BUILDING LGBTQ-INCLUSIVE CHEMICAL ENGINEERING CLASSROOMS AND DEPARTMENTS

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The health and relevance of the chemical engineering profession relies on attracting and retaining talent and energy from all corners. As educators of nascent engineers, we are particularly obligated to support a climate of inclusion for all students. This responsibility is especially important in areas where there exists a history of marginalization, which has discouraged participation in our profession.

Recent years have seen significant progress toward LGBTQ+[1] (lesbian, gay, bisexual, transgender, and queer) equality in the United States through legislation and societal acceptance, but research examining perceptions and experiences of LGBTQ+ people on college campuses clearly demonstrates the prevalence of negative experiences that range from exclusionary behavior to overt discrimination.[1-6] Thus, there is a compelling need to improve the climate for students who, among their many gifts and characteristics, are diverse in gender, biological sex, and orientation.

While increasing diversity and inclusion in engineering is an area of vigorous research, scholarship on LGBTQ+ inclusion in engineering is an emerging area. In 2015, the National Science Foundation funded a transformative project that links diversity research with a faculty development initiative to promote LGBTQ+ equality in engineering. The aims of this research-to-practice project hosted by the American Society of Engineering Education are to (1) identify aspects of engineering culture that present barriers to LGBTQ+ equality, (2) build knowledge and skills to disrupt discrimination and promote LGBTQ+ equality in engineering departments on college campuses, and (3) identify promising practices for promoting LGBTQ+ equality in engineering. An action-oriented Virtual Community of Practice (VCP) was created whose members are committed to advancing LGBTQ+ equality in engineering. The members of this VCP have advocated for LGBTQ+

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1 There are several commonly used acronyms used to represent diversity in sex, gender, and sexual orientation. We have chosen to use the acronym LGBTQ+ in this paper. In the section on terminology we discuss the longer acronym LGBTQIA+. LGBTQIA+ is an abbreviation for lesbian, gay, bisexual, transgender, queer, intersex, asexual, and other identities. In both acronyms, the + indicates that the list is not exhaustive. When referring to research, we use the acronym that reflects the particular population subset that was studied in the work cited.

equality in their own departments and have implemented a major national Safe Zone ally training initiative through webinars hosted by ASEE and workshops at professional society conferences such as ASEE, AIChE, and ACS.[7-9] This paper highlights the research-informed promising practices used by this VCP in their engineering classrooms and laboratories, and in workplaces, to advance LGBTQ+ equality, and used by the authors to support students and faculty in their chemical engineering departments. Specifically, we focus on strategies that can be adopted by individual engineering faculty members to build an inclusive environment for LGBTQ+ students and faculty in engineering.

DIVERSITY AND INCLUSION

The American Association of Colleges and Universities provides useful guiding definitions of diversity and inclusion that are particularly helpful for educators as we frame the issue of terminology.[10] We begin with these definitions because LGBTQ+, among other groups, have historically been left out of traditional efforts to increase diversity.

> *Diversity: Individual differences (*e.g.*, personality, learning styles, and life experiences) and group/social differences (*e.g.*, race/ethnicity, class, gender, sexual orientation, country of origin, and ability as well as cultural, political, religious, or other affiliations).*
>
> *Inclusion: The active, intentional, and ongoing engagement with diversity—in the curriculum, in the co-curriculum, and in communities (intellectual, social, cultural, geographical) with which individuals might connect—in ways that increase awareness, content knowledge, cognitive sophistication, and empathic understanding of the complex ways individuals interact within systems and institutions.*

It is in this context that promising practices were developed in this work to build a more inclusive learning environment for LGBTQ+ students. Strategies presented here involve (1) understanding LGBTQ+ concepts and using appropriate terminology, (2) understanding experiences of LGBTQ+ students, and (3) welcoming and supporting LGBTQ+ individuals in engineering. While this paper focuses on LGBTQ+ students, many of the practices that we suggest will contribute to an environment that is inclusive to both students and faculty from a wide range of backgrounds and demographic groups.

STRATEGY: UNDERSTANDING LGBTQ+ CONCEPTS AND USING APPROPRIATE TERMINOLOGY

The growing acronyms in the realms of gender, sex, and orientation can seem confusing, and even unnecessary to faculty who have had no personal reason to consider these human variations. In this section on terminology and concepts, we will refer to the longer acronym LGBTQIA+. This list of letters is useful to capture accurately the reality of human complexity, just as we use a host of variables to describe engineering concepts. To simplify matters, our students may be thought of as occupying some volume within a three-dimensional space of orthogonal variable—here, sex, gender, and attraction (Figure 1), similar to a P-V-T phase diagram.

