

Let's talk about sex: instructor views and hesitations related to sex and gender in the biology classroom

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Number of Text Boxes: 1

Number of Figures: 3

Number of Tables: 4

Supplemental Materials: 1 Appendix

Word count: 8147 (excluding abstract and references)

Keywords: inclusive teaching; sex; gender; biology education

Abstract

There is much current debate in the US regarding how sex and gender are approached in science and medical classrooms. There does not seem to be sufficient consensus around why it must be taught and how it should be implemented. State-enacted restrictions to both education and healthcare in recent years demonstrate the relevance and importance of sex and gender in the college classroom, not only including but *especially* in the biology classroom. Given the areas comprising the Society for Integrative and Comparative Biology (SICB), these topics of sex and gender in biology instruction are incredibly salient to our members. Thus, this survey aimed to determine instructors' views of and experiences with sex-diverse gender-inclusive biology. College-level biology instructors who are members of SICB were surveyed about their views of science, views of sex and gender, teaching philosophy, and their experiences with inclusive teaching and with sex-diverse gender-inclusive teaching. The resulting data lead us to implore academic biology to provide more sex-diverse and gender-inclusive teaching tools and resources to educators, while minimizing potential fear of retaliation and backlash to instructors who utilize these teaching methods.

Introduction

Teaching, research, and service are the three pillars of academia, and academics are typically quite familiar with these critical roles of the profession. However, pedagogical training is not consistently incorporated into biology graduate programs, despite there being a vast literature on effective pedagogy and discipline-based education research. Due to variation in training and professional development in teaching, presentations of course content vary in their angles and approaches. Depending on instructors' individual time demands and teaching loads, familiarity with and training in the course content, and textbooks (chosen or required) for use, the same content may be covered in vastly different manners. This variation can absolutely be a benefit. However, it can also pose challenges and concerns, especially with certain topics and pedagogical approaches, such as sex diversity and gender inclusivity.

Sex diversity and gender inclusivity (see Box 1) in science, medicine, and society have gained much attention. For example, in recent years, many states in the United States (US) have placed (new) restrictions on instruction, trainings, or other content related to sex, gender, and/or sexuality in public education settings (Natanson, Tierney, Morse 2024). Simultaneously, countless laws or policies have banned gender-affirming care for minors in various states (Human Rights Council Foundation 2024), and many more bans have been proposed (Equality Federation 2024). The number of laws, policies, and proposed bans on gender-affirming care changes so rapidly that these authors elect not to include the current counts here, but urge readers to check current mapped data. Tensions around sex diversity and gender inclusion in science and medicine are apparent in a collection of articles titled "Special Section: "Cancel Culture": Its Impact on Sex/Gender Teaching, Clinical Practice, and Research" (*Archives of Sexual Behavior* 2023). Despite – or perhaps, to some degree, in response to – the increasing scrutiny and restriction of sex, gender, and sexuality in educational, medical, and other settings in the US, there is increasing attention to the historical and ongoing sex- and gender-related biases in science and medicine. *Nature* (2024) and *Cell* (2024) both published special issues on sex and gender this year, and *The New England Journal of Medicine* has collections on "Medicine and Society" (2024a) and "Recognizing Historical Injustices and the *Journal*" (2024b) that present past and ongoing biases and injustices in medicine, many of which relate to sex and/or gender. Additionally, recent *Society of Integrative and Comparative Biology* (SICB) symposia and corresponding *Integrative and Comparative Biology* manuscripts have covered topics of sex, gender, and bias in biology (e.g., Lewis and Sharpe 2023; Hayssen and Orr 2020). Thus, we were interested in how this recent focus on sex and gender may be making its way (or not) into course content that SICB members teach. Prior to the 2024 annual meeting, we conducted a survey of SICB members to examine instructors' experiences with inclusive teaching, views on sex and gender, and if/how they incorporate sex-diverse gender-inclusive content into their courses. We used these data to help inform a 2024 conference workshop, "Incorporating sex diversity and gender inclusivity in biology undergraduate classrooms," and to provide a report of where we are as a Society. This paper aims to present a current snapshot of SICB members' relationships to sex-diverse gender-inclusive biology in the classroom.

Box 1. Survey Terms

Broadly, inclusive teaching serves the needs of all our students, regardless of background or identity. Inclusive teaching can take multiple forms, including: culturally competent teaching, trauma-informed teaching, and universal design for learning, among others. Inclusive teaching is not limited to the delivery of material, but can encompass all aspects of the learning environment (e.g., classroom policies and climate) and process. The following definitions were provided to survey respondents to assist them in answering questions about sex and gender:

Sex = (1) reproduction or sexual activity; or (2) anatomical and physiological traits such as genotype, internal and external sex organs, hormone levels, secondary sex characteristics; or (3) assigned sex or sex categories

Sex diversity = within-sex, hermaphroditic, and intersex diversity; as well as diversity in the number of sexes or sex morphs, extent and expression of differing modes of mating and parental care, and the extent and type of sexual dimorphisms or differences (Zemenick et al 2022)

Sex inclusion = incorporating aspects of sex diversity in a non-judgmental and inclusive manner

Gender = (1) one's understanding of oneself in relation to concepts like man, woman, trans, genderqueer, and many others; or (2) behaviors that express (or can be interpreted as expressing) something about gender; or (3) social structure within society that is relational, meaning that it is constructed through interactions between individuals, groups and institutions.

Gender diversity = umbrella term that is used to describe gender identities that demonstrate a diversity of identities and expression beyond the binary framework

Gender inclusion = incorporating aspects of gender diversity in a non-judgmental and inclusive manner

Biology instructors teach biology—the study of life—to students, to *people*, and people are more than bags of cells or collections of chemical reactions. Therefore, teaching students (and future medical and STEM professionals) about critical biological processes (e.g., energy production and flow; evolution) is absolutely necessary, but students must also be equipped with biopsychosocial and integrative knowledge about biology and the ways in which biology interacts with people, society, and policy. Future medical professionals will treat people, not just walking embodiments of textbook information. People are complex multifaceted beings whose health and behavior are indisputably impacted by biology but also by social, political, and policy decisions (see Wear et al. 2017; Matathia and Tello 2020). Identities, of which a person holds many, represent a mix of biology, society, culture, and experiences. Societies are constructed around social norms, conventions, worldviews, and ideals, which all comprise our cultures. Those sociocultural and structural environments matter, as they influence all aspects of our lives – including education, diet, access to resource, exposure to pollutants, housing, and economics. In human development, social psychology, and public health arenas, these multifaceted interactions are often described using Bronfenbrenner’s ecological model which highlights the nested nature of individuals within social groups, communities, societies, norms, cultures, and laws and policies (Bronfenbrenner 1977). The use of these integrative frameworks is common in aspects of health care and psychology (Reifsnider et al. 2005; Lehman et al. 2017; Wade and Halligan 2017). A lifecourse approach, highlighting environmental, behavioral, biological, and sociocultural influences on individuals over time, is recommended for health disparities research related to aging (Hill et al. 2015). The World Health Organization champions integration of biopsychosocial aspects of health and for the right to the highest attainable standards of physical and mental health without discrimination (World Health Organization 2023). Additionally, the importance of biopsychosocial aspects have been addressed in inclusive education (Basham et al. 2010).

