-0.003	0.094		
Mother has college degree							0.221	0.118		
High school academic performance										
HS GPA							0.282	0.050	***	5.51%
SAT or ACT equivalent score (scaled by 100)							0.193	0.044	***	3.85%
Institutional characteristics										
Selectivity (avg. SAT score, scaled by 100)							-0.251	0.106	*	-5.47%
Institutional type: four-year college							0.091	0.256		
Institutional control: private							0.823	0.456		

Average student support for marriage equality					0.196	0.189		
STEM fields at college entry								
Engineering major (ref: biological sciences)					0.819	0.161	***	14.93 %
Physical science major					-0.118	0.127		
Health profession major					-0.168	0.147		
Math or computer science major					0.522	0.245	*	10.24 %
Senior year self-concept								
Academic self-concept construct (scaled by 10)					0.037	0.059		
Social self-concept construct (scaled by 10)					-0.315	0.051	***	-6.94%
Importance of being recognized for contributions to one's field					-0.266	0.059	***	-5.80%
Importance of making a theoretical contribution to science					0.785	0.050	***	13.45 %
STEM retention activities								
Frequency studied with other students					0.311	0.064	***	6.03%
Hours per week homework or studying					0.220	0.032	***	4.36%
Participated in undergraduate research					0.674	0.168	***	13.61 %
Student-faculty interaction construct (scaled by 10)					-0.064	0.102		
Goodness of fit								
Deviance	4905.175		4837.344			4040.523		
$\Delta\chi 2$	29.954	***	67.831	***		796.820	***	
Δdf	1		6			26		

Note: * p<0.05, ** p<0.01, *** p<0.001

Table 4
Final HGLM predicting STEM retention, disaggregated by sexual minority status

	Heterosexual					LGBQ				
	B	SE	z	sig	Delta-p	B	SE	z	sig	Delta-p
Constant	-0.347	2.750	-0.13			-0.810	2.260	-0.36		
Push/pull factors										
Taken a women's studies course	-0.928	0.431	-2.15	*	-20.52%	-0.588	0.296	-1.99	*	-13.73%
Participated in LGBTQ student organization	-1.731	0.862	-2.01	*	-40.57%	-0.210	0.371	-0.57		
Sense of belonging construct (scaled by 10)	0.073	0.184	0.4			0.310	0.139	2.23	*	6.80%
Work off campus	0.004	0.434	0.01			-0.096	0.368	-0.26		
Commuter student	0.000	0.386	0			0.622	0.320	1.95		
Frequency sought counseling	0.026	0.259	0.1			0.150	0.236	0.64		
Demographics										
Sex: female	-0.361	0.311	-1.16			0.496	0.287	1.73		
Student of color	0.255	0.297	0.86			0.314	0.379	0.83		
Either parent employed in STEM	0.190	0.351	0.54			0.515	0.396	1.3		
Low income (ref: middle income)	0.865	0.657	1.32			-0.008	0.499	-0.02		
Middle-low income	0.334	0.443	0.75			-0.346	0.465	-0.75		
Middle-high income	0.781	0.446	1.75			-0.248	0.395	-0.63		
High income	0.237	0.455	0.52			0.591	0.400	1.48		
Mother has college degree	-0.182	0.371	-0.49			0.567	0.335	1.69		
High school academic performance										
HS GPA	0.028	0.161	0.18			0.342	0.150	2.27	*	7.47%
SAT or ACT equivalent score (scaled by 100)	0.235	0.181	1.3			0.252	0.100	2.51	*	5.59%
Institutional characteristics										
Selectivity (avg. SAT score, scaled by 100)	-0.395	0.324	-1.22			-0.123	0.150	-0.82		
Institutional type: four-year college	-0.465	0.518	-0.9			0.433	0.331	1.31		
Institutional control: private	0.935	0.436	2.14	*	21.46%	-0.900	0.479	-1.88		
Average student support for marriage equality	0.577	1.008	0.57			0.101	0.672	0.15		
Senior year self-concept										
Academic self-concept construct (scaled by 10)	0.171	0.209	0.82			0.101	0.181	0.56		
Social self-concept construct (scaled by 10)	-0.299	0.247	-1.21			-0.424	0.205	-2.06	*	-10.23%
Importance of being recognized for contributions to one's field	-0.058	0.174	-0.33			-0.404	0.223	-1.81		
Importance of making a theoretical contribution to science	1.038	0.251	4.14	***	16.08%	0.834	0.174	4.78	***	16.42%
STEM retention activities										
Frequency studied with other students	0.620	0.407	1.53			0.103	0.225	0.46		