On one axis we have biological sex. Most people will appear to fit into a dichotomous phenotype of male or female. However, there exists a wide range of genetic, hormonal, and physiological variation that may result in a person who does not accurately fit into a single category of male or female; these individuals may have physical traits and internal biology that we typically associate with being exclusively in either men or women. Intersex (the I in LGBTQIA+) is the term used to describe the variety of conditions that accounts for up to 2% of live human births.[11]

A person's gender identity—one's innermost concept of gender—is on a separate axis. Just as an intersex person, for example, may appear to have a distinct male biological sex on the surface and yet have internal female anatomy, a person may have apparently male biology and yet have an internal female identity. If a person's biological sex aligns with that person's self-identity, as is most common, the person is referred to as being cisgender; otherwise, that person may be referred to as transgender (T). Roughly 0.5% of people self-identify as transgender in the United States.[12] This includes individuals who identify as male, female, both, fluid, or neither gender.

On the third axis is a person's orientation, and this refers to the innate attraction experienced towards others. If a person's gender is male and their orientation is towards male, they are generally referred to as gay (G); the term homosexual is typically reserved for use in a clinical or biological context. A woman oriented towards women is referred to as a lesbian (L), although they may also use the term gay. It is important to recognize that orientation may be completely separate from a student's public actions. Many faculty encounter students who struggle reconciling their orientation with familial, religious, and social forces; they may appear heterosexual, but they may still benefit from measures to support LGBTQ+ students.

This three-axis description is a significant simplification; each axis may contain added dimensions and they do not necessarily span between binaries. For example, orientation may have divergent romantic and physical components, or varying levels of intensity (the A refers to asexual). The term queer (Q), though once thought of as a pejorative, will sometimes now be used as a blanket term to capture this complexity in one term and cover all sexual and gender minorities.

The list LGBTQIA+ is a collection of the less common, often marginalized aspects of orientation (LGBA), gender (T), and biological sex (I). This terminology may change with time; for example, it is becoming more common for students to self-identify as queer (Q), denoting an umbrella for any or many aspects of gender/sex/orientation. Furthermore, Q

will sometimes refer to "questioning" individuals, who are currently exploring or testing their identities.

An additional, very important and growing segment of our student body are allies of LGBTQ+ individuals, standing with and speaking out with them for a climate of greater acceptance.[13-16] Allies can show support for LGBTQ+ students by continuing to learn and use respectful terms used by individual students in describing themselves and their experience. Lastly, with the marked increase in same-sex couples raising children around the beginning of the century, faculty should soon expect increasing numbers of students with same-sex parents.

STRATEGY: WHO ARE OUR LGBTQ+ STUDENTS?

All of our students come to us with a wide range of intersecting identities and histories. Most of them are openly cisgender and heterosexual. However, student identities as part of the LGBTQ+ community are often hidden, and they may work very hard to keep it that way, for fear of discrimination or hostility.