Positionality, the social and political context that creates a person’s identity, impacts the questions one asks, how one interprets data, and the conclusions drawn. Referring to research questions being shaped by experience and bias, a roundtable participant in the Sexual Diversity and Variation symposium at the 2023 Society for Integrative and Comparative Biology Meeting said, “I’ve had people be more pointed about it at me: ‘Well, you’re nonbinary, so you’re just projecting your own thing onto the animals,’ but if you’re cisgender and not interrogating the role of the binary in the questions you’re asking, you’re coming in with your own biases and your experience is shaping the questions you’re asking—it’s just that you don’t have to account for that in the same way as those of us who live outside those binaries do” (Sharpe et al. 2023). Importantly, college students want lessons that are inclusive of diverse sex, gender, and sexuality, and positionality may impact this. A survey of undergraduate and postgraduate anatomy students at St. George’s, University of London (London, UK) determined that a majority (71.2%) of students surveyed agreed or strongly agreed that “improving inclusivity in anatomy education should be educators’ priority” (Longhurst et al. 2024). Longhurst et al. (2024) also found statistically significant correlations of certain genders and sexualities with responses about sex-diverse gender-inclusive anatomy teaching methods, demonstrating the relevance of positionality in the anatomy classroom, in particular, that students’ positionalities influence what and how they want to be taught. Aspects of sex determination and differentiation

processes, sex ratios, sexual anatomy and physiology, sexual behavior, and reproductive outcomes are topics that are intimately tied to evolution, natural selection, anatomy, physiology, ecology and population genetics, and myriad other topics and courses. It is impossible for instructors and students to check identities and social contexts at the door. Thus, these authors note that whether we, as instructors, realize it or not, the decision to discuss or not to discuss social, contextual, or psychological aspects of course topics is a choice with repercussions; when teaching content that has social impacts, none of our decisions are “neutral” (Kamath et al. 2022; Zemenick et al. 2022; Lewis and Sharpe 2023). Within the topics of sex and gender, not including the robust nature of this information is “taking a stance” and does, in fact, send a message to our students and to others. No matter the biological courses we teach, concepts of sex are relevant. To understand how some of these factors are at play in our SICB community, in this current sociopolitical moment, we surveyed members. Our survey asked college-level biology instructors about their experiences with inclusive teaching broadly and sex-diverse gender-inclusive teaching in particular, their views on sex, gender, and scientific objectivity, and how they teach about sex and/or gender in their own courses.

Methods

All methods used in this survey were subject to approval by the University at Buffalo (State University of New York) Institutional Review Board (Study 00007296). The full survey, including all questions asked, can be found in Supplemental Materials (Appendix A). Because the primary goal of this survey was intended to inform our workshop on the topic of teaching undergraduate courses using sex-diverse and gender-inclusive material, we selected survey questions that would be most helpful in designing the workshop. We used a mixture of survey questions belonging to research-validated surveys (Beatty et al. 2023) and our own questions. The survey consisted of 50 questions followed by 17 questions related to demographics and respondents’ teaching institutions. The survey was designed using Qualtrics survey software and the Qualtrics online survey was distributed to members of the Society for Integrative and Comparative Biology (SICB) through a member email listserv. Respondents were able to skip questions if they did not want to provide answers, leading to varying response rates for questions. Data reports were generated in Qualtrics and exported into and analyzed in Microsoft Excel. Descriptive statistical methods were used to determine percentages of responses. Open-ended responses were reviewed by BH and KL and responses were summarized in the results section. This survey received a low response rate, and the study is limited by the sample size. This small, descriptive study does not intend to provide conclusions that should be necessarily extrapolated to a larger population, but it does aim to provide a snapshot of SICB members’ views, perspectives, and experiences. Responses are not assessed based on demographics due to the sample size. Percentages and counts are reported throughout. Neutral and no opinion responses were reported in a combined “neutral or no opinion” category. A word cloud (Figure 3) was generated using artificial intelligence (AI) after filler words were removed. The authors take a constructivist and postpositivist approach to this project: objectivity cannot be obtained due to the authors’ assumptions and biases, and the context and manner of data collection and analysis can influence the findings.

Participant demographics

This survey had 147 United States (US)-based respondents who consented to participate in the study. Respondents who indicated that they do not teach in the US were removed from the study, due to this study's aim to focus on sex-diverse gender-inclusive biology in the current US sociopolitical climate. Not all 147 respondents completed every question in the survey. Survey questions typically received responses from between 105 and 132 participants. The number of respondents for a particular survey answer is provided along with the percentage throughout the survey results reported here. 89.81% (97) of responding participants identified as White (or a synonymous term), 3.70% (4) as Hispanic or Latino/a/x, 1.85% (2) as Asian or Asian-American, 1.85% (2) as Ashkenazi, 0.93% (1) as Black or African-American, and 0.93% (1) as South Asian or South Asian-American, while 1 preferred not to answer. 75.96% (79) of responding participants did not identify as a person with a disability or other chronic condition, while 22.12% (23) did, and 2 preferred not to answer. When asked about the gender participants think of themselves as, participants identified as: cisgender woman (47.79%, 54), cisgender man (27.43%, 31), non-binary (7.96%, 9), genderqueer (5.31%, 6), transgender men or transmasculine (2.65%, 3), transgender woman or transfeminine (1.77%, 2), genderfluid (1.77%, 2), and agender (1.77%, 2). Four participants (3.54%) chose to write in their gender identity in place of one of the listed genders. When asked "have you ever been diagnosed by a health professional with an intersex trait or condition or a difference of sex development (DSD), or were you born with (or developed naturally during puberty) genitals, reproductive organs, or chromosomal patterns that do not fit standard definitions of male or female," 2.91% (3) respondents answered yes, 1.94% (2) preferred not to answer, and 0.97% (1) did not know. Participants identified themselves as having a range of sexualities/sexual orientations; just more than half identified as straight or heterosexual (55.08%, 65) and nearly half (44.92%, 53) identified in non-straight/heterosexual ways. Respondents identified as queer (14.41%, 17), bisexual (12.71%, 15), gay (5.93%, 7), asexual (4.24%, 5), "I do not know" (1.69%, 2), lesbian (1.69%, 2), or using a term that was not listed (3.39%, 4), these individuals self-identified as pansexual (2), demisexual (1), and bi demiromantic (2)).

