Few LGBTQ+ Science and Engineering Instructors Come Out to Students, Despite Potential Benefits

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ABSTRACT

LGBTQ+ undergraduates have higher attrition from science and engineering (S&E) than straight and cisgender undergraduates and perceive that having LGBTQ+ instructors would benefit them. However, it is unknown how many S&E instructors are LGBTQ+, the extent to which they disclose this information to students, and how disclosure affects *all* students, both LGBTQ+ and non-LGBTQ+. In study I, we surveyed 108 LGBTQ+ S&E instructors across the U.S. to explore the extent to which they reveal their LGBTQ+ identities across professional contexts and why they reveal or conceal their identities to undergraduates. Overall, 75% of instructors came out to at least some colleagues but only 48% came out to any undergraduates. Instructors most commonly chose to conceal LGBTQ+ identities from undergraduates because they perceived their identities to be irrelevant to course content and anticipated negative student reactions. In study II, 666 introductory biology undergraduates were randomly assigned to evaluate one of two identical teaching demonstration videos except the instructor revealed her LGBTQ+ identity in one but not the other. We assessed differences in students' impressions of the instructor across conditions. We found no differences in most ratings of the instructor except participants reported higher rapport with the instructor when she came out.

INTRODUCTION

Lesbian, gay, bisexual, transgender, and queer (LGBTQ+) individuals are considered to be underrepresented and underserved in science and engineering (S&E), including in undergraduate programs (Hughes, 2018; Maloy *et al.*, 2022) and professional development opportunities across S&E occupations (Cech and Waidzunas, 2021). This is hypothesized to be in part because the S&E academic climate has not been friendly toward the LGBTQ+ community. For example, recent studies have found that LGBTQ+ environmental scientists working on academic teams are less likely than their non-LGBTQ+ counterparts to report that their colleagues always treat them with respect (Cech *et al.*, 2021) and LGBTQ+ S&E professionals in the U.S. are more likely than their non-LGBTQ+ peers to have experienced harassment at work (Cech and Waidzunas, 2021). Additionally, in a climate survey led by the American Physical Society committee on LGBT+ physicists, nearly a quarter of LGBTQ+ physicists reported experiencing exclusionary behavior such as being shunned, ignored, intimidated, or harassed within the year before their participation (Barthelemy *et al.*, 2022). Because S&E environments are perceived as unwelcoming of LGBTQ+ individuals (Cech and Pham, 2017; Cech and Waidzunas, 2021; Vaccaro *et al.*, 2021), there is a resulting lack of belonging among LGBTQ+ individuals, including undergraduates (Cooper and Brownell, 2016; Casper *et al.*, 2022; Hughes and Kothari, 2023).

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Potential Student Benefits from Instructor Reveal

The hierarchical nature of academia positions instructors to be highly influential for undergraduate S&E students, including the content instructors choose to teach, how they teach, and even what identities they represent in the classroom (Tanner and Allen, 2002; Hoffmann and Oreopoulos, 2009; Beatty *et al.*, 2023). Prior work has shown that undergraduates with the same identity as instructors can have improved sense of belonging (Rosenthal *et al.*, 2013; Linley *et al.*, 2016; Harmsen, 2018; Rainey *et al.*, 2018) and self-efficacy (Cotner *et al.*, 2011; Stout *et al.*, 2011; Shin *et al.*, 2016). While most research has examined attributes that signal identity similarity between instructors and students that are typically visible (e.g., gender or race), emerging research has begun to explore the impacts of an instructor revealing identities that are potentially concealable, such as LGBTQ+ identities. However, although gender and race are often considered to be visible identities (Quinn, 2006; Quinn and Chaudoir, 2009), they can be concealable and the visibility of identities really exists along a spectrum rather than in a binary (Le Forestier *et al.*, 2023). Further, assumptions about another person's gender identity are informed by their gender expression (Koene, 2017; Adomaitis *et al.*, 2024) and may not be accurate. This is particularly relevant for individuals with nonbinary, genderqueer, transgender, or other gender identities that fall outside the cisgender binary. For instructors who consider their LGBTQ+ identities to be concealable (i.e., not visible), some recognize the potential benefit of revealing their identity to be a role model for their students as someone who is a successful LGBTQ+ scientist (Cooper *et al.*, 2019). In cases where instructors have intentionally revealed an LGBTQ+ identity to undergraduates, they report doing so to foster students' sense of belonging and science identity (Knezz, 2019), model authenticity (Nielsen and Alderson, 2014), better relate to their students (Nielsen and Alderson, 2014), or to increase students' comfort in the class (Cooper *et al.*, 2019). LGBTQ+ undergraduates anticipate similar benefits from knowing an LGBTQ+ instructor, including feeling more comfortable in the class and feeling connected to the instructor based on their LGBTQ+ identity (Cooper and Brownell, 2016; Mattheis *et al.*, 2020). Undergraduate biology students, particularly LGBTQ+ students and women, who had an instructor reveal their LGBTQ+ identity perceived benefits such as enhanced sense of belonging in the course and the scientific community, as well as increased confidence in pursuing a career in science (Busch *et al.*, 2022). The extent to which these benefits are experienced has only recently been considered, but recent studies indicate that students, especially LGBTQ+ students, likely benefit from an instructor revealing their LGBTQ+ identity. Further, a greater proportion of people in younger generations in the U.S. (i.e., the undergraduate population) hold an LGBTQ+ identity than previous generations (Jones, 2023), so the potential benefit to students from having an LGBTQ+ role model in science is growing.

Choosing to Reveal LGBTQ+ Identities

While the potential benefits to students of having LGBTQ+ role models are starting to be established, it is unknown to what extent LGBTQ+ identities are represented among S&E instructors, to what extent these identities are shared with students, and the positive and negative impacts that sharing this identity may have on both LGBTQ+ and non-LGBTQ+ undergraduates.

One contributing factor for why we do not know much about LGBTQ+ representation in S&E is because the data are rarely collected in a systematic way. The National Science Foundation routinely collects data on binary gender, race/ethnicity, and disability status in science and engineering but does not include questions about LGBTQ+ identities (Freeman, 2018, 2022; National Center for Science and Engineering Statistics [NCSES], 2023). Further, in professional settings, some LGBTQ+ individuals may choose to conceal their identity to avoid repercussions. Notably, the extent to which LGBTQ+ identities are visible varies (Le Forestier *et al.*, 2023) and many individuals consider their LGBTQ+ identity to be a concealable stigmatized identity. That is, they need to reveal their LGBTQ+ identity for others to know they hold the identity and doing so may lead to social prejudice (Link and Phelan, 2001; Quinn, 2006). Specifically, LGBTQ+ physicists express worry about judgment from colleagues if they were to be open about their identities (Atherton *et al.*, 2016) and LGBT science and engineering faculty keep their LGBT identities concealed out of fear of suspicion and hostility (Bilimoria and Stewart, 2009). Conversely, LGBTQ+ individuals are more likely to reveal their identity if it is more important to their sense of self (Law *et al.*, 2011; King *et al.*, 2017), they have greater self-acceptance (Griffith and Hebl, 2002; Rostosky and Riggle, 2002), or they are more out in other situations and anticipate a supportive response (Griffith and Hebl, 2002; Sabat *et al.*, 2014; Yoder and Mattheis, 2016). Prior studies indicate that LGBTQ+ science instructors are more likely to be out to their work colleagues than to students (Cooper *et al.*, 2019; Lee, 2023) and LGBTQ+ biology instructors indicated that they were concerned about whether it was appropriate to reveal their LGBTQ+ identity to students, whether it would take up too much class time, and whether they would face negative opinions or attitudes that could affect them professionally (Cooper *et al.*, 2019).

Coming Out to Undergraduates

Personal identities are often avoided in the sciences (Seymour and Hewitt, 1997; Christe, 2013; Seymour and Hunter, 2019), so revealing an LGBTQ+ identity might be seen as irrelevant in science contexts. Further, LGBTQ+ identities in particular can be perceived as inappropriate to share in a professional setting due to the sexualization of the identity (Russ *et al.*, 2002; Anderson and Kanner, 2011). Prior studies indicate that instructors are least willing to reveal their identity to students compared with others in the academy such as colleagues or research groups, which may be due to the perceived need for professionalism in the context of the classroom (Yoder and Mattheis, 2016; Cooper *et al.*, 2019; Lee, 2023). LGBQ biology instructors have reported that they did not come out to undergraduates out of concern for students' negative opinions of LGBTQ+ people (Cooper *et al.*, 2019). Similarly, LGBTQ+ instructors worry about students using their LGBTQ+ status to undermine them (Lee, 2023) and LGBTQ+ undergraduates express concern that other students may submit negative course evaluations for an LGBTQ+ instructor if they revealed their identity (Cooper and Brownell, 2016), which was supported by a 2002 study (Russ *et al.*, 2002). While these concerns are valid (see *Reasons instructors conceal their LGBTQ+ identity from undergraduates* for elaboration), emerging evidence suggests that students may not respond as negatively as instructors may anticipate (Jennings, 2010; Boren and McPherson, 2018; De Souza, 2018)

and in fact can perceive benefits from an instructor coming out during class (Busch *et al.*, 2022). Therefore, undergraduates potentially have much to gain if an instructor reveals their identity due to their early career stage and the importance of positive role models in improving student outcomes such as self-efficacy and persistence (Stout *et al.*, 2011; Rosenthal *et al.*, 2013; Shin *et al.*, 2016; Busch *et al.*, 2022).