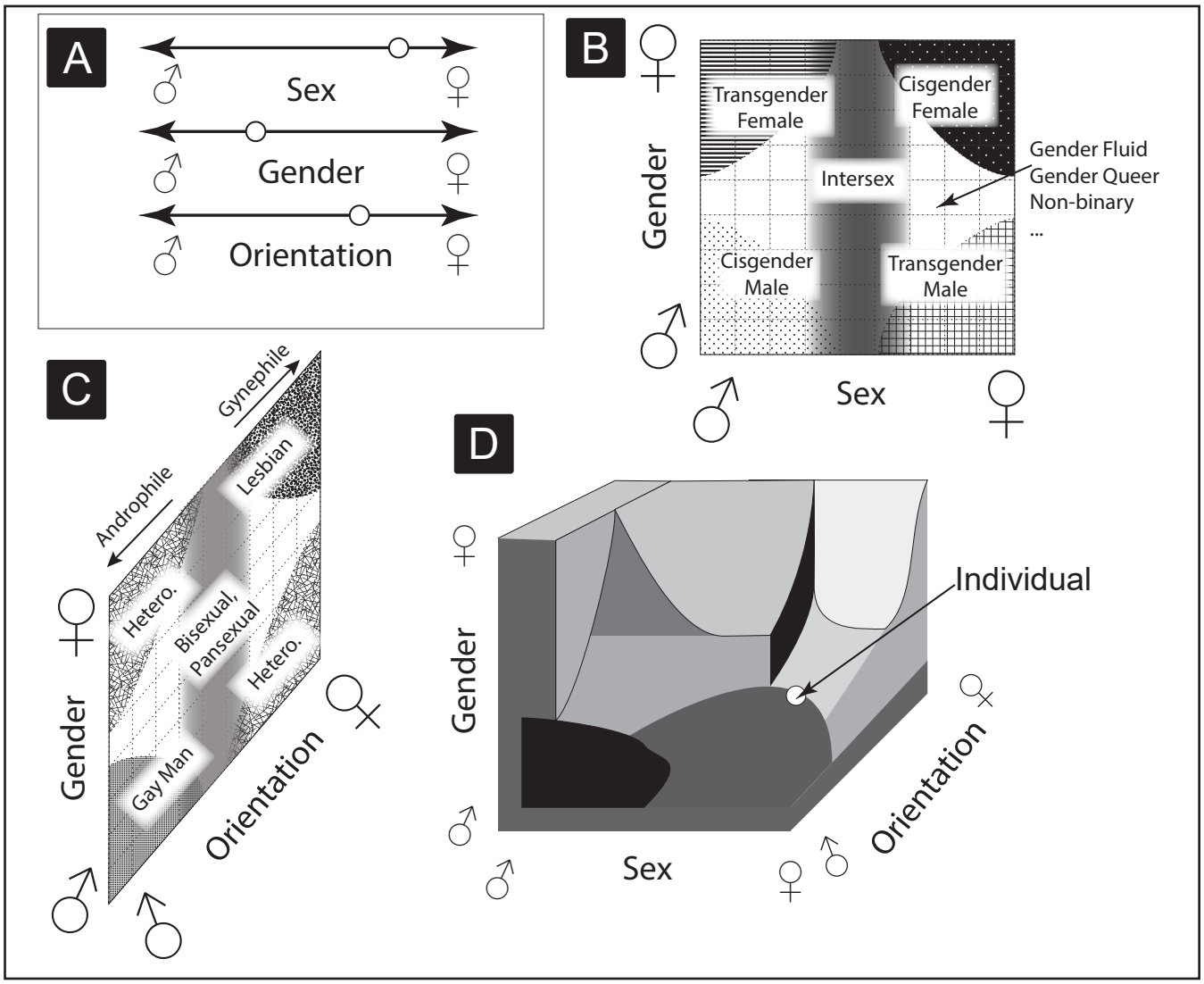

Figure 1. *Three Axes of LGBTQIA+. (A) Each person can be considered to have three independent orthogonal characteristics: 1. a biological sex resulting in male to female physical phenotypes; 2. a gender identity describing how the individual internally experiences themselves as being male or female, or both, fluid, or neither gender; and 3. an orientation towards coupling with people of certain gender expressions. (B) A person occupies some area within the plane of gender and sex and (C) the plane of orientation and gender. (D) This interplay of sex, gender, and orientation leads to complex interactions of biological realities, innate drives, and personal identities within a three-dimensional space, much like the interplay between pressure, volume, and temperature can be used to describe the state of a specific substance within a P-V-T diagram. Reality, however, is significantly more complex—with additional dimensions and fluidity—and what boundaries might appear only represent social constructs, functions of culture and history.*

Another non-typical quality of sex and gender minority populations is that they show up in roughly the same percentages across the country. Data on how many LGBTQ+ students are in STEM, in engineering, or in chemical engineering are only now being gathered and analyzed; what is available is sparse. In this section, we will give a glimpse of what that data show so far. It is important for faculty to be aware that we *do* have LGBTQ+ students, even though their LGBTQ+ identity might not be visible.

In a survey of more than 140,000 undergraduates in all majors from almost 200 different 4-year universities,[17] more than 5% self-identify as L,G,B,T and/or Q: about 3.2% as bisexual, 1.1% as gay, 0.6% as lesbian, 0.3% as transgender, and 0.5% as queer. Even more have LGBTQ+ family—for instance, children of same-sex parents account for 0.6%. However, self-reporting may result in a significant underestimation, particularly from youth who may not yet be open about their identities. In another recent study of the participation and experiences of women, racial and ethnic minorities, and LGBTQ students in U.S. engineering programs, 8.7% of the 1,729 respondents self-identified as LGBTQ.[18] The availability of data regarding gender diversity in engineering is even scarcer. For the first time, in 2017 AIChE offered a third gender option on the AIChE Salary Survey, with 0.3% of respondents choosing "other."[19] We are aware of only one source of gender diversity data for engineering students: Cech, Farrell[18] report that 1% of engineering students identify as gender non-binary. It is challenging to understand whether these numbers reflect the proportion of LGBTQ-identifying students and professionals overall, because the results may be influenced by sampling bias (which would result in overestimation) or discomfort in disclosing LGBTQ+ identity (which would result in underestimation).