The majority of responding participants (80.39%, 82) hold PhD/EdD degrees as their highest level of education; 10.78% (11) hold Bachelor's degrees, and 8.82% (9) hold Master's degrees. Respondents predominantly hold their highest degrees in biological sciences (including integrative/organismal biology), ecology and evolution, zoology, and neuroscience/neurobiology/behavior. Few participants hold degrees in geology, geophysical sciences, paleontology, botany, and anatomy. Most participants teach at PhD-granting institutions (48.08%, 50) or Primarily Undergraduate Institutions (PUIs; 45.19%, 47). Others teach at Master's-granting institutions (2.88%, 3), community colleges (0.96%, 1), or other institutions (museums or outside of academia). The institutions participants teach at are mostly public (60.19%, 62) and 39.81% (41) are affiliated with private universities. Most respondents (76.70%, 79) do not teach at Minority Serving Institutions (MSIs), which include Hispanic-serving institutions (HSIs) or Historically Black Colleges or Universities (HBCUs). 21.36% (22) of respondents indicated that they were affiliated with MSIs, while 1.94% (2) were not sure.

Location data: we categorized geographical regions of the United States following the United States Census Regions and Divisions: Northeast (CT, ME, MA, NH, RI, VT, NJ, NY, PA), Midwest (IL, IN, MI, OH, WI, IA, KS, MN, MO, NE, ND, SD), South (AL, AR, DE, DC, FL, GA,

LA, KY, MD, MI, OK, NC, SC, TN, TX, VA, WV), and West (AZ, CO, CA, HI, OR, ID, MT, NV, NM, UT, WY, WA). We received responses from participants in 34 different states, plus 8 participants (7.8%) who did not wish to disclose. Among those in the United States, participants' institutions were located in the South (27.2%, 28), West (24.2%, 25), Northeast (22.3%, 23), and Midwest (18.4%, 19). Most survey participants (49.07%, 53) are tenure-track research faculty, followed by graduate students (22.22%, 24), tenure-track teaching faculty (13.89%, 15), Postdoctoral researchers (9.26%, 10), Emeritus faculty (2.78%, 3), non-tenure track faculty (1.85%, 2), and adjunct instructors (0.93%, 1). Participants largely are involved in the instruction of biology courses in higher education (89.32%, 92). Courses taught include introductory biology classes, anatomy and physiology (including environmental physiology and comparative courses), animal behavior, genetics/genomics, ecology/evolution, biodiversity, cellular and molecular biology, zoology (including specific courses such as ornithology, mammalogy, invertebrate biology, and entomology), neuroscience, sensory biology, neuroendocrinology, botany, science policy, science writing, histology, and developmental biology. Our survey participants reported that they teach upper-level courses that require at least one pre-requisite (34.4%, 54), a combination of lower level, upper level, or graduate courses (24.8%, 39), lower level majors (introductory) courses (20.4%, 32), graduate level only (10.2%, 16), lower level non-majors or general education courses (7.6%, 12), or they reported that they do not teach (2.6%, 4). Most respondents report that they teach classes with 25 or fewer students per class (40.0%, 50), between 25-50 students per class (32.8%, 41), between 50-100 students per class (17.6%, 22), between 100-200 students per class (5.6%, 7), or more than 200 students per class (4.0%, 5).

Results

This survey asked college-level biology instructors about their views on sex and gender, and how these are addressed in their college classrooms (see "Views on sex and gender"). Due to the prevalence of "scientific objectivity" in objections to sex-diverse gender-inclusive biology, respondents were asked about their science and scientific objectivism (see "Views on science"). Respondents were asked about their own experiences with inclusive teaching and sex-diverse gender-inclusive teaching (see "Experiences with inclusive teaching," "Teaching philosophy"). This survey asked participants about their knowledge of and comfort with incorporating sex-diverse gender-inclusive information in their courses (see "Knowledge of and comfort with sex and gender diversity and inclusion") and why they did or did not do so (see "To include or not to include? Personal and professional concerns and consequences"). Given both the topic and the goals/nature of this survey, there were a variety of responses to these questions. Finally, this survey asked college-level biology instructors what support or resources would be necessary or helpful to improve the implementation of gender diversity/inclusivity topics, and what the worst-case scenario of implementing sex-diverse and gender-inclusive material in courses may be (see "To include or not to include? Personal and professional concerns and consequences").

Views on sex and gender

Respondents were surveyed about their views of sex and gender. The vast majority (88.99%, 97) of respondents agree that *biological sex occurs on a spectrum or mosaic* (68.81%,

75, absolutely agree, 20.18%, 22, somewhat agree), and even more respondents (95.33%, 102) agree that *gender occurs on a spectrum or mosaic* (93.46%, 100, absolutely agree, 1.87%, 2, somewhat agree) (Figure 1). More respondents consider gender to be socially constructed than sex: 42.4% of respondents agree that *sex is socially constructed* (13.76%, 15, absolutely agree, 28.44%, 31, somewhat agree), while 91.59% agree that *gender is socially constructed* (71.03%, 76, absolutely agree, 20.56%, 22, somewhat agree) (Figure 1). This difference may be because gender is often defined as a social construct, but considering sex to be socially constructed feels counter to the major definitions of sex that biologists are taught. However, since *people* characterize and define the various (biological) components of sex (i.e., genomic, gonadal, gametic, hormonal, morphological, etc.), and sex is assigned to infants at birth (typically via external genitalia morphology) by *people*, then it is reasonable to say that sex is socially constructed. In summary, instructors largely agreed that sex and gender are both best discussed as spectra or mosaics, and that culture plays a role in these constructs.