Given that the decision to reveal an LGBTQ+ identity depends on internal factors and external climate, it is unknown to what extent science instructors come out to their undergraduate students, and how that compares to other professional contexts such as graduate courses that they teach, research labs that they lead, or colleagues in their department. Due to the general increase in acceptance of LGBTQ+ identities in the U.S. (*Obergefell v. Hodges*, 2015; GLAAD, 2017; Goodman, 2018; *Bostock v. Clayton County*, 2020), in addition to national efforts to increase representation (*500 Queer Scientists Visibility Campaign*, 2023), instructors' willingness to disclose to undergraduates may be evolving, although there has also been an increase in anti-LGBTQ+ and antitransgender legislation which may make instructors hesitant to be open about their LGBTQ+ identities (Trans Legislation Tracker, 2023).

Reasons Instructors Conceal their LGBTQ+ Identity from Undergraduates

LGBTQ+ individuals may keep their identities concealed in the workplace for a variety of reasons, including anticipating negative reactions from coworkers (Griffith and Hebl, 2002; Hastings *et al.*, 2021), perceiving their LGBTQ+ identity as not central to their self-concept (Holman *et al.*, 2022), or negative previous experiences with disclosure (Chaudoir and Quinn, 2010). While these factors likely affect instructors' decisions of revealing their LGBTQ+ identities, additional reasons specific to their position in the classroom affect their choices as well. Instructors often keep LGBTQ+ identities concealed due to their perception that revealing their identity may waste class time, the potential to lose their job, and anticipation of negative reactions from students (Connell, 2012; McKenna-Buchanan *et al.*, 2015; Cooper *et al.*, 2019). Undergraduates' negative reactions may be expressed on evaluations of teaching (Russ *et al.*, 2002; Cooper and Brownell, 2016), often a component of tenure and promotion decisions (Hobson and Talbot, 2001; Boring and Ottoboni, 2016; Hornstein, 2017), so there are potential lasting professional consequences for the instructor. The timing and way in which an instructor reveals their LGBTQ+ identity may affect students' opinions (Cayanus and Martin, 2008; Goodboy *et al.*, 2014; Nielsen and Alderson, 2014). Specifically, more frequent, relevant, and positive instructor self-disclosure is associated with decreased student dissent and improved learning outcomes (Goodboy *et al.*, 2014) and relevant instructor self-disclosure is associated with higher performance on a short-term recall test (Kromka and Goodboy, 2021). However, LGBTQ+ identities may be examples of self-disclosure that are not acceptable for instructors (Cayanus and Martin, 2008; Goodboy *et al.*, 2014) and the heteronormativity of S&E spaces may exacerbate that perspective (Cech and Waidzunas, 2021; Cech, 2022). Therefore, instructor LGBTQ+ disclosure may be seen negatively by students without additional context or if it is completely disconnected from course content. However, LGBQ instructors attributed keeping their identity concealed to not considering potential benefits more often than concern about consequences (Cooper and Brownell, 2016). A recent study of the impact undergraduates perceive of an instructor coming out during class challenges some of these assumptions about the extent to which these anticipated negative reactions from students are realized (Busch *et al.*, 2022). Overall, most students reported that the instructor coming out in class increased their sense of belonging, feelings of connection with the instructor, and how approachable they found the instructor. Further, LGBTQ+ students in particular reported disproportionate benefits, as did women and nonreligious students (Busch *et al.*, 2022). Few students thought the instructor coming out in class negatively impacted their course experience and while Christian students were less likely to perceive a benefit, the study design was not able to discern whether that result indicated the instructor coming out impacted them negatively or not at all (Busch *et al.*, 2022). Further, the generalizability of the findings is limited because only one instructor was involved, and students' perspectives may have been affected by their relationship with the instructor, course characteristics (e.g., structure), or the sociopolitical climate of the state and institution.

Why *all* Undergraduates may Benefit from an Instructor Coming Out

All students, including those who do and do not identify as LGBTQ+, may benefit from an instructor coming out in class because it can represent a counterstereotypical example of a scientist, build the student-instructor relationship, and provide verbal immediacy. Depictions of scientists that represent diverse backgrounds and counterstereotypical examples have been shown to benefit students, specifically increasing their ability to relate to scientists and decreasing their stereotypical views of who does science (Schinske *et al.*, 2016; Yonas *et al.*, 2020; Metzger *et al.*, 2023). An instructor coming out to students would provide both a same-identity role model to LGBTQ+ students and model an aspect of themselves that is counterstereotypical in science for all students (Cech and Waidzunas, 2021). Undergraduates likely expect that a professor has always succeeded (Simpson and Maltese, 2017). According to expectancy violations theory, if these expectations are challenged by learning about a counterstereotypical identity of a scientist, then this positive violation is likely to have positive effects such as increased credibility and likability (Burgoon, 2015). Additionally, an instructor coming out to students humanizes the authority figure in the classroom (Busch *et al.*, 2022). This likely enhances students' perceptions of their relationship with the instructor. With large course enrollments increasingly common in U.S. universities (Mulryan-Kyne, 2010; Cash *et al.*, 2017), it is logistically challenging for instructors to maintain individual relationships with students. However, instructors can foster parasocial relationships with their students; that is, allow students to feel as though they know the instructor and develop one-sided relationships (Horton and Richard Wohl, 1956; Dibble *et al.*, 2016). Perceiving similarity in attitudes, interests, and ways of treating others, or attitude homophily (McCroskey *et al.*, 2006), helps to build these parasocial relationships (Tukachinsky *et al.*, 2020). Additionally, instructor personal disclosure can enhance rapport because it helps to foster a personal connection, leading to an understanding of each other's ideas or feelings (Gremler and Gwinner, 2000;

Frisby and Martin, 2010; Webb and Barrett, 2014) and consequently feeling a stronger relationship with the instructor. Finally, an instructor coming out is an example of verbal immediacy (Gorham, 1988). Instructor verbal immediacy, which includes actions such as using students' names (Cooper *et al.*, 2017), using appropriate humor (Cooper *et al.*, 2018; Cooper *et al.*, 2020b), and noncontent information that enhances the learning experience (i.e., Instructor Talk [Seidel *et al.*, 2015]), has been linked to student learning, confidence, improved classroom environment, and instructor relatability and approachability. Therefore, while LGBTQ+ students are likely to disproportionately benefit from an instructor coming out, all students may experience positive effects.

LGBTQ+ as an Umbrella Term

Throughout, we use LGBTQ+ as an umbrella term to capture any identity that is not cisgender or straight, including pansexual, asexual, and gender nonbinary. When referencing prior work, we use the acronym most appropriate for the study sample (e.g., LGBQ+ for studies which focused on identities related to orientation). LGBTQ+ identities are not a monolith and each identity category within the LGBTQ+ umbrella is distinct and associated with widely variable experiences. Notably, individuals with LGBTQ+ gender identities tend to report more instances of harassment than cisgender individuals with LGBTQ+ orientation identities, including in academic sciences (Barthelemy *et al.*, 2022). We chose to use LGBTQ+ as an umbrella term in this study to protect the confidentiality of participants and because the small number of participants within each identity group under the LGBTQ+ umbrella was too small to consider in statistical analyses. Additionally, we did not separate LGBTQ+ orientation and gender identities in our analyses because all of the participants who reported an LGBTQ+ gender identity also reported an LGBTQ+ orientation.

Current Studies

In this pair of studies, we assessed the patterns of LGBTQ+ science and engineering instructors coming out to better understand instructors' decisions as well as experimentally tested whether students' impressions of an instructor are affected by an instructor coming out during a self-introduction, which provides context for LGBTQ+ disclosure and eliminates the potential confound of participants' relationship with the instructor. We first describe the presence (or lack) of LGBTQ+ role models in undergraduate S&E classrooms using a national data collection and characterize the factors that influence instructors' decisions to reveal or conceal their LGBTQ+ identities. Because instructors have often attributed keeping their LGBTQ+ identities concealed due to concern about negative reactions from students, we assessed undergraduates' reactions in a controlled experimental design. Together, these studies can provide a detailed perspective on why instructors choose to conceal their LGBTQ+ identities and provide evidence to refute (or support) the assumption that students will judge an instructor negatively if they disclose an LGBTQ+ identity.

Study I. We surveyed a national sample of science and engineering instructors across very high research activity doctoral-granting (R1) institutions to understand:

1. The extent to which they consider their identities concealable and whether LGBTQ+ identity predicts this,
2. The extent to which they reveal their LGBTQ+ identity in various contexts (i.e., colleagues, labs, graduate courses, undergraduate courses),
3. What factors affect their decision to reveal their LGBTQ+ identity to undergraduates,
4. How instructors reveal their LGBTQ+ identity to undergraduates,
5. For instructors who conceal their LGBTQ+ identity, to what extent they perceive benefits to undergraduates from revealing and what those benefits are, and
6. What factors affect their decision to conceal their LGBTQ+ identity.