It would be important to better understand the representation of LGBTQ+ individuals among the general population and student population, for example, because there are concerns about developing student community, along with funding implications associated with underrepresentation. It is worthwhile for colleges and professional societies to collect those data and track trends, to begin to understand how their members self-identify. As pointed out in an excellent piece by Elena Rodriguez-Falcon, it should be of concern to engineering faculty if representation seems low, whether this might result from underreporting (due to stigma) or from exclusion (due to unwelcoming climate).[20] However, knowing the specific percentage of LGBTQ-identifying engineering students and professionals is not needed in order to build a more diverse, informed, and inclusive profession.

STRATEGY – LEARN ABOUT THE EXPERIENCES OF LGBTQ+ STUDENTS

A landmark study involving more than 5,100 students, faculty, and administrators from all 50 states in all fields was conducted to explore how LGBT people experience campus climate and to examine behavioral and institutional responses to LGBT issues.[21] The following examples illustrate several disturbing trends that emerge from the study:

- *Within the previous year, 29% of LGBTQ students and faculty experienced harassment and discrimination.*
- *13% of LGBQ, 22% of transmasculine, 17.9% of transfeminine, and 17.3% of gender nonconforming respondents feared for their physical safety on campus.*
- *31% of LGBTQ respondents were not comfortable with the campus climate; an even higher percentage (37%) of students were not comfortable in the classroom.*
- *30% of LGBTQ individuals seriously considered leaving their institution due to negative experiences and perceptions. This percentage was highest (42%) for faculty and first-year students (72%).*

These experiences and perceptions are attributed directly to sexual orientation and gender identity, and they extend to both students and faculty. Within engineering specifically, LGBTQ+ students have different perceptions and experiences than their non-LGBTQ peers. In a national study of 1,729 students across eight institutions, LGBTQ-identifying students were more likely to report a chilly climate, less likely to report that their work is respected, and more likely to report experiencing or witnessing unfair treatment toward underrepresented students than their non-LGBTQ peers.[18] The surprising lack of variation across schools suggests that issues of LGBTQ inequality are embedded in the culture practices of engineering education and not merely reflective of program- or institution-specific climate.[18] Engineering departments have also proven more impervious to change than most other disciplines,[1-3,6,18,22,23] and LGBTQ+ engineering students are immersed in often unwelcoming and sometimes hostile heteronormative environments.[2,23] Prejudicial cultural norms and perceptions of competence can limit their opportunities for success—causing stress, social and academic isolation, and anxiety over future job security.[2,24]

One predictor of climate in STEM fields for LGBTQ+ students is the existing climate for women in these fields. Sexism has long been known to be strongly correlated with homophobia and transphobia[25-28] and this relationship seems to be no different in STEM fields. Yoder, et al. found, in STEM academia, that fields that attracted a higher percentages of women significantly correlated with greater openness for LGBT+ colleagues.[6] One clear path to improving the climate for our LGBTQ+ students is to work on further improving the climate for women engineers in our chemical engineering departments. Chemical engineering, at about 30% women engineers, has somewhat better representation than the average engineering field, at about 20%,[6] which may suggest that our discipline is a more welcoming climate for LGBTQ+ students and faculty, relatively. However, as it is for our women chemical engineers, much more can be done to improve our departments' cultures.

STRATEGY: SETTING THE CLASSROOM TONE

A CDC survey of approximately 15,000 high school students found that LGB adolescents have more often experienced school as a hostile environment than their peers, not unlike the experiences of LGBTQ college students mentioned above. LGB adolescents are more likely to have been bullied on school property (34% vs 18%) and to have skipped classes for fear for their safety (13% vs 5%).[29] It is important to recognize that these experiences may result in LGBTQ+ students experiencing apprehension in creating study groups and participating in team assignments in the lab or in the classroom. Furthermore, strained inter-student dynamics (due to anti-LGBTQ+ bias) may more likely be kept hidden from the professor. Because students may not feel comfortable disclosing their identity in a "professional setting" or for fear of bias, faculty need to be alert to invisible sources of conflict. An urgent need for increased faculty sensitivity is also revealed in a recent survey of engineering deans,[30] with 35% of engineering deans recognizing negative climate issues for LGBTQ individuals in their colleges.