Views on science

Respondents were asked questions that related to their views on scientific objectivism - that is, the belief that science is an objective process, free from bias or outside influences, which provides data and conclusions that are close approximations of natural, objective “truths”. Most scientists likely agree that attempts to remain objective and to limit bias, in experimental methods and data interpretation, is an important ideal of science and the scientific method. Scientists should make every possible attempt to limit bias and influence in scientific experimentation. However, there seems to be less agreement on how well we, as humans that live in society, can fully do that – it is not clear that we can ever be truly and fully objective, given our own lived experiences and views. Respondents’ views did not support an objectivism mindset, as the majority absolutely (44.23%, 46) or somewhat (33.65%, 35) disagreed with the following statement: *Scientific experimentation, data collection, and data interpretation are completely objective, unbiased, and apolitical*. These outcomes are in line with recent publications highlighting the role of scientist identities and how they influence how we shape our scientific questions, analyses, and conclusions (Saini 2020; Kamath et al. 2022; Lewis and Sharpe 2023; Nelson 2017; Thorp 2023). This is also incredibly salient to health care, as social determinants of health – factors such as conditions in which people live and work, income level and security, education level, employment, gender, culture, social support, and social norms and attitudes (World Health Organization 2024; Healthy People 2030 US Department of Health and Human Services) – highlight how social and societal aspects matter for health and disease. These connections of health, environment, and context are also true for other organisms and the interaction of science, society, and policy is relevant across areas of biology. In summary, instructors agreed that science is not purely and wholly objective.

Experiences with inclusive teaching

Respondents were asked questions related to their understanding of and experiences with inclusive teaching. The majority of respondents (85.04%, 108) agree, and 8.66% (11) slightly agree, with the statement *efforts towards inclusive teaching are personally important to me*. When respondents were asked how well they feel they understand the core concepts underlying inclusive teaching overall, the majority (59.09%, 78) have read some materials or

attended workshops/presentations, but still feel they have a lot to learn, while fewer (18.94%, 25) feel they have a basic understanding, but have not read much literature, or (18.18%, 24) they read widely (and/or publish) in this area, try to keep up to date with new literature, and feel they have a solid understanding of inclusive teaching. A very small number (3.03%, 4) were unsure or not at all (0.76%, 1). Survey respondents were likely to *voluntarily attend a workshop, presentation, or session with a focus on inclusive teaching* (40.91%, 54, extremely likely, 38.64%, 51, moderately likely, 13.64%, 18, somewhat likely). Most respondents (73.48%, 97) have *attended a voluntary workshop on inclusive teaching*, while fewer than half (46.21%, 61) had *participated in inclusive teaching trainings or programs within the past 12 months*. Overall, most survey respondents value inclusive teaching and were interested in learning more about inclusive teaching and would voluntarily attend inclusive teaching training(s).

Respondents were asked about emphasis on inclusive teaching. Most respondents disagreed (64.57%, 82) or slightly disagreed (21.26%, 27) with the statement *in general, there is too much emphasis placed on inclusive teaching*. Similarly, 36.22% (46) agreed and 37.80% (48) slightly agreed that *in general, there is not enough emphasis placed on inclusive teaching*. Many survey respondents think that *efforts towards inclusive teaching are important at their academic institutions* (38.58%, 49, agreed, 28.35%, 36, slightly agreed), although 21.26% (27) responded neutrally. When asked about access to inclusive teaching resources—*In my home institution, or via societies I am part of, I have access to resources that support inclusive teaching practices*—most respondents reported having access to such resources (36.22%, 46, agreed, 37.01%, 47, slightly agreed). When asked about inclusive teaching in relation to the mission of academia, most respondents disagreed (82.26%, 102) or slightly disagreed (8.87%, 11) that *efforts towards inclusive teaching distract us from the mission of academia*, and most respondents agreed (82.26%, 102) or slightly agreed (11.29%, 14) that *efforts toward inclusive teaching enhance the mission academia*. Overall, survey respondents are in support of emphasis on inclusive teaching, many feel that their institutions value inclusive teaching, and consider inclusive teaching to be part of the mission of academia.

Teaching philosophy

Respondents felt that *the classroom is a useful site for discussing social and societal issues as they relate to course content* (65.32%, 81, agree; 25.81%, 32, slightly agree), and that *science education should not remain separate from social and societal issues* (68.55%, 85, disagreed and 21.77%, 27, slightly disagreed that science education should remain separate from social and societal issues). Respondents consider it to be important for *students to be exposed to sex inclusive* (69.81%, 74, extremely important, 17.92%, 19, moderately important) and *gender inclusive materials* (68.87%, 73, extremely important, 16.98%, 18, moderately important) (Figure 2). Respondents also believe it is important for *students graduating from their own institutions to be exposed to a curriculum that includes perspectives on sex diversity and inclusivity* (70.09%, 75, extremely important, 16.82%, 18, moderately important) and *diverse perspectives on gender and inclusion* (69.81%, 74, extremely important, 15.09%, 16, moderately important) (Figure 2). Thus, opposition to inclusive teaching, in general, or inclusion of sex and gender diverse items, specifically, do not appear to be reasons why instructors do not teach about sex and gender. Thus, these results suggest our SICB respondents feel that context matters in science, and that social and societal issues are not only relevant but should be discussed in the classroom.

Therefore, it does not seem instructors exclude sex and gender inclusive material due to their overall philosophical views of course design.

After being asked *how important do you believe it is for students graduating from your institution to have exposure to a curriculum that includes perspectives on sex diversity and inclusivity?* Respondents were then prompted: *explain your reasoning for your answer to the above question about your views on if students graduating from your institution should have exposure to a curriculum that includes diverse perspectives on sex diversity and inclusivity.* Respondents discussed scientific accuracy (e.g., variation is the norm in science and teaching sex and gender diversity is good, accurate science), real-world implications (e.g., students will be exposed to this content after school and in the professional workforce), dismantling barriers (e.g., social justice and equity relevance), inclusion of current students (e.g., increase belonging for students who are sex and gender diverse), and relevance (e.g., sex and gender are salient in all aspects of our society). A few specific examples of those responses are below.

"Students should leave a science program educated about gender/sex diversity to go out into the world where these topics are socially misinformed and students should be knowledgeable about recognizing misinformation and with the ability to supply accurate information."

"I think the more people who are willing to consider that biology isn't about assigning discrete categories to continuous processes, the better! Not only for their own understanding of biology, but of the nuance present every day in the world around us and the people we interact with."