Study II. We used an audit survey of introductory biology students at an R1 institution in the southwest U.S. where participants watched one of two identical videos of a candidate for an instructor position, the only difference being the instructor actor revealed an LGBTQ+ identity in one, to assess:

1. The extent to which there are differences in undergraduates' evaluations of an instructor actor when she revealed an LGBTQ+ identity compared with when she did not,
2. The extent to which there are differences in undergraduates' anticipated experiences in a course with the instructor actor when she revealed an LGBTQ+ identity compared with when she did not, and
7. The extent to which and why students think it is appropriate for an instructor to reveal an LGTBQ+ identity to a class and whether their peers will perceive it positively, neutrally, or negatively.

POSITIONALITY STATEMENT

A majority of the authors identify as LGBTQ+. The research team includes individuals who identify as gay, queer, men, women, cisgender, white, and brown. One is an undergraduate researcher, one a graduate student, and two are biology faculty who regularly teach large-enrollment courses and come out to students in those settings. Some members of the research team have had an undergraduate science instructor come out during class when they were a student. Our lived experiences as LGBTQ+ individuals in the sciences piqued our curiosity with the research subject and informed the research questions addressed in these studies. We also heavily relied on prior literature to inform the survey design and items in order to incorporate perspectives outside of our own. We leveraged our diverse perspectives and experiences to counteract biases in the study design and data analysis by critically engaging with the study materials before data collection and questioning each other's assumptions when analyzing and communicating about the data (Chenail, 2009; Intemann, 2009).

STUDY I

Study I Methods

This study was approved by the Arizona State University Institutional Review Board (protocol no. 00013208).

Instructor survey development

We developed a survey with closed- and open-ended questions to assess our research questions. To establish cognitive validity

of the survey, we conducted six think aloud interviews with undergraduate science and engineering instructors to ensure items were being interpreted as intended (Trenor *et al.*, 2011). The survey was iteratively revised after each think aloud until all items were clear and being interpreted as intended.

The survey began by asking participants whether they taught undergraduates. If a participant did not teach undergraduates, they were sent to the end of the survey and did not receive any additional questions. We asked all instructors a series of demographic questions, including gender and whether they identify as a member of the LGBTQ+ community. For each of the following sets of questions, instructors who reported an LGBTQ+ gender identity(ies) (e.g., nonbinary) or an LGBTQ+ orientation identity(ies) (e.g., bisexual) were asked the questions specific to that identity(ies), which was phrased as either their LGBTQ+ gender identity or LGBTQ+ identity related to sexuality and/or romantic attraction. Participants who reported both an LGBTQ+ gender identity(ies) and orientation identity(ies) (e.g., nonbinary and bisexual) received two sets of questions parallel in structure. There was no limit to the number of LGBTQ+ gender or orientation identities that participants could select.

Concealability and Extent of Revealing. We first asked participants whether they perceived their LGBTQ+ identity was concealable and the extent to which they revealed their LGBTQ+ identity to departmental colleagues, to postdocs and/or graduate students in their research lab, to students in graduate courses, and to students in undergraduate courses with the option to select that they reveal the identity to all, some, or none of the individuals in each group or that they do not interact with these individuals (e.g., they do not have a research lab). Next, participants reported whether they shared their LGBTQ+ identity on a public platform.

Revealing or Concealing to Undergraduates. We asked participants who revealed their LGBTQ+ identity to some or all undergraduate students to describe how they revealed their identity to students. Then, participants indicated whether revealing their LGBTQ+ identity to students was a choice they made intentionally, was inadvertent or unintentional, or if they were outed by someone else. Participants who intentionally chose to reveal their LGBTQ+ identity to all undergraduates reported the factors that influenced their decision by selecting all that applied from a list of 14 reasons (e.g., "I felt that revealing my LGBTQ+ identity was relevant to course content," "I wanted to serve as a mentor to students with LGBTQ+ identities") with the option to describe any additional factors that influenced their decision. Participants who revealed their LGBTQ+ identity to only some or to none of their undergraduate students were asked if before taking the survey they had considered that revealing their LGBTQ+ identity to all undergraduates could benefit students. If so, they described any potential benefits. Then, participants reported the factors that influenced their decision to conceal their LGBTQ+ identity by selecting all reasons that applied from a list of 12 (e.g., "I did not feel my LGBTQ+ identity was relevant to students in the course," "I was concerned students would have a negative opinion about my LGBTQ+ identity") with the option to describe any additional factors that influenced their decision. The reasons to reveal or conceal LGBTQ+ identities provided on the survey was derived from prior interview studies exploring the disclosure of concealable stigmatized identities in scientific environments (e.g., Cooper and Brownell, 2016; Cooper *et al.*, 2020a; Barnes *et al.*, 2021) or theoretical frameworks of concealable identity disclosure (e.g., Quinn and Chaudoir, 2009; Chaudoir and Fisher, 2010; Quinn and Earnshaw, 2011). All survey questions analyzed can be found in the Supplemental Material.

Survey Recruitment and Distribution

We recruited science and engineering instructors from very high research activity doctoral-granting (R1) institutions by identifying every faculty member and instructor listed on publicly available department websites. This comprised 131 institutions, over 2000 science and engineering departments, and 56,033 total faculty or instructors with publicly available contact information. We exclusively sampled R1 institutions due to the large undergraduate enrollments at these institutions compared with other institution types (*Doctoral Universities*, 2021) and we hypothesized that the research focus for faculty at R1 institutions may make them less likely to disclose LGBTQ+ identities to students so would represent a conservative estimate of LGBTQ+ disclosure among college science instructors (Rozhenkova *et al.*, 2023). Using a mail merge service, we emailed instructors inviting them to participate in our study in November 2021. We sent a final reminder in February 2022. We incentivized participation by providing the first 50 participants with a $100 gift card and entering all participants into a drawing for one of two $500 awards. Importantly, the recruitment information did not mention LGBTQ+ identities; materials were targeted to instructors of undergraduate science and engineering courses to "help improve undergraduate STEM education."

Data Analysis

Closed-Ended Survey Questions. For each research question, we calculated the percent of participants who selected a particular response. We first calculated the extent to which instructors revealed their LGBTQ+ identities to all, some, or none of their colleagues, those in their research lab, and students in their undergraduate and graduate courses. For instructors who reported both LGBTQ+ orientation and gender identities, we employed an inclusive estimation method. Instructors who revealed either their orientation or gender identity to everyone were categorized as "all," while those who did not reveal either of their identities to anyone were categorized as "none." The remaining instructors who revealed one of their identities to some, and the other identity to some or no one, were categorized as "some." Similarly, in calculating the percent of instructors who selected each reason to reveal or conceal their LGBTQ+ identities, if an instructor who reported both an LGBTQ+ orientation and gender identity selected a particular reason for either identity, they were included in the count for that reason. If the participant selected the same reason for revealing or concealing both their gender and orientation identities, they were only counted once for that reason.

We then determined the percentage of instructors who considered their LGBTQ+ identities to be concealable and evaluated whether individuals differentially perceived their identity

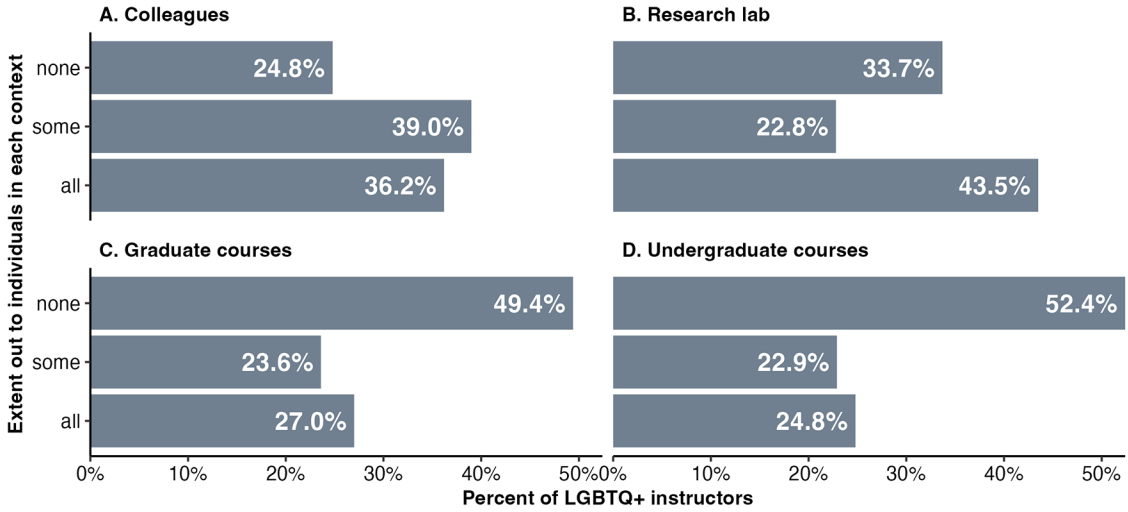

FIGURE 1. Percent of LGBTQ+ instructors who are out to all, some, or none of the individuals among (A) their colleagues, (B) the graduate students and postdocs in their research lab, (C) the students in the graduate courses they teach, and (D) the students in the undergraduate courses they teach.