Faculty can help by setting the tone of the classroom early. In our chemical engineering classrooms, we have found it valuable to include diversity statements in our syllabi, point out their presence, and discuss their meaning and importance to our role as their faculty on the first day of each class. This sends the message to LGBTQ+ students (and many other marginalized groups) that, at minimum, they will have faculty support and less of a chance to encounter hostile behavior from peers. An example of a diversity statement is below:

> *I consider this classroom to be a place where you will be treated with respect, and I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability, veteran status—and any other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming, and inclusive environment for every other member of the class.*

This sets the tone for an inclusive classroom; of course, we need to be prepared, if we see marginalizing behavior, to address it immediately. When we address unacceptable behavior quickly, we both support the student who is being targeted right away and we also communicate professional values for everyone present. If we fail to address marginalizing behavior directly, we risk inadvertent communication of implicit approval of the behavior; this would be harmful to the whole class as well as to the student being targeted.

Because our students may not identify with their gendered legal name or biological sex, it is also important to ask students for their preferred names on the first day of class. If your university does not allow students to indicate a preferred name in the student information system, the class list that you download will display students' legal names, which may not be their preferred names. Rather than use these names when you call roll and wait for a student to correct you, we suggest coming prepared with a roster containing last names only. When you call roll, all students will have a chance to indicate their preferred name.

It is also inclusive to ask students what pronouns they would like you to use for them. One way to do this is through a first-day homework assignment: For example, each student is asked to prepare an index card with name, photo, and pronouns on the front and personal interests on the back. This approach allows students time to consider which pronouns to use in the context of the class (a decision that is often made based on perceived safety and sense of inclusion); by asking all students to provide this information in a private homework assignment, no student is singled out.

STRATEGY: ADVOCATE FOR AND SUPPORT STEM-SPECIFIC LGBTQ+ STUDENT GROUPS

Another important measure faculty can take to support students is to promote and advise LGBTQ+ STEM groups and support their activities. Research on college groups is not available, but high schools with LGBTQ+ supportive clubs correlate with significantly fewer instances of at-school victimization, including fear for safety, homophobic comments, and harassment based on sexual orientation.[14] For example, we have seen significant benefits from organizing an oSTEM chapter (Out in STEM, <https://www.ostem.org/>) at the University of Utah. This student chapter began with four students, and the next year we grew to around a dozen, almost all from the department of the faculty advisor. Now, four years later, Utah's oSTEM chapter has approximately 80 student members spanning several colleges. This group has hosted Safe Zone trainings specific to STEM culture, conducted STEM outreach at the local LGBT community center to encourage LGBTQ+ youth to consider STEM careers, and managed a table at Utah's Pride Festival. We have also found oSTEM to act as important means to open dialogue and resolve conflict between students and college decision makers. Furthermore, the mere existence of the club, and its inclusion on college websites, and in official college diversity efforts, sends a message of inclusion in STEM culture to students who may not ever become members. The National Organization of Gay and Lesbian Science and Technology Professionals (NOGLSTP, <http://www.noglstp.org/>) also has active student chapters and recognizes LGBTQ+ students through scholarships and awards.

Even if you are not a faculty advisor of an LGBTQ+ student group, you can show support by advocating for them, attending events, and posting membership brochures, conference announcements, or scholarship opportunities. We have found that students pay close attention to who attends such meetings and word quickly spreads among them which engineering faculty are perceived as allies and which are not.

STRATEGY: ASSIST IN ACCESS TO SUPPORT NETWORKS

Unlike many other minority groups, the vast majority of LGBT+ students are not raised by families who share their same minority status. When they come out, many face hostility from parents, siblings, and friends; more face the dread of possible hostility or rejection if the climate seems unwelcoming. They may remain closeted or hyper-vigilant to avoid notice. Approximately a third of LGB people report loss of familial support upon coming out, and that loss of emotional and material support is also associated with negative health outcomes.[31] Some of our LGBT+ students find themselves suddenly without a place to live or money for tuition once their parents discover their status as a sexual or gender minority, which can lead to significant disruptions in their academic trajectory. Furthermore, if a student's parents are uncooperative, they may have added difficulties qualifying for financial aid through the Free Application for Federal Student Aid (FAFSA). For some international students, "home" may be unaccepting or dangerous in larger ways than we imagine for a student even from an unaccepting family or community in the United States.