"Students must be exposed to the biological realities of sex, not just the simple (e.g., binary) ways we've chosen to portray sex in textbooks. From a practical standpoint, giving students these perspectives prepares them for the reality of VARIATION in sex (so, perhaps they won't be so surprised in real life). From an academic standpoint, "diverse perspectives on sex diversity and inclusivity" is inevitable if one is to provide students with state-of-the art, scientifically sound perspectives. It's lazy to present sex in any way BUT with diversity and inclusivity in mind (imo!)"

Overall, the responses were overwhelmingly in favor/supportive of inclusion of sex and gender inclusive and diverse materials. Of those few respondents who were less supportive of these topics, the comments tended to focus on divergent philosophical views – for example, that sex and gender diversity violates objective truths, a disbelief in the constructs, or that students/institutions may not be receptive to the material. A few examples of those responses are below.

"sex is binary"

"Not pertinent in Biology and I don't have time to focus on issues that impact less than 1% of the population."

"I teach biology, not sociology. Is factual not opinion"

“Again, gender of humans is not pertinent to biology. If it is on a spectrum and changes over short periods of time based on mental state, how are we to cover this in class and why?”

“Because while people who don't fit the XX or XY chromosome profile exist, they are extremely rare, so it seems weird to say in class here's how X and Y's work except for these few cases here where that's not the case? Gender inclusivity is important, sexual orientation inclusivity is important, body diversity is important, but sex inclusivity is so rare that it seems odd to discuss?”

“because i agree that gender is a social construct, I tend to not think about it in my classes, as I typically don't cover human social interactions”

Knowledge of and comfort with sex and gender diversity and inclusion

Interestingly, despite the above overall views (i.e., that science is not objective, that social and societal issues should be addressed as they relate to course content, that sex and gender are spectra/mosaics, and that students should learn sex and gender diverse content), there was less agreement on how comfortable the survey respondents felt with their knowledge and coverage of these topics.

Respondents were surveyed about their general knowledge and comfort around the topics of sex diversity and inclusion. Overall, approximately one in five (20.37%, 22) respondents absolutely *feel they have the vocabulary, knowledge base, and understanding to confidently and inclusively discuss sex topics in the classroom*, and approximately half (49.07%, 53) somewhat feel they have this. Approximately one in five (21.30%, 23) slightly feel they have this, and the remaining 9.26% (10) answered not at all. Respondents were slightly less confident in their *understanding of core ideas and concepts underlying sex inclusive teaching*, as almost half (43.52%, 47) indicated *I have read some materials or attended workshops/presentations, but I still feel I have a lot to learn*, and approximately one third of respondents (32.41%, 35) answered *I feel I have a rudimentary understanding, but have not read much literature*, and only 15.74% (17) of respondents *read widely (and/or publish in this area, try to keep up to date with new literature, and feel they have a solid understanding of inclusive teaching*. Thus, it appears instructors have some confidence in their knowledge and preparation for sex-inclusive teaching, but most feel they have more to learn. These views on personal mastery could factor into the decision to include or not include certain materials. When asked about their *comfort level in teaching sex diversity in their course(s)*, 23.15% (25) of respondents were extremely comfortable, 42.59% (46) were moderately comfortable, and 21.30% (23) were somewhat comfortable, while 6.48% (7) were slightly comfortable, and 6.48% (7) were not comfortable at all. Respondents were then asked about how comfortable they are with how their course curricula handle topics related to sex diversity and inclusion. Roughly half of respondents reported being very (23.42%, 26) or somewhat (31.53%, 35) comfortable, 12.61% (14) being somewhat uncomfortable, ~1% (0.90%, 1) being very uncomfortable, and 31.53% (35) responding neutral or no opinion on *how comfortable they are with how their course curricula handles topics related to sex diversity*. For *how comfortable they are with how their curricula handles topics related to sex inclusion*, we got similar responses with nearly half being very (19.82%, 22) or somewhat (31.53%, 35) comfortable, 11.71% (13) being slightly uncomfortable, 1.8% (2) being very uncomfortable, and 35.14% (38) responding neutral or no

opinion. Overall, respondents have some level of comfort with teaching about sex diversity and with how their courses handle sex diversity and inclusion.

Respondents were also surveyed about their general knowledge and comfort around the topics of gender diversity and inclusion. Overall, as with knowledge about sex, approximately one in five (20.56%, 22) absolutely feel and nearly half (45.79%, 49) somewhat feel that they *have the vocabulary, knowledge base, and understanding to confidently and inclusively discuss gender topics in the classroom*, while 28.04% (30) slightly feel they have this, and 5.61% (6) do not at all feel they have this. Respondents were slightly less confident in *their understanding of core ideas and concepts underlying gender inclusive teaching*, as more than half (52.34%, 56) chose *I have read some materials or attended workshops/presentations, but I still feel I have a lot to learn*, and approximately one quarter of respondents (24.30%, 26) chose *I feel I have a rudimentary understanding, but have not read much literature*, and only 15.89% (17) of respondents *read widely (and/or publish in this area, try to keep up to date with new literature, and feel they have a solid understanding of inclusive teaching*. This survey found that instructors have some confidence in their knowledge and preparation for gender inclusive teaching, but most feel they have more to learn. When asked *how comfortable they are teaching concepts of gender diversity in their course(s)*, approximately a quarter (25.23%, 27) of respondents reported being extremely comfortable, nearly one-third (32.71%, 35) moderately comfortable, 17.76% (19) somewhat comfortable, 14.02% (15) slightly comfortable, and 10.28% (11) not at all comfortable. When asked *how comfortable they are with how their course curricula handle topics related to gender diversity/inclusivity*, nearly half of respondents reported being very (19.81%, 21) or somewhat (27.36%, 29) comfortable, nearly two-fifths (39.62%, 42) neutral or no opinion, 11.32% (12) somewhat uncomfortable, and 1.89% (2) very uncomfortable. Overall, respondents have some level of comfort with teaching about gender diversity and with how their courses handle gender diversity and inclusion.

Given the nature of the survey and wording, we cannot know the motivation behind the comfortable/uncomfortable rating (e.g., are they comfortable as they have the material included and they like that; are they comfortable because they do not have the material and they like that; are they uncomfortable because they do not have the material and feel they'd like to, etc.). However, most instructors reported being comfortable with their knowledge of sex and gender diversity and inclusion, and with coverage of these topics in their course curriculum. Thus, comfort and mastery of material may play a role in if and how instructors incorporate diverse sex and gender material into the curriculum.