to be concealable based on their LGBTQ+ identity (i.e., whether bisexual individuals were more or less likely to perceive their LGBTQ+ identity to be concealable compared with those who identified as gay) using binary regression in R with the stats package (R Core Team, 2022). In our models, we included LGBTQ+ identity as the predictor with whether the identity was perceived as concealable as the outcome. For this model, queer, pansexual, asexual, aromantic, and other identities that participants wrote in under the "Other, please describe" option were grouped under the "queer +" umbrella. Genderqueer individuals are categorized with nonbinary individuals. (Model: concealable (y/n) ~ LGBTQ+ identity (gay, bisexual, queer+, trans, nonbinary). We chose these identity categories for our predictor due to the low number of participants who reported each individual identity and to retain as many participants as possible in the model. Each instance of reporting an identity and perceiving it as concealable was considered independently. For example, if a participant identified as gay and nonbinary and perceived that their gay identity is concealable but their nonbinary identity is not, those responses were considered independent from each other (i.e., as two separate rows in our data frame). We confirmed there were no outliers and calculated the variance inflation factor (VIF) using the car package in R (Fox and Weisberg, 2019), which determined no issues with multicollinearity among the predictors.

Open-Ended Data Analysis. Two researchers (C.A.B. and P.B.B.) reviewed all open-ended responses to identify themes specific to each of the three open-ended prompts: 1) how instructors revealed their LGBTQ+ identity, 2) the potential benefits to students from revealing their LGBTQ+ identity, and 3) additional reasons why they *conceal* their LGBTQ+ identity from undergraduates. No participants provided additional reasons why they *reveal* their LGBTQ+ identity to undergraduates. After initially reviewing the responses, they met to discuss their preliminary themes. The researchers combined redundant themes and discussed their descriptions to ensure each theme was independent from all others and all of their initial themes were represented in the final coding rubrics (Saldaña, 2021). Using the three finalized rubrics (how instructors revealed their LGBTQ+ identity, potential benefits from revealing, additional reasons to conceal), the researchers used each rubric to code their respective responses. Due to the small numbers of responses (59, 45, and 22, respectively), the researchers met to compare their coding and discussed all disagreements to reach consensus. Full coding rubrics with descriptions can be found in the Supplemental Material.

Study I Results

Of the 2013 total instructor participants, 108 (5.4%) identify as LGBTQ+, including both gender and orientation identities. Most LGBTQ+ instructors (85.3%) consider their LGBTQ+ identities to be concealable and there were no significant differences in perceiving an LGBTQ+ identity as concealable across LGBTQ+ identities (i.e., gay or lesbian, bisexual, queer+, transgender, genderqueer, or nonbinary; $p > 0.05$; full results in Supplemental Table S1).

Study I Finding 1: Instructors are Generally Open about LGBTQ+ Identities to Colleagues and their Research Labs, but Over Half do not Reveal to Undergraduates. Just over one-third (36.2%, $n = 38$) of instructors are out to all of their colleagues, with 39.0% ($n = 41$) out to some colleagues and 24.8% ($n = 26$) out to none of their colleagues (Figure 1A). In regard to their research labs, 43.5% ($n = 40$) are out to all postdocs and graduate students in their lab, 22.8% ($n = 21$) out to some, and 33.7% ($n = 31$) out to none (Figure 1B). When considering students in their graduate courses, 27.0% ($n = 24$) of instructors are out to all students, 23.6% ($n = 21$) out to some students, and 49.4% ($n = 44$) out to no students (Figure 1C). This pattern is also reflected in undergraduate courses; 24.8% ($n = 26$) of instructors are out to all undergraduates they teach, 22.9% ($n = 24$) are out to some, and 52.4% ($n = 55$) are out to none of the undergraduates they teach (Figure 1D). Additionally, 46.3% ($n = 50$) of participants reported their LGBTQ+ identity being publicly available.

TABLE 1. Reasons that LGBTQ+ instructors reported revealing their identity to all undergraduate students

Reason to reveal LGBTQ+ identity	% (*n*) selected
I wanted to be an example to my students of someone with an LGBTQ+ identity	78.6 (22)
I typically share my LGBTQ+ identity with people	71.4 (20)
I feel better when I can live authentically or be open about my LGBTQ+ identity	71.4 (20)
I wanted to be known as a supporter of LGBTQ+ individuals	67.9 (19)
I thought revealing my LGBTQ+ identity to students in this course was appropriate	60.7 (17)
I wanted to serve as a mentor to LGBTQ+ students	60.7 (17)
I thought revealing my LGBTQ+ identity could make students more comfortable	50.0 (14)
I thought revealing my LGBTQ+ identity could make me more relatable	42.9 (12)
I felt my LGBTQ+ identity was relevant to the students in this course	32.1 (9)
I felt like I had a personal relationship with the students in the course	21.4 (6)
I thought revealing my LGBTQ+ identity could help students understand me or my circumstances better	21.4 (6)
I thought I could engage students in course material by making a connection between my LGBTQ+ identity and course content	21.4 (6)
I felt my LGBTQ+ identity was relevant to the course content	14.3 (4)
I knew others in the department who had revealed a similar identity	7.1 (2)

Study I Finding 2: Instructors Most Often Come out to All Undergraduates because they Want to be an Example to Students or Prefer to Live Authentically. Instructors who revealed their LGBTQ+ identity to all undergraduates in their courses most commonly did so to be an example to students (78.6%, n = 22), because they typically share their LGBTQ+ identity (71.4%, n = 20), or because they prefer to live authentically or be open about their LGBTQ+ identity (71.4%, n = 20; Table 1).

Study I Finding 3: Most Often, Instructors Come Out to Undergraduates during their Self-Introduction to the Class or by Referring to their Significant Other. When revealing their LGBTQ+ identity to all undergraduate students in their course, instructors most commonly do so during their self-introduction (53.6%, n = 15) and/or by mentioning their spouse or partner (53.6%, n = 15). When revealing their LGBTQ+ identity to some undergraduates, they most often do so in small group discussions such as office hours (34.5%, n = 10) and by mentioning their spouse or partner (27.6%, n = 8). Other common ways to reveal their LGBTQ+ identity to all or some students were through visible indicators such as their attire or office decor (17.9%, n = 5 and 17.2%, n = 5, respectively; Supplemental Table S2). There was slight variation between the reasons instructors revealed an LGBTQ+ orientation versus gender identity but based on the number of responses we do not have the statistical power for hypothesis testing. For example, 21 of the 47 responses (44.7%) regarding revealing an orientation identity include mentioning a spouse/partner compared with 2 of 12 (16.7%) responses regarding revealing a gender identity that included mentioning a spouse/partner.

Study I Finding 4: Instructors Who Keep their LGBTQ+ Identities Concealed Often do not Anticipate Student Benefits from Coming Out. Of instructors who do not reveal their LGBTQ+ identity to all undergraduates, less than half (48.1%, n = 39) reported that they previously considered that coming out to all undergraduates may benefit students. Instructors who did not reveal their LGBTQ+ identity to all students but identified a potential benefit most commonly described that they could serve as a role model for LGBTQ+ students (65.9%, n = 29), followed by normalizing LGBTQ+ identities (27.3%, n = 12), and that they become a known supporter of the LGBTQ+ community (27.3%, n = 12; Supplemental Table S3).

Study I Finding 5: Instructors Often Keep their LGBTQ+ Identities Concealed because they Perceive it to be Irrelevant to Content and to Students. Of instructors who do not reveal their LGBTQ+ identity to all undergraduates, they most often cited that their identity was not relevant to course content (46.7%, n = 43), they did not have a personal enough relationship with students (40.2%, n = 37), or they do not typically share their LGBTQ+ identity (40.2%, n = 37). Relatively few instructors kept their LGBTQ+ identity hidden out of concern for being subjected to departmental disciplinary action (9.8%, n = 9) or being fired (4.3%, n = 4; Table 2).

In addition to the reasons to select provided, participants could describe additional factors in their decision to conceal their LGBTQ+ identity from undergraduates. Twenty (21.3%) responses included an additional factor. These additional reasons most commonly included anticipated personal harm (40.0%, n = 8, of the open-ended responses), followed by their LGBTQ+ identity being irrelevant to teaching (35.0%, n = 7), and the instructor's understanding of their own identity was evolving (10.0%, n = 2; Supplemental Table S4).

STUDY II

Study II Methods

This study was approved by the Arizona State University Institutional Review Board (protocol no. 00012431).