Hours per week homework or studying	0.329	0.130	2.53	*	6.20%	0.195	0.111	1.75
Participated in undergraduate research	1.206	0.387	3.12	**	23.04%	0.138	0.297	0.47
Student-faculty interaction construct (scaled by 10)	-1.019	0.300	-3.4	**	-23.95%	-0.240	0.253	-0.95

Note: * $p<0.05$, ** $p<0.01$, *** $p<0.001$

	Goodness of Fit			
Heterosexual	Model 1		Model 2	
Deviance	368.855		279.694	
Δχ2	13.936	*	89.161	***
Δdf	6		22	
LGBQ				
Deviance	407.161		327.767	
Δχ2	9.008	†	79.394	***
Δdf	6		22	

Note: † $p<0.10$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$. Model 1 is with push/pull factor variables only; model 2 is the complete model.

Appendix A

List of STEM Majors

Life Sciences
Biology (general)
Biochemistry or Biophysics
Botany
Environmental Science
Marine (Life) Science
Microbiology or Bacteriology
Zoology
Other Biological Science
Agriculture
Engineering
Aeronautical or Astronautical Engineering
Civil Engineering
Chemical Engineering
Computer Engineering
Electrical or Electronic Engineering
Industrial Engineering
Mechanical Engineering
Other Engineering
Physical Sciences and Mathematics
Astronomy
Atmospheric Science (incl. Meteorology)
Chemistry
Earth Science
Marine Science (incl. Oceanography)
Physics
Other Physical Science
Health-related Fields
Health Technology (medical, dental, laboratory)
Medicine, Dentistry, Veterinary Medicine
Nursing
Pharmacy
Mathematics and Computer Science
Mathematics
Computer Science

Appendix B

List of Variables and Coding

Dependent variable		
STEM major in 2015	1	Non-STEM major
	2	STEM major
Independent variables		
Student background characteristics		
Sexual minority	1	No
	2	Yes
Your sex:	1	Male
	2	Female
Student of Color	1	No
	2	Yes
Either parent employed in STEM	1	No
	2	Yes
Family income		
Low income (less than $25,000)	1	No
Middle-low income ($25,000 to $49,999)	2	Yes
Middle income ($50,000 to $99,999)		
Middle-high income ($100,000 to $199,999)		
High income ($200,000 or higher)		
Mother completed at least a college degree	1	No
	2	Yes
Pre-college academic preparation		
What was your average grade in high school?	1	D
	2	C
	3	C+
	4	B-
	5	B
	6	B+
	7	A-
	8	A or A+
SAT score (or ACT equivalent)		
Institutional characteristics		
Institutional selectivity		Avg. SAT score
Institution type	1	University
	2	4-year
Institution control	1	Public
	2	Private
Agg support for same-sex marriage		

Same-sex couples should have the right to legal marital status	1	Disagree Strongly
	2	Disagree Somewhat
	3	Agree Somewhat
	4	Agree Strongly
Expectations and self-concept		
STEM major fields at college entry	1	Biological sciences (ref)
	2	Engineering
	3	Physical sciences
	4	Health professions
	5	Math/computer science
Academic self-concept construct score		(for construct technical information, see Sharkness et al., 2010)
Social self-concept construct score		
Goal: Obtaining recognition from my colleagues for contributions to my special field	1	Not important
	2	Somewhat important
	3	Very important
Goal: Making a theoretical contribution to science	4	Essential
STEM-related college experiences		
Frequency studied with other students	1	Not at all
	2	Occasionally
	3	Frequently
HPW: studying or homework	1	None
	2	1 to 5 hours
	3	6 to 10 hours
	4	11 to 15 hours
	5	16 to 20 hours
	6	Over 20 hours
Participated in an undergraduate research program	1	No
	2	Yes
Faculty interaction construct score		
Pull factors		
Taken a women's studies course	1	No
Participated in an LGBTQ student organization	2	Yes
Sense of belonging construct score		
Worked off campus	1	No
Commuter student	2	Yes
Frequency sought personal counseling in past year	1	Not at all
	2	Occasionally
	3	Frequently