To include or not to include? Personal and professional concerns and consequences

Participants were asked whether they *purposefully build sex and gender inclusive language into their biology courses*, and four of five (80.51%, 95) respondents said yes, whereas the other one in five have not done this (14.41%, 17, answered no, I have not added it; and the remaining 5.08%, 6, answered no, it because I am not familiar with what it is). For respondents that do not (or did not yet) purposefully add sex and gender inclusive language, they discussed (1) lack of control over content (e.g., being a graduate student TA; teaching one section of a large intro course with a prescribed curriculum), (2) philosophical disagreements (e.g., adherence to the binary framework of sex), (3) not justified (e.g., not relevant, my courses do not address sex and gender, not enough time, too much effort), (4) unfamiliarity. Among

those that do purposefully build sex and gender inclusive language into their biology courses, and they reported many reasons for doing this, including: (1) they don't want to present cisgender and heterosexual norms that are often explicitly or implicitly taught in biology and/or they want to present the diversity of sex and/or gender, (2) inclusion, i.e. it helps students feel more comfortable and included, (3) they believe it is important, and (4) accuracy. Respondents also reported that they build sex and gender inclusive language into their courses in an effort to validate and respect LGBTQIA+ people, because of their own identities and related experiences, and/or because it is important for current legislation in the US. While 58.18% (64) of respondents have *implemented sex diverse content in their classroom(s)*, fewer have implemented gender inclusive content. It's possible that gender inclusive language and sex diverse content are more accessible, easier, or seem more relevant to course topics than gender-inclusive content for instructors to implement: fewer instructors (only 38.68%, 41) have *implemented gender inclusive content in their classrooms* (32.08%, 34, responded "no" and 29.25%, 31, responded "not sure"). Survey respondents who indicated they have implemented gender inclusive content in their classrooms did this in many ways (Table 1).

In this survey, respondents were asked *what support or resources would be necessary or helpful to improve the implementation of gender diversity/inclusivity topics* and the most requested item was access to ready-made materials or activities (30.43%, 28). Instructors also indicated that more personal knowledge on the topic of (gender) inclusive teaching (22.83%, 21), more buy-in from department and/or upper admin (16.30%, 15), and more time in their syllabus (10.87%, 10) would be necessary or helpful for improving implementation of gender diversity/inclusivity. Fewer instructors surveyed indicated that more personal knowledge of the topic of gender diversity (2.17%, 2), more personal knowledge on the benefits of teaching sex diversity and inclusivity (3.26%, 3), or more buy-in from students (3.26%, 3) would be helpful. Respondents were also asked *what support or resources would be necessary or helpful to improve the implementation of sex diversity/inclusivity topics* (Table 2) and the most requested item was more personal knowledge on the concept of (sex) inclusive teaching (21.64%, 58), although nearly as many respondents indicated it would be necessary or helpful to have access to ready-made materials or activities (20.90%, 56). Instructors also indicated that more personal knowledge of the topic of sex diversity (14.18%, 38), more buy-in from department and/or upper admin (13.43%, 36), and more time in their syllabus (13.06%, 35) would be necessary or helpful. Fewer instructors surveyed indicated that they would benefit from more buy-in from students (8.21%, 22) or more personal knowledge on the benefits of teaching sex diversity and inclusivity (4.85%, 13). Respondents were able to select multiple responses to this question. Based on these responses, training on the concepts of sex and gender inclusive teaching and ready-made course materials and activities would be helpful for biology instructors.

The majority of respondents (78.30%, 83) *feel that in their place of work, they have the freedom to discuss topics of sex and gender within their curricula*, approximately one in ten (10.38%, 11) do not feel they have that freedom due to institutional concerns, and another approximate one in ten (9.43%, 10) do not feel they have that freedom due to concerns outside or broader than their institution. Most respondents felt that, to some degree, their *department's culture supports discussions of sex and gender within their classrooms* (38.10%, 40, absolutely agree; 38.10%,

40, somewhat agree), while some disagreed (9.52%, 10, somewhat disagree; 1.90%, 2, absolutely disagree), and a small number of respondents felt neutral or had no opinion (12.38%, 13) regarding their department's culture supporting discussions of sex and gender in their classrooms. Although most respondents felt free to discuss sex and gender in their place of work and supported to have these conversations in the classroom, concerns about retaliation came to light when participants were asked the following: *Some people may report concerns about implementing this material into courses. In these cases, what do you think is the worst-case scenario of implementing sex diverse and gender inclusive material in your course?* There were several responses about retaliation, fear, and pushback (Figure 3). These responses highlighted concerns about consequences and harassment, particularly with relation to their own career and safety (e.g., poor student evaluations; student and/or parent complaints; lack of administrative support; being fired; involvement of reactionary or political groups; doxxing), are very real, especially for individuals in states with anti-diversity, equity, and inclusion (DEI) legislation and/or with conservative leadership.

Discussion

This survey was sent to active members of the Society of Integrative and Comparative Biology (SICB) and asked college-level instructors (of any academic position) to complete a survey regarding sex-diverse and gender-inclusive biology education. This survey was an initial examination of SICB members who are also instructors; results may be skewed by who would elect to complete a survey on sex-diverse gender-inclusive biology to include proportionally more instructors who are engaged with these topics already. Of those who chose to respond, the majority had some familiarity with the topic, but felt they had more to learn. From college-level biology instructors' perspectives: these topics are relevant, should be included in curricula (when applicable), and students should be exposed to these topics during their educational careers. Most respondents have previously attended a voluntary workshop on inclusive teaching, find efforts towards inclusive teaching to be personally important, are interested in learning more about inclusive teaching, and would voluntarily attend inclusive teaching training(s). As with any topic or pedagogical approach, buy-in from students and administration is important (see Harris et al. 2020). Given our own experiences and discussions with peers, the authors hypothesized that fears of retaliation or pushback and lack of buy-in would underlie a significant lack of sex-diverse gender-inclusive language and content in biology classrooms. We found that most respondents felt they had the freedom to discuss sex and gender in their place of work, and most reported that their department's culture supported discussions of sex and gender in their classrooms, but some respondents did express fear of retaliation and backlash. We also found that instructors would find it necessary or helpful to have more personal knowledge on the concepts of sex and gender inclusive teaching, as well as access to ready-made materials or activities, both of which could be offered by either individual institutions, a network of biologists, or academic societies.