Survey Development

We developed a survey to address our research questions using an audit design with closed- and open-ended questions. An audit study is a controlled field experiment where participants evaluate a randomly assigned set of materials, often a job application, in one of several conditions. Each condition has a single detail altered, which is hypothesized to be a source of bias or discrimination. Assessing differences in evaluations across conditions can elucidate potentially discriminatory practices or

TABLE 2. Reasons that LGBTQ+ instructors reported concealing their identity from all undergraduate students from a provided list

Reason to conceal LGBTQ+ identity	% (*n*) selected
I did not feel my LGBTQ+ identity was relevant to the course content	46.7 (43)
I did not feel like I had a personal enough relationship with the students in this course	40.2 (37)
I typically do not share my LGBTQ+ identity with people	40.2 (37)
I did not feel my LGBTQ+ identity was relevant to the students in this course	29.3 (27)
I was concerned students would have a negative opinion about my LGBTQ+ identity	29.3 (27)
I thought revealing my LGBTQ+ identity to all undergraduates in this course was inappropriate	27.2 (25)
I had never thought about revealing my LGBTQ+ identity to all students in this course	25.0 (23)
I did not know others in the department who had revealed a similar identity	20.7 (19)
I was concerned that revealing my LGBTQ+ identity would result in poor course evaluations	20.7 (19)
I was concerned that revealing my LGBTQ+ identity would waste class time	12.0 (11)
I was concerned that I would be subjected to departmental disciplinary action	9.8 (9)
I was concerned I could be fired	4.3 (4)

biases (Gaddis, 2018). This study is the first to our knowledge to use an audit design to assess students' reactions to an instructor coming out in an undergraduate science course. In this study, the survey began with a teaching demonstration video, followed by a number of scales to assess the instructor actor in the video, described in detail below (*Impressions of instructor measures*). After assessing the instructor based on the video, students were directly asked a series of questions about their general perception of college science instructors revealing their LGBTQ+ identities during class (see *Perceptions of science instructors coming out*). The survey ended with a series of demographic questions including gender, religion, and LGBTQ+ status (yes/no). Importantly, the recruitment script stated that we were conducting a study "to learn more students' experiences in their college science courses" and "to better understand the effect of instructors on students' sense of belonging and confidence in science." Participants were not aware that the purpose of the study pertained to LGBTQ+ identities. A full copy of the undergraduate survey is available in the Supplemental Material.

Teaching Demonstration Video. Participants were randomly assigned to watch the treatment or control video with an instructor actor. In both videos, the instructor actor followed a self-introduction with a brief (~6 min) lesson on introductory biology content. The self-introduction for both videos included identical information about the instructor's research interests, education, and hobbies. In the treatment condition, the instructor revealed being part of the LGBTQ+ community during the self-introduction portion of the video which took less than 5 seconds (e.g., "I am a member of the LGBTQ+ community"). In the control condition, the instructor did not reveal her LGBTQ+ identity. Notably, the instructor actor's visible appearance, provided as a headshot on the introductory slide, did not include any visible indicators of an LGBTQ+ identity (Griffin, 1992; Meyer, 2003; Hanson, 2017; Gates, 2022). In the mini lesson on introductory biology content, the instructor posed questions to students to engage them in their learning based on best practices (Driessen *et al.*, 2020). The information and slides presented in the teaching demonstration video were the same across both versions except for the LGBTQ+ disclosure, and the length of the two videos was equivalent. The content of the survey was identical except for the two versions of the teaching demonstration video.

Impressions of Instructor Measures. In both conditions, after confirming that they had watched the teaching demonstration video, participants rated the instructor on a number of previously developed measures based on their initial impressions. These outcomes have been used to assess bias in audit studies (Moss-Racusin *et al.*, 2012; Barnes *et al.*, 2020; Abraham *et al.*, 2022), are associated with impacts on students from an instructor revealing her LGBTQ+ identity in a biology course (Busch *et al.*, 2022), and are hypothesized to be outcomes likely affected by instructor disclosure based on prior literature (Goodboy *et al.*, 2014; Cooper and Brownell, 2016; Cooper *et al.*, 2019). For each scale, we created an aggregate score using the mean of its items and ensured internal consistency with Cronbach's alpha (Gliem and Gliem, 2003).

Hireability, Competence, and Likeability. We assessed students' perceptions of the instructor's hireability, competence, and likeability using previously-developed scales used in audit studies (Moss-Racusin *et al.*, 2012; Barnes *et al.*, 2020; Abraham *et al.*, 2022). Each of the three scales consists of three items that participants rate on a 7-point Likert scale from not at all (1) to very much (7) so that higher values indicate greater hireability, competence, or likeability. Cronbach's α of 0.92, 0.88, and 0.92 indicate good internal consistency in our sample for hireability, competence, and likeability, respectively.

Attitude Homophily. To assess the extent to which students perceive that they are similar to the instructor, they reported the extent to which they agreed to a series of 15 items on a 7-point Likert scale from strongly disagree (1) to strongly agree (7). The scale was developed by McCroskey and colleagues (2006) with evidence of validity and reliability in college student populations (McCroskey *et al.*, 2006) and excellent internal consistency in this study (Cronbach's $\alpha = 0.91$).

Student-Instructor Rapport. We measured rapport with the Student-Instructor Rapport Scale from Lammers and Gillaspy (2013). The scale consists of nine items rated on a 5-point Likert scale from not at all (1) to very much so (5). The scale has evidence of internal consistency, concurrent validity, and predictive validity in university student populations (Lammers and Gillaspy, 2013) and we tested for internal consistency in this study and demonstrated excellent internal consistency (Cronbach's $\alpha = 0.96$).

Approachability. To assess the extent to which students perceive the instructor as approachable, we used the scale developed by Porter and colleagues (2007) which contains 20 pairs of oppositely worded adjectives which participants rate on a 7-point scale. Lower values indicate perceiving the instructor as more approachable whereas higher values on the scale indicate less approachability. The scale was developed to assess the degree to which subordinates feel comfortable approaching their managers and has support for the one-factor structure as well as excellent internal reliability in a population of service industry employees in the U.S. (Porter *et al.*, 2007). In this study, we slightly modified the instructions so that the participants considered the student-instructor relationship when responding. The scale demonstrated excellent internal consistency in this study (Cronbach's $\alpha = 0.98$).

Course Cohesion. After rating the instructor, students were asked to imagine being a student in the instructor's course and provide their impression of whether they would feel a sense of belonging or feelings of morale associated with the course using the course cohesion scale developed by Bollen and Hoyle (1990). The scale consists of two subscales and has been validated in college populations (Bollen and Hoyle, 1990). In the current study, Cronbach's α indicated adequate internal consistency for both the sense of belonging (0.94) and feelings of morale (0.91) subscales.

Comfort in Class. Similarly to course cohesion, students indicated their anticipated comfort in a science class taught by the instructor using a modified version of the scale developed by Micari and Drane (2011). The scale includes four items rated on a 7-point Likert scale from strongly disagree (1) to strongly agree (7). In STEM college students, the scale was developed to assess student comfort in small groups and had evidence of reliability and internal validity (Micari and Drane, 2011). In the current study, we modified the items so that participants considered a science class. For example, "I feel comfortable offering my own ideas in this group" was modified to "I would feel comfortable offering my own ideas in this science course." The scale had excellent internal consistency in this sample (Cronbach's $\alpha = 0.94$).

Perceptions of Science Instructors Coming Out. After responding to questions specific to the instructor in the teaching demonstration video, all students were asked whether they perceived that a college science instructor revealing their LGBTQ+ identity during class would be perceived negatively, as neutral, or positively by undergraduate students in the class (slightly modified from Busch *et al.*, 2022). Based on their responses, participants were asked to explain their choice in a follow-up open-ended item.

Then, participants were asked to describe the circumstances, if any, in which they thought it would be beneficial for a college science instructor to reveal their LGBTQ+ identity to undergraduates during class and to describe any circumstances in which it would be detrimental.

Finally, all participants were asked to what extent they agreed with the statement "I think it is completely appropriate for science instructors to reveal that they are a member of the LGBTQ+ community" on a 6-point Likert scale from strongly disagree (1) to strongly agree (6). Based on their responses, participants were asked to explain why they thought it is appropriate or not appropriate for science instructors to reveal that they are a member of the LGBTQ+ community (Busch *et al.*, 2022).

Survey Recruitment and Distribution

We contacted instructors of introductory biology courses across all campuses at a very high research activity doctoral-granting institution in the southwest U.S. Of the 11 instructors contacted, two (18.1%) agreed to distribute our survey to students. Students were incentivized to participate with a small number of extra credit points. Data were collected in November 2022.

Data Analysis

For each of the scales (see *Impressions of instructor measures* for descriptions), we calculated aggregate scores for each outcome by averaging the scores of the items included in each scale. For single closed-ended items (*Perceptions of science instructors coming out*), we calculated the percent of participants who chose each option.