Faculty and academic advisors must be prepared to instruct students on how to find appropriate resources for housing and help negotiating financial aid within their institutions without parental cooperation. Many institutions have a dean of students who can assist in the resolution of problems regarding housing and financial aid. Regarding counseling and mental health, we recommend that faculty learn what services are available to students on their campus, and have the contact information and location readily available for student referral. When a student is in serious distress, it can be very difficult for the student to take the first step to seek help, so we recommend that you personally escort the student to the counseling center. This investment in our students' well-being may seem time consuming, but is small with respect to the consequences, and being able to direct students to needed services should be regarded as a professional responsibility of the faculty and the university.

We have also found it important to check in with LGBTQ+ students before academic breaks. After coming out, some students may not be welcome in their family homes and we have found that the social networks generated within an engineering department can act as a stand-in support network over holidays.

To best serve our academic mission, faculty often adjust their interactions to account for the emotional state of their students. Impositions of personal lives on academic achievement may be more frequent with LGBTQ+ students, particularly if they are losing familial connections. As a result of negative personal experiences (experiencing marginalization in their engineering programs, devaluation of their professional contributions, and hostility and unfair treatment) LGBTQ students are significantly more likely than their non-LGBTQ peers to experience personal consequences such as nervousness, stress, depression, and difficulty sleeping to the point that it interferes with school performance.[18] It is important, in general, for faculty to make themselves aware of the campus resources available to all struggling students, and to check in with students when they show sudden declines in academic performance; having a good grasp of these resources can be an added benefit to our LGBTQ+ students.

STRATEGY: ASSIST ALL STUDENTS BY BEING VISIBLE AS AN ALLY

The term ally is used to describe a person who will stand up for the rights of other individuals in a marginalized group. The term is commonly used in the LGBTQ+ community, but other groups can benefit from the engagement, advocacy, and support of allies as well. Allies recognize their privilege and use this power to interrupt bias and prejudice, dismantle stereotypes, influence positive change, and provide support to individuals in a group with less privilege. An ally can make a tremendous impact without leading a major organizational initiative. Some of the most impactful contributions of an ally can be through everyday interaction such as speaking up for a colleague, interrupting an inappropriate joke, or listening with empathy.

Without ally visibility it is difficult for LGBTQ+ students to know who their allies are. Visible symbols of alliance such as a sign or sticker displayed in the workplace can help raise visibility of allies. Safe Zone stickers are commonly awarded to those who complete Safe Zone ally training and have been shown to benefit LGBTQ+ students and faculty in powerful and meaningful ways.[32] Other simple ways of signaling allyship include the syllabus statements described earlier in this paper, displaying information about LGBTQ+ professional events, and attending campus LGBTQ+ events.

RESOURCES FOR FACULTY

Professional societies have begun to offer LGBTQ+ ally training at their annual conferences. Since 2014 ASEE has offered multiple Safe Zone LGBTQ+ ally training workshops during technical session timeslots at its annual conference. In 2016, the American Institute of Chemical Engineers (AIChE) introduced Safe Zone training at its Annual Spring and Fall Meetings. The American Chemical Society (ACS) offered Safe Zone Level 1 and Level 2 training at its annual conference in 2016.

ASEE hosts a series of Safe Zone webinars every fall and spring during the academic year. These webinars include Safe Zone Level 1, Safe Zone Level 2, and Deep Dives on LGBTQ+ topics. More information about these webinars, and recordings of previous webinars, can be found on the ASEE LGBTQ Equality website (<http://diversity.asee.org/lgbtq/safe-zone-workshops/>).

Additional resources on LGBTQ+ inclusion in STEM have been compiled from a variety of sources including journal articles, professional society reports, and news articles, and are available at <http://diversity.asee.org/lgbtq/resources/>.

TAKEAWAY RECOMMENDATIONS

- *Include a course-specific diversity statement, supporting LGBTQ+ students along with all other listed marginalized groups, in your class syllabus.*
- *Invite all students to share their preferred name and pronouns.*
- *Know the specific resources that are available on campus to support LGBTQ+ students, including LGBTQ+ organizations, the dean of students, and counseling and mental health services.*
- *If your campus has a STEM-specific LGBTQ+ organization such as oSTEM or NOGLSTP, support their activities and have a visible presence at their events. If your university does not have one, consider helping to start a student chapter.*
- *Be visible as a supporter of LGBTQ+ students, faculty, and staff.*
- *Address anti-LGBTQ+ marginalization or discrimination when it happens.*

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