For biology educators who prioritize sex-diverse gender-inclusive biology education, this may be primarily the result of wanting students to feel valued and included. While this should be reason enough for all biology educators, some individuals, either in academic biology or outside of it, find this controversial, and it is crucial to emphasize that sex-diverse gender-inclusive

biology is, in addition to helping students feel valued and included, simply the most accurate and appropriate pedagogical approach. There is a long history of binary sex essentialism being taught, researched, and accepted in biology as factual. Historically, the large gamete (egg) reproductive system has been treated as passive, without autonomy, and secondary in importance or interest to the small gamete (sperm) reproductive system for much of biology's history and ongoing research and education (Orr et al. 2020). It is past time to correct this bias, and to do so without binary sex essentialism, cisheteronormativity (the assumption that being cisgender and heterosexual are the norm), or the exclusion of intersex, transgender, and nonbinary individuals. Sex-diverse gender-inclusive biology education minimizes confusion and harms no one. It is simply more precise to define terms before their use, and more accurate to refer directly to the traits in question. Inclusive educational practices are not reviewed here, and these authors direct readers to Harris et al. (2024) for these, and to Sharpe et al. (2023) for a sex-diverse gender-inclusive biology resources list. However, we do provide an initial list of examples below. For more details, please see the noted papers (and references therein).

Examples of sex-diverse gender-inclusive changes include:

- Defining how the terms “sex” and “gender” and other terms related to sex traits are used, and using accurate, precise, appropriate language without invoking gender, e.g. it is more accurate and concise to say that ovaries produce eggs, rather than saying “women” or “females” produce eggs or large gametes
- The use of gender-inclusive genetics tools such as pedigree charts and Punnett squares that refer to large gamete producers, egg givers, or egg parents rather than females, women, or mothers
- Teaching sex-diverse sexual development, i.e. including intersex variations (InterACT n.d.) in the developmental trajectories of anatomies and physiologies in a manner that does not “other” or pathologize intersex variations

Recommendations have been made for sex, gender, and sexuality diversity inclusion in biology classrooms. According to the science educators behind the “Gender-Inclusive Biology” website, Long, Steller, and Suh (2021) recommend using five attributes to guide adapting a lesson to be inclusive of diverse sex, gender, or sexuality (Long, Steller, & Suh 2021, summarized in Table 3). Although these recommendations are intended for high school science teachers, they are applicable and important for college-level biology classrooms, as well. Zemenick et al. (2022), several of whom are behind Project Biodiversify (Project Biodiversify n.d.), proposed six principles for embracing gender and sexual diversity in postsecondary biology classrooms (Zemenick et al. 2022, summarized in Table 4). A set of fourteen recommendations for creating a more inclusive environment for LGBTQ+ people in academic biology has been proposed by a group of LGBTQ+ biology educators that stemmed from an LGBTQ+ special interest group at the Society of the Advancement of Biology Education Research (SABER) annual meeting (Cooper et al., 2020). These recommendations include, but are not limited to, creating an inclusive biology classroom and discussing the diversity of gender and sexuality in biology classes (Cooper et al. 2020).

Research on STEM education reform in academic departments has found many barriers to instructional innovation (Shadle et al. 2017; Brownell and Tanner 2012). Broadly speaking, barriers to faculty change are lack of time, training, and incentives (Brownell and Tanner 2012). Specifically, barriers to instructional innovation and/or faculty change include lack of pedagogical training (Walczyk et al. 2007), fears that colleagues will have negative views of spending too much time on teaching compared with research (Parker et al. 2016), teaching effectiveness not being significantly weighted or unknown weight assigned for tenure and promotion (Walczyk et al. 2017), and course redesigns not being considered for tenure and promotion (Parker et al., 2016) (summarized in Shadle et al. 2017). We suspect that similar barriers could be at play with sex-diverse gender-inclusive biology, compounded by sociopolitical impacts such as fear of retribution and fear of job loss. Faculty change towards teaching biology in a sex-diverse gender-inclusive manner is likely subject to the barriers found for faculty change in teaching, with additional significant barriers of lack of support and lack of protection. In order to increase prevalence of sex-diverse gender-inclusive biology education, both cultural and institutional changes will be necessary. Cultural changes within academic science towards valuing teaching as much as research paired with institutional changes providing more weight to teaching in tenure and promotion may increase faculty investment in teaching, making room for the labor of implementing gender-inclusive pedagogy and content in biology classrooms. Potentially impactful institutional changes include providing time for instructional innovation, such as through course releases; institutional funding and labor to provide gender-inclusive science education workshops for faculty, instructional staff, and teaching assistants; and revising tenure and promotion guidelines to incentivize inclusive teaching. Important for gender-inclusive biology education in particular, institutional protections for faculty, instructional staff, and teaching assistants who elect to teach their biology courses in a gender-inclusive manner must be enacted, whether these protections are secured by department, college, university, or union.

There is much current and recent debate in the US regarding how sex and gender are approached in science and medicine (*Archives of Sexual Behavior* 2023; *Nature* 2024; *Cell* 2024). There does not seem to be sufficient consensus around why sex diversity and gender inclusion must be taught and how it should be implemented. This survey aimed to determine what instructors' experiences are of and with sex-diverse gender-inclusive biology. Previous conversations at the Sex Diversity and Variation symposium at the 2023 Society for Integrative and Comparative Biology conference (Sharpe et al. 2023) and at gender-inclusive biology presentations at Society for Integrative and Comparative Biology conferences led these authors to hypothesize that biology instructors want to teach in a sex-diverse gender-inclusive manner, but lack the support and resources to do so. These data implore academic biology to provide more sex-diverse and gender-inclusive teaching tools and resources to educators, while minimizing potential fear of retaliation and backlash to instructors who utilize these teaching methods. Policymakers need to protect educators, not limit what they can be trained on and what they can teach. Educational institutions need to support instructional innovation. This survey can be used to inform future efforts for sex-diverse gender-inclusive biology education: access to ready-made activities and materials and more personal knowledge on sex and gender inclusive teaching would be the most helpful for instructors to implement sex and gender

diversity and inclusivity in their courses. We hope to see academic societies, universities, and organizations support instructional innovation for sex-diverse gender-inclusive biology, with protection rather than persecution from state legislature.

Acknowledgments

Many thanks to Cissy Ballen, Associate Professor at Auburn University, who offered guidance on survey development and analysis. Thanks to the SICB members who took the time to complete the survey and to SICB for distributing the survey to its member email listserv. Special thanks to SICB for its support of the 2024 symposium “What do trade-offs mean to reproducing females?: An integrative look at whole-organism trade-offs” and for past symposium support. As always, we are grateful to our colleagues and particularly our past SICB symposium co-organizers, Sam Sharpe and Virginia Hayssen, for the time and energy devoted to those projects, which have been influential in our own SICB experiences and efforts.