Quantitative Analyses. To assess the effect of the treatment as well as demographic differences for the outcomes (*Impressions of instructor measures*), we performed linear regression analyses in R using the stats package (R Core Team, 2022). For all models, we first assessed whether there was an effect of treatment while controlling for gender (man/woman or nonbinary), religion (nonreligious/Christian/religious not Christian), and LGBTQ+ status (no/yes). (Model: outcome ~ treatment + gender + religion + LGBTQ+ status). Transgender identity was not considered in our analyses. The item which collected gender included the options man, woman, genderqueer or nonbinary, and a gender not listed, so if, for example, a transgender man selected "man" that is where he would be categorized in the regression analysis. We combined women, genderqueer, and nonbinary participants because there were not enough genderqueer or nonbinary participants to have a third gender category in our model and we wanted to preserve their responses (a regression model cannot consider values of N/A). We collapsed participants' religious identities into one of three categories: nonreligious which included those who selected not religious, agnostic, or atheist; Christian which included all denominations of Christianity including Catholic and Protestant; and religious not Christian which included all other non-Christian religious identities including Hindu, Buddhist, Jewish, and Muslim. We hypothesized that a student's religious identity would affect their impression of an instructor disclosing their LGBTQ+ identity due to the historic and current ostracization of LGBTQ+ individuals from some religious communities (*Faith Positions*, 2021). We further disaggregated Christian religious affiliations from other religious affiliations due to the distribution of responses and because in the U.S. Christian identities are associated with views that oppose LGBTQ+ individuals and communities (Woodford *et al.*, 2012; Worthen *et al.*, 2017; Wilcox, 2020).

Because we hypothesized that some groups may be disproportionately affected by the instructor revealing her LGBTQ+ identity, we used an interactive model to assess the extent to which each of the demographic groups included in the original

model were differentially affected by treatment (model: outcome ~ treatment*gender + treatment*religion + treatment*LGBTQ+ status). To test for an association between whether students would recommend a class with the instructor to their peers (yes/no) and treatment condition, we used a Fisher's exact test.

We used multinomial logistic regression to assess the extent to which there was an effect of treatment or demographic differences in whether students perceived that an instructor coming out would be perceived negatively, as neutral, or positively by undergraduates with the same predictors as described above using the nnet package in R (Venables and Ripley, 2002). We used ordinal regression to assess the effect of treatment and demographic differences in students' perceptions of an instructor coming out as appropriate using the ordinal package in R (Christensen, 2022).

For all regression analyses, we used the car package in R (Fox and Weisberg, 2019) to calculate the VIF; VIF values indicated no issues with multicollinearity among the predictors. For all linear regressions, assumptions of linearity, homoscedasticity, and normality were checked and met. For the multinomial logistic regression, we checked that there were no extreme outliers and confirmed that each observation was independent. Finally, for the ordinal regression, we confirmed that the proportional odds assumption was met (UCLA: Statistical Consulting Group, n.d.). For all analyses, we use the threshold of $p < 0.05$ to determine statistical significance; we report the full results from all regression analyses in the Supplemental Material. The code for all analyses and figures can be found in a GitHub repository (https://github.com/carlybusch/Few-science-engineering-instructors-come-out.git).

Open-Ended Data Analysis. Each participant received one of the impact-positive, impact-neutral, or impact-negative prompts depending on their response to the preceding close-ended survey question. Similarly, participants answered either the appropriate or the not appropriate prompt depending on their answer to the preceding survey question. All participants received both the beneficial and the detrimental prompts. Two researchers (C.A.B. and P.B.B.) each reviewed two randomly selected sets of 10% of each response set to identify themes and establish a coding rubric for six prompts: (1) the positive impact of an instructor revealing LGBTQ+ identity in class ($n = 21$), (2) the neutral impact of such disclosure ($n = 42$), (3) the circumstances wherein such disclosure would be beneficial ($n = 66$), (4) the circumstances wherein it would be detrimental ($n = 66$), (5) when it would be considered appropriate ($n = 54$), and (6) when it would not be considered appropriate ($n = 12$). The two researchers then met to develop initial coding rubrics by identifying and describing preliminary themes, and combining redundant themes (Saldaña, 2021). Afterward, one researcher (P.B.B.) tested the initial rubric on an additional 10% of randomly selected response sets to ensure that no additional themes were necessary and that all major themes were represented in the rubric. Subsequently, the two researchers calculated the Inter-Rater Reliability (IRR) based on an additional 15% of randomly selected response sets. An acceptable Cohen's Kappa was achieved for all six prompts: 1) impact-positive ($k = 0.89$), 2) impact-neutral ($k = 0.93$), 3) beneficial ($k = 0.94$), 4) detrimental ($k = 0.90$), 5) appropriate ($k = 0.86$), and 6) not appropriate ($k = 1.0$). One researcher (P.B.B.) then coded the remaining responses for all the prompts.

Owing to the limited number of responses to the prompt concerning the negative impact of an instructor disclosing their LGBTQ+ identity ($n = 37$), two researchers (C.A.B. and P.B.B.) each reviewed two randomly selected sets of 50% of the response set in the initial round. They discussed the initial themes they identified to establish a coding rubric. Subsequently, the two researchers calculated the IRR based on a randomly selected 50% ($n = 18$) of responses. Cohen's Kappa was acceptable ($k = 1.0$) and one researcher (P.B.B.) coded the remaining responses. Full coding rubrics for all prompts with descriptions can be found in the Supplemental Material.

Study II Results

Study II Finding 1: No Evidence of Bias against the Instructor when she Came Out, but Improved Rapport. We assessed whether the "reveal" treatment condition (i.e., revealing LGBTQ+ identity) predicted each outcome using linear regression while controlling for gender, religion, and LGBTQ+ status. We found no effect of treatment for hireability, competence, likeability, attitude homophily, and approachability (all $p > 0.05$). Contrary to our hypotheses, we found that students in the "reveal" condition rated the instructor higher on student-instructor rapport ($\beta = 0.15$, $p = 0.01$; Figure 2) than the control condition. In the model, gender, religion, and LGBTQ+ status were associated with attitude homophily such that women and nonbinary individuals ($\beta = 0.28$, $p = 0.001$), non-religious students ($\beta = 0.35$, $p = 0.002$), and LGBTQ+ students ($\beta = 0.21$, $p = 0.049$) rated the instructor higher than men, religious non-Christian students, and LGBTQ+ students respectively. Additionally, women and nonbinary individuals rated the instructor lower on the approachability scale ($\beta = -0.20$, $p = 0.046$) than men; this indicates that they found the instructor *more* approachable than men as lower values on the scale are associated with greater approachability. Full results for all regressions are available in Supplemental Table S5. Despite rating the instructor statistically lower than their respective counterparts, men and religious non-Christian students still rated the instructor highly on attitude homophily, with an average of 4.51 ± 0.87 and 4.43 ± 0.94 on a 7-point scale, respectively. Similarly, men rated the instructor as fairly approachable with an overall average of 2.18 ± 1.01 on a 7-point scale, where lower values indicate greater approachability. We report means and standard deviations for each outcome disaggregated by demographic groups in Supplemental Tables S6–S8.

Based on our interactive models between treatment and gender, treatment and religion, and treatment and LGBTQ+ status, we found that LGBTQ+ students in the treatment condition rated the instructor higher on attitude homophily ($\beta = 0.44$, $p = 0.04$) compared with non-LGBTQ+ students. There were no additional effects from the interactive model for attitude homophily and no significant effects from our interactive models for hireability, competence, likeability, rapport, or approachability (all $p > 0.05$). Full results in Supplemental Table S9.

Study II Finding 2: Whether the Instructor Came Out did not Affect Students' Anticipated Course Experiences. We found no effect of treatment, gender, religion, or LGBTQ+ status on

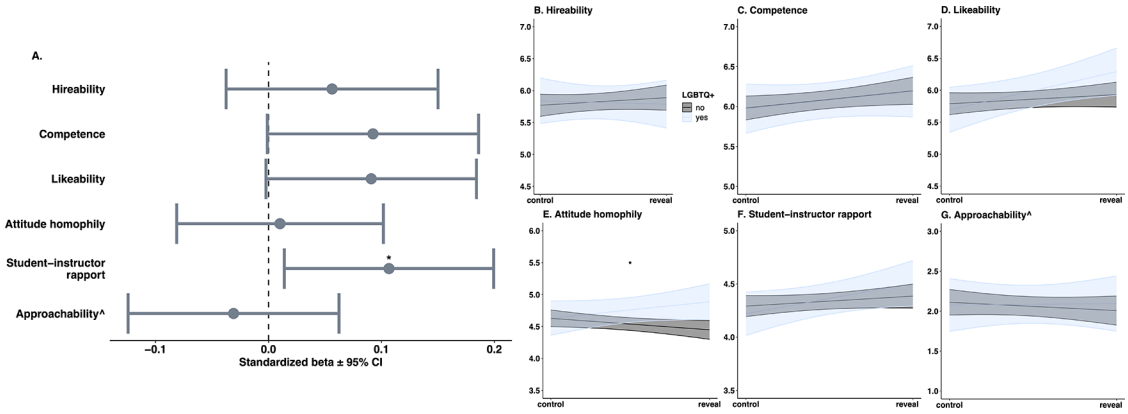

FIGURE 2. A. Standardized effect size of treatment on the six instructor outcomes: 1) hireability, 2) competence, 3) likeability, 4) attitude homophily, 5) rapport, and 6) approachability. Confidence intervals which do not cross the dashed line indicate statistical significance; points to the right of the line indicate a positive association between the outcome and treatment. Treatment*LGBTQ+ status interactive term for (B) hireability, (C) competence, (D) likeability, (E.) attitude homophily, (F) student-instructor rapport, and (G) approachability. ^Lower values for approachability indicate perceiving the instructor as *more* approachable. Statistical significance ($p < 0.05$) indicated by an asterisk (*). *Note: All outcomes are on a 7-point scale, except for rapport which is on a 5-point scale. The limits do not span the full ranges of the scales in order to better illustrate the interactive effects. Supplemental Figure S1 displays these results with the full ranges of the scales.*

students' anticipated course cohesion or comfort in class (all $p > 0.05$). Full regression results in Supplemental Table S10. Additionally, we found no association between whether students would recommend a class with the instructor to their peers and treatment condition (Fisher's exact test, two-tailed $p = 0.41$).

Study II Finding 3: Undergraduates Largely Reported an Instructor Coming out Would be Perceived Neutrally or Positively by their Peers and is Appropriate. When asked directly whether undergraduates would perceive an instructor revealing an LGBTQ+ identity during class as positively, neutrally, or negatively, 62.8% of participants reported that they perceived it would be seen neutrally, 31.4% said positively, and 5.9% said negatively. There was no effect of treatment on students' responses ($p > 0.05$; full results in Supplemental Table S11). When asked why it would be perceived positively, students most commonly reported a generational shift towards a more accepting society, increased visibility and a role model for LGBTQ+ students, and the humanization of the instructor making them more approachable (Table 3). Students who reported a neutral perception mentioned indifference towards LGBTQ+ identities, the irrelevance of LGBTQ+ identities in classroom settings, and a generational change leading to a neutral outlook on LGBTQ+ identities (Table 3). Students reporting a negative perception noted the fear of prejudice from fellow students and the irrelevance of LGBTQ+ identities to teaching and learning (Table 3). The full coding rubric with theme descriptions is available in Supplemental Table S12.

We asked undergraduate participants to describe any circumstances when it would be beneficial for a college science instructor to reveal their LGBTQ+ identity to undergraduates during class. Students explained that it would be beneficial for an instructor to come out when LGBTQ+ students in particular would benefit from the representation (45.6%), when it humanizes the instructor (15.2%), or makes the classroom environment more inclusive for all students (7.5%). Notably, 11.5% of the participants noted that under no circumstances would revealing an LGBTQ+ identity be beneficial, while an additional 13.0% held a neutral view on it, believing that such a disclosure would be neither beneficial nor detrimental.

Conversely, students described that it would be detrimental for an instructor to come out when students have prejudiced views of LGBTQ+ individuals (34.2%), when it wastes time and is too personal for the classroom context (10.5%), or when doing so makes the students feel uncomfortable, unwelcomed, or isolated in class (6.7%). However, 30.7% of the participants noted that under no circumstances would revealing an LGBTQ+ identity be detrimental. The full coding rubric with theme descriptions is available in Supplemental Table S13.

Overall, 81.6% of undergraduates agreed that it would be appropriate for an instructor to come out to students during class. Participants in the treatment group were more likely than their counterparts in the control condition to agree more strongly that it would be appropriate for an instructor to come out ($\beta = 0.39$, $p = 0.02$). Additionally, women and nonbinary students were more likely than men ($\beta = 0.60$, $p < 0.001$), nonreligious students were more likely than non-Christian religious students ($\beta = 0.95$, $p < 0.001$) and Christian students ($\beta = 0.83$, $p < 0.001$), and LGBTQ+ students were more likely than non-LGBTQ+ students ($\beta = 0.62$, $p = 0.009$) to agree more strongly that it would be appropriate. Full regression results are available in Supplemental Table S14.

Students explained that it was appropriate because revealing an LGBTQ+ identity would not be considered inappropriate, that it is an integral part of an instructor's identity, and because they have the right to reveal their LGBTQ+ identity to students if they so choose (Table 4). While below our threshold of 10% to report in Table 4, 9.8% of the participants ($n = 53$) reported that disclosure of LGBTQ+ identities would be appropriate because LGBTQ+ identities are normal and the same as straight identities in terms of being appropriate for a college science classroom. Students who did not think it was appropriate

TABLE 3. Themes from students' responses as to why an instructor coming out during class would be perceived positively, neutrally, or negatively by their peers

Theme	% (*n*) responses which included the theme	Example quote
Positive (*N* = 209)		
Generational norms of undergraduates are such that they are accepting	28.2 (59)	Student 98: "I feel as though the modern generation is excited and extremely open to a more diverse group of instructors and leaders!"
Benefit LGBTQ+ students and provide a role model	24.9 (52)	Student 108: "As a member of this community, seeing a staff member reveal that they are like me would bring me hope for my future career and opportunities in science."
Humanize the instructor and make them more relatable	16.8 (35)	Student 365: "It makes [the instructor] more relatable and not like a robot who is only something that exists during lectures."
Generally positive impression of an instructor coming out	11.0 (23)	Student 360: "It is okay to be a part of the LGBTQ+ community, and I am proud of her for coming out and letting us know about her [identity]."
Make classroom a more inclusive environment	10.0 (21)	Student 212: "Students would feel that the teacher is open and wants to create an environment where everyone is comfortable with themself"
Neutral (*N* = 413)		
Undergraduates are indifferent towards LGBTQ+ identities	28.1 (116)	Student 41: "Sexual orientation does not affect most people. I wouldn't even think twice about someone's sexuality because it really isn't that big of a deal"
LGBTQ+ identities are irrelevant to teaching and learning	26.9 (111)	Student 25: "It has no bearing on the class material so I don't see why it would affect anyone."
Generational norms of undergraduates are such that they see LGBTQ+ identities as neutral	19.9 (82)	Student 358: "I think current undergraduate students are one of the most accepting generations to date and most likely very few will be offended or upset by this."
Net neutral: the positive and negative reactions will even out	19.4 (80)	Student 352: "I think some people would react very positively and some would act negatively, but it would average out."
Negative (*N* = 37)		
Undergraduates may have discriminatory or prejudiced views of LGBTQ+ individuals	59.5 (22)	Student 21: "I had an LGBTQ+ professor and no one in the class really respected their preferred pronouns and would mock them if it was brought up. Just prejudice I guess."
Irrelevant to teaching and learning	32.4 (12)	Student 331: "It is not a relevant piece of information. As a student, I would not care."

explained that revealing an LGBTQ+ identity would be irrelevant to the course material and could expose the instructor to biases or discriminatory beliefs from students (Table 4). Full coding rubrics are available in Supplemental Table S15.

DISCUSSION

These studies in concert highlight that even though most LGBTQ+ instructors are not out to their undergraduate students, revealing an LGBTQ+ identity does not seem to result in negative student perceptions of an instructor after disclosure. This is the largest scale study that we know of that has examined the extent to which science and engineering instructors identify as LGBTQ+ and are out to their undergraduate students. Our recruitment strategy of emailing every R1 science and engineering instructor the survey without priming them to consider their LGBTQ+ identity was intended to be as unbiased as possible. Even though it is likely that we are underestimating the percentage of LGBTQ+ individuals given the stigma associated with these identities which might result in a lack of disclosure on a survey, these data can now be used to support the assertion that LGBTQ+ individuals are underrepresented in science and engineering compared with the general population (Freeman, 2020).

Individuals often do not reveal concealable stigmatized identities due to anticipated or experienced stigma (Quinn and Chaudoir, 2009; Chaudoir and Quinn, 2010), but LGBTQ+ science and engineering instructors in study I generally reported keeping their identities concealed primarily because they do not anticipate benefits to students from disclosure rather than concern for consequences, which aligns with a prior interview study with LGBTQ+ biology instructors (Cooper *et al.*, 2019). Conversely, instructor disclosure seems to be largely motivated by benefits to students. In study II, we found that undergraduates did not react negatively to the instructor actor in the video coming out, and in fact reported enhanced rapport with the instructor when she came out. The increase in rapport may be because the instructor coming out humanized the instructor (Busch *et al.*, 2022) and therefore functioned as a positive violation of students' expectations for science instructors (Burgoon, 2015). Science and engineering curricula and class environments are often situated in a culture of depoliticization (Cech, 2013; Hughes and Kothari, 2023), meaning that personal

TABLE 4. Themes and example quotes for why students perceive an instructor coming out during class is appropriate or not appropriate