Conflict of Interest (COI) Statement

These authors have no formal “conflicts” to declare, although they acknowledge that positionality is, in fact, always a conflict in its own way.

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ORIGINAL UNEDITED MANUSCRIPT

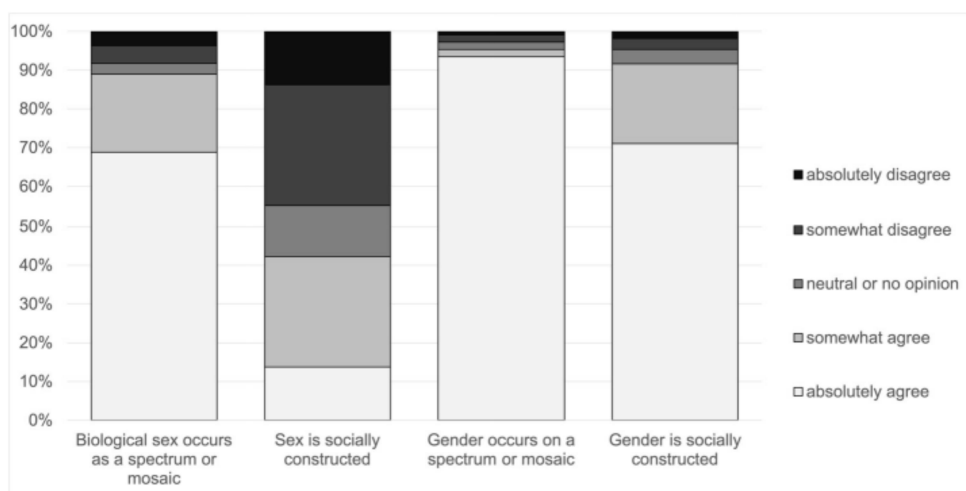


Figure 1. Respondents' views on sex and gender

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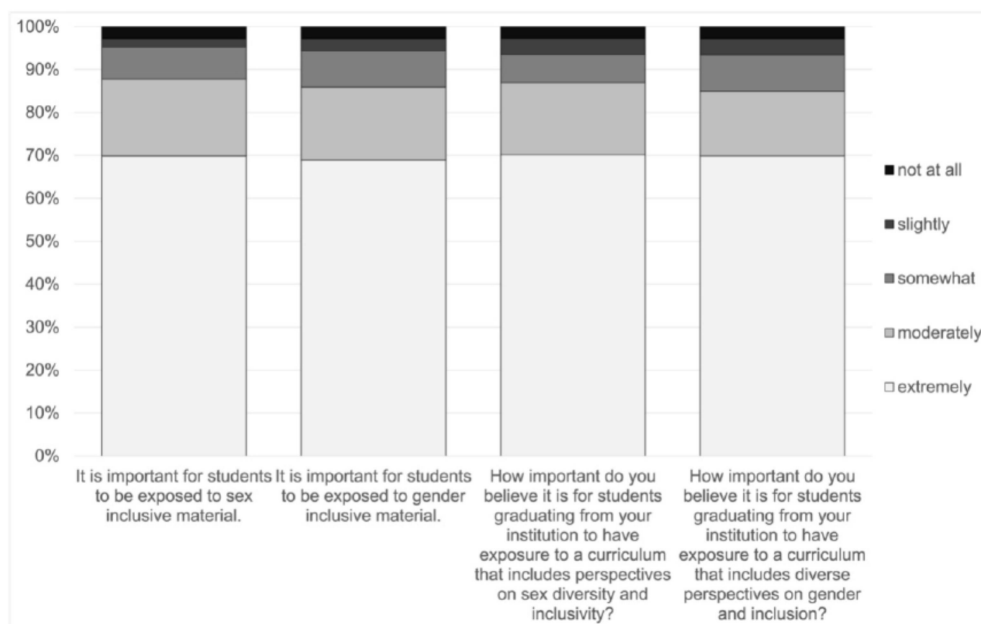


Figure 2. Respondents' valuation of sex and gender inclusive material and curricula

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Table 1. Gender inclusive content that respondents have implemented in their classrooms

Creating space in the course for name and pronoun sharing (survey, name tags, etc.)
Gender-inclusive language
Gender neutral pronouns for parents in human-centric questions
Not using man/woman or male/female regarding reproduction
Sibling taxa rather than sister taxa
Class discussions on sex and gender Including specific readings and/or content <ul style="list-style-type: none"> • Gender studies and biology, feminist biology, and feminist science studies readings (Hyde et al. 2018; Joel 2021; Joel 2020; Joel et al. 2015; Saguy et al. 2021) • Queer theory • Gender and sociology scholarly literature • Materials from Project Biodiversify (Project Biodiversify n.d.)

Table 2. Support or resources that would be necessary or helpful to improve the implementation of sex diversity/inclusivity topics.

Access to ready-made materials or activities	20.90%
More personal knowledge on the topic of (sex) inclusive teaching	21.64%
More buy-in from department and/or upper admin	13.43%
More time in my syllabus	13.06%
More personal knowledge of the topic of sex diversity	14.18%
More personal knowledge on the benefits of teaching sex diversity and inclusivity	4.85%
More buy-in from students	8.21%
Other	3.73%

Table 3. Long, Steller, and Suh's five proposed attributes to guide adapting a lesson to be inclusive of diverse sex, gender, or sexuality (Long, Steller, & Suh 2021).

Attributes to guide adapting a lesson to be inclusive of diverse sex, gender, or sexuality	How to adapt lessons
Authenticity	Use accurate content and language, e.g. "testes produce sperm" rather than "men produce sperm"
Continuity	Use a consistently inclusive lens, rather than a tokenizing special topic lesson
Affirmation	Highlight naturally occurring diversity, rather than sensationalizing or pathologizing diversity
Anti-oppression	Recognize injustices related to the topics at hand and society's and science's roles in oppression
Student agency	Give students choices in their learning about sex, gender, and sexuality, and to provide feedback on the material

Table 4. Summary of Zemenick et al.'s six principles for embracing gender and sexual diversity in postsecondary biology classrooms (Zemenick et al., 2022).

Principles for embracing sexual and gender diversity in postsecondary biology classrooms
Diversity first
Present the social and historical context of science
Use inclusive language
Show the iterative process of science
Present diverse role models
Develop a classroom culture of respect and inclusion