Theme	% (*n*) responses which included the theme	Example quote
Appropriate (*N* = 540)		
Coming out is not inappropriate	38.0 (205)	Student 106: "There is nothing inappropriate about [being] LGBTQ+, there is no reason why it would be inappropriate for an instructor to share that about themself."
LGBTQ+ identity is an important aspect of instructor	18.3 (99)	Student 59: "[An LGBTQ+ identity] is a part of who they are. There is no reason [the instructor] should feel trapped if they want to […] express themselves."
The instructor may choose to reveal	14.1 (76)	Student 98: "I believe that people should have the freedom to share whatever they want about themselves to others."
Humanizes the instructor	11.9 (64)	Student 123: "I always feel more willing to talk to teachers when I know a little bit about their history. If we are going to spend an entire semester together it's important that we can act like humans and share stories."
Increases LGBTQ+ visibility and provides a role model	10.6 (57)	Student 318: "Many young LGBTQ+ people want to go into the sciences but rarely ever see themselves represented, leading them to believe that it 'isn't for them', positive representation can help fix this issue."
Not appropriate (*N* = 114)		
Irrelevant to teaching and learning	80.7 (92)	Student 458: "I don't think it is something that needs to be said or revealed in a classroom setting as it provides no benefit to the academic environment."
Rationale rooted in prejudice, bias, or stigma against LGBTQ+ individuals	10.5 (12)	Student 91: "It ruins the impression about the teacher. I don't want someone from LGBTQ+ [community] to be my teacher."

identities and connections between content and social and political topics are often avoided. Importantly, attempts at depoliticization which preclude discussion of social and political topics reinforce dominant ideologies and norms while communicating to individuals with marginalized identities that they are not welcome, and therefore do not *actually* remove social and political contexts (Cech, 2013; King *et al.*, 2023; Morton, 2023; Morton *et al.*, 2023). Attempts at depoliticization are reflected in the general lack of instructor disclosure of concealable stigmatized identities in undergraduate science classrooms (Busch *et al.*, 2024). Humanizing content, whether via examples of counterstereotypical scientists (Schinske *et al.*, 2016; Yonas *et al.*, 2020; Metzger *et al.*, 2023) or connecting content to the biases, stereotypes, and assumptions that shaped it (Adams *et al.*, 2023; Beatty *et al.*, 2023; Costello *et al.*, 2023), can violate students' expectations of an undergraduate science or engineering course by raising points outside of expected course material (Graham *et al.*, 2022; Costello *et al.*, 2023). If an undergraduate student welcomes this unexpected humanization in a science or engineering course, then this is a positive violation of their expectations and may increase credibility, likeability, and certainty about the interpersonal connection (White, 2008; Burgoon, 2015), which are outcomes associated with increased rapport (Frisby and Martin, 2010; Webb and Barrett, 2014).

While mixed reactions from undergraduates may be expected because coming out often challenges norms in S&E due to the depoliticization of science (Cech, 2013; Cech *et al.*, 2021) and the politicization of LGBTQ+ identities in the U.S. (American Civil Liberties Union, 2023; Hughes and Kothari, 2023; Trans Legislation Tracker, 2023), our results indicate that an instructor revealing their LGBTQ+ identity would be a welcome challenge to current expectations. Further, increased calls to humanize science (Sjöström and Talanquer, 2014; Costello *et al.*, 2023; Jones *et al.*, 2023) and the growing acceptance of LGBTQ+ identities (*Obergefell v. Hodges*, 2015; GLAAD, 2017; Goodman, 2018; *Bostock v. Clayton County*, 2020) may make negative reactions from students less likely. Indeed, 82% of the undergraduate participants agreed that an instructor coming out was appropriate. This is less than the 96% of undergraduate participants who agreed that an instructor coming out was appropriate in a prior study where the instructor of a course they were currently enrolled in, rather than an instructor actor in a teaching demonstration video, revealed her LGBTQ+ identity to students during a self-introduction (Busch *et al.*, 2022). This disparity between participants' perceptions as to whether an instructor coming out is appropriate may be due to the relationships that students formed with the instructor throughout the course of the semester in the prior study (Busch *et al.*, 2022). Extended interactions with an individual with a stigmatized identity (i.e., LGBTQ+) likely positively affects the extent to which disclosing that identity is considered to be appropriate. Overall, the overwhelming majority of undergraduates who perceive an instructor revealing an LGBTQ+ identity is appropriate across both studies may be encouraging for LGBTQ+ instructors who are considering disclosure.

Some instructors expressed concern about negative student reactions, but we found no evidence of undergraduate bias against the instructor actor in the video when she revealed her LGBTQ+ identity. Specifically, most undergraduates in study II thought coming out was appropriate, particularly if they had seen an example of the instructor doing so in the video. This difference between the two conditions may be due to the common misconception that coming out has to be overly personal or time-consuming (McKenna-Buchanan *et al.*, 2015; Cooper *et al.*, 2019). Students who watched the control video where the

instructor did not reveal an LGBTQ+ identity may have imagined a scenario in which the instructor coming out was time-intensive or elaborate whereas students in the treatment condition saw that it can be done in a matter of seconds. Most instructors in study I reported coming out in their self-introduction, which provides context in the course, and in the audit video the instructor coming out took less than 5 seconds, so disclosure does not need to take significant time to be impactful. The majority of undergraduates surveyed thought their peers would perceive instructors coming out as positive or neutral, which may be due to generational norms of LGBTQ+ acceptance or ambivalence. Given that the population of LGBTQ+ individuals who are open about their identities is growing, especially among younger generations – recent national data indicates that 20% of Gen Z identifies as LGBTQ+, compared with 11% of Millennials and 3% of Generation X and Baby Boomers (Jones, 2023) – visible LGBTQ+ role models in S&E are increasingly important as we seek to recruit and retain a diverse group of future scientists among our undergraduate population.

Limitations and Future Directions

In study I, we recruited exclusively from very high research activity doctoral-granting institutions; the culture and norms of science departments may vary by institution type, so future studies should consider instructor disclosure decisions at a variety of institution types. The survey recruitment for instructors included language to "help improve undergraduate education," which may have led to increased participation among instructors involved in evidence-based pedagogy reforms and diversity, equity, and inclusion initiatives. Due to the survey design, we do not know why instructors reveal or conceal their LGBTQ+ identities in contexts other than undergraduate courses. These patterns of revealing are likely related, so future work can further explore how the decision to come out in one professional context influences the decision to come out in other contexts. In study II, we only surveyed introductory biology undergraduates at a single institution in the southwest U.S., so the results may not be generalizable across other regions, institutions, or disciplines. For example, while the state is not considered to be highly LGBTQ+ friendly, the campus and surrounding city are, and this LGBTQ+ visibility could factor into students' perceptions. Although the instructor actor teaches at the same institution, it was highly unlikely that the undergraduate participants recognized the instructor actor as she teaches upper division courses and is not involved in any first-year programs. Additionally, the survey was distributed in the fall semester, so introductory biology was likely the first biology course participants had taken. Future iterations of study II should include a wider undergraduate sample from different institutions and disciplines as well as areas of the country with various levels of LGBTQ+ acceptance. Additionally, undergraduate participants may not have felt comfortable answering in ways that may demonstrate discriminatory or biased views of LGBTQ+ individuals due to social desirability bias (Paulhus, 1984). However, the audit study design hid the purpose of the study from participants and because some participants did describe overtly discriminatory views of LGBTQ+ individuals, we believe the impact of social desirability bias was at least somewhat mitigated. It is possible that despite the study design some participants concealed their discriminatory or biased views, which would minimize any potential differences in evaluations of the instructor between the two videos. The study design did not allow us to explore how additional typically visible identities of the instructor (e.g., race, gender) affected the impact of revealing her LGBTQ+ identity. The instructor actor was perceived to be a younger white woman, so future studies could introduce additional conditions where the visible identities of the instructor vary to better understand the effects of those identities on undergraduates' reactions to LGBTQ+ disclosure. Finally, undergraduate reactions to an instructor disclosing an LGBTQ+ identity in a teaching demonstration video may not be reflective of how students would respond over the course of a semester with that instructor. However, initial impressions are predictive of student evaluations of teaching at the end of the semester so we expect the results of study II to reflect how students would respond after a semester with the instructor (Buchert *et al.*, 2008).

CONCLUSION

In these studies, using a national sampling approach of instructors at very high research activity doctoral-granting institutions, we found that while instructors are typically open with their colleagues and research labs about their LGBTQ+ identities, most do not come out to undergraduates. The decision to conceal is primarily driven by not recognizing benefits to students from doing so or perceiving their LGBTQ+ identity to be irrelevant to the course. Instructors attributed revealing their LGBTQ+ identities to the potential benefits to students and came out during their self-introduction at the start of class. In an audit study where undergraduates were randomly assigned to watch one of two identical videos, except in one the instructor actor revealed her LGBTQ+ identity, we found no evidence of bias against the instructor when she came out, and instead found improved rapport. Most undergraduates anticipated their peers would perceive an instructor coming out to be positive or neutral, and thought it was appropriate to come out to students. This pair of studies illustrates that undergraduates have a positive impression of an instructor actor when she came out and when coupled with a greater understanding of the benefit to students from an instructor coming out, more LGBTQ+ instructors may be motivated to provide much-needed role models in S&E contexts by disclosing their own identities.

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