"It's been a Process": A Multiple Case Study of Biology Instructor Efforts to Reform their Sex and Gender Curriculum to be More Inclusive of Students with Queer Genders and Intersex Students

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ABSTRACT

Inaccurate sex and gender narratives have saturated the political landscape, resulting in legal restrictions for people with queer genders. Biology educators can correct these false narratives by teaching scientifically accurate and queer gender and intersex inclusive sex and gender curriculum. Here, we interviewed four undergraduate biology instructors who were working to reform their sex and gender curriculum. Using their reformed curriculum to promote conversation in the interviews, we asked participants about their curriculum, their reform process, and the obstacles they faced in implementing their reformed curriculum. We noticed the instructors' journeys to reforming involved intense personal work and education, both at the beginning and iteratively throughout implementation. We found instructors focused on changing language and using a variety of inclusive activities in their undergraduate biology classroom, ranging from highlighting scientists with queer genders to assigning students to research the experiences of people with queer genders with adolescent hormone therapy. Instructors mentioned obstacles to implementing reformed curriculum, including fear of potentially isolating students and concern about the instructor's own positionality. Removing obstacles and supporting the process of unlearning exclusive ways of teaching sex and gender topics may bolster instructor efforts to provide more accurate and inclusive biology education.

INTRODUCTION

Society often defines sex using supposedly clear-cut, binary categories of male and female (Morgenroth and Ryan, 2021). However, biologically, categorizing and defining sex is complicated. This contrast between the "common knowledge" of sex as a simple binary, and the incredible biological complexity of sex can create challenges for teaching this topic (Štrkalj and Pather, 2021; Zemenick *et al.*, 2022a, 2023). Yet, teaching this complexity is essential, both to ensure accurate scientific understanding and for equity and inclusion, given that the concepts of sex and gender have strong social significance. In this study, we introduce a preliminary investigation of how biology instructors—who are working to teach sex and gender topics inclusively to students with queer genders and intersex students—learn about and teach these topics in the classroom, noting the obstacles they faced in the process.

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Explaining Our Language Choices

While we define sex- and gender-related terms throughout this paper using footnotes—indicated by a superscript number[1] which signals there is more information on this word or phrase after the reference section—we would like to explain and justify our language choices here (i.e., *queer, queer genders, intersex, and hermaphrodite*) before continuing to detail the importance of teaching sex and gender inclusively for students with queer genders and intersex students.

When describing people who identify as either—or both—an individual with a queer gender or queer sexual orientation, we use the term queer.[2] Similarly, when describing people who identify with a gender that does not align with the sex they were assigned at birth, we use the term queer gender.[3] Although many consider the term queer to have been reclaimed by the lesbian, gay, bisexual, transgender, plus (LGBT+) community, after it has historically been used pejoratively, not all members of the community use or accept this term. However, here, we decided to use the word queer to refer to any and all genders and sexual orientations that differ from societal expectations of the female/male binary and heterosexuality (Cambridge English Dictionary, 2024). The use of this term demonstrates the status of these queer communities as marginalized and allows us to avoid repetitive and verbose language. Additionally, the term queer has been used in previous literature by undergraduate students with nonheterosexual orientations and noncisgender identities as their chosen label (Yoder and Mattheis, 2016; Rankin *et al.*, 2019; Mattheis *et al.*, 2020).

Next, in defining the term intersex,[4] we elected to use Blackless *et al.*'s (2000) definition: any person with a difference from the binary male or female sex categories, including all chromosomal, anatomical, and hormonal differences (e.g., XXY chromosomes, androgen insensitivity). We used this definition as it includes all individuals with differences from binary male or female sex categories, rather than focusing merely on people who receive genital surgery (Blackless *et al.*, 2000). It is important to note that this term is not universally used by people who would be labeled as intersex by this definition. Some people who would be labeled intersex based on the definitions used in biology to label nonhuman organisms use a range of language. These labels include differences in sexual development, variations in sexual development, and only using the label specific to them, such as having Kleinfelter's syndrome (Viloria and Nieto, 2020).

Finally, we use the term hermaphrodite[5] in select cases as a biologically accurate term for organisms that produce *both* eggs and sperm, either simultaneously or sequentially across their lifespan (Leonard, 2018) because it is a term that refers to a specific biological characteristic of some nonhuman organisms. We acknowledge this term has been incorrectly and harmfully misused to refer to intersex people (Dreger, 2000; Intersex Society of North America, 2008) and that—while some intersex people have reclaimed the term (Costello, 2016)—some intersex people continue to consider the term hermaphrodite derogatory (Viloria and Nieto, 2020).

Why Does It Matter How Sex and Gender are Taught?

The way sex and gender topics are represented in biology classrooms matters because these topics have strong social impacts. In the year 2024 alone, the United States passed 42 bills that reinforce sex and gender binaries (Trans Formations Project, 2024). These bills often invoke oversimplified definitions of sex and gender. For example, Louisiana House Bill 121, which focuses on pronoun use in schools, assumes that all of a person's sex markers will align as female or male and that binary sex corresponds to binary gender (Crews, 2024). However, the definitions of sex and gender in these bills do not align with biological complexity, and these bills negatively impact people who have queer genders and intersex people (i.e., roughly 4% of the population,[6] a figure that is twice the number of people in the United States with red hair; Cunningham *et al.*, 2010).

The classroom experiences of students with queer genders and intersex students are influenced by the way sex and gender topics are taught, and their experiences matter. At the high school level, a lack of gender inclusive curriculum in science, technology, engineering, and mathematics (STEM) courses reduced queer students' interest in majoring in STEM in college

[1]This is an example of what a footnote looks like, for reference.

[2]We use queer as an umbrella term for persons whose sexual and/or gender identity does not correspond to established norms of sexuality and genders (i.e., cisheteronormativity). This includes—but is not limited to—individuals who identify as lesbian, gay, bisexual, asexual, pansexual, transgender, nonbinary, and/or gender nonconforming (Cambridge English Dictionary, 2024).

[3]Queer genders is an umbrella term for persons whose gender, including identity and expression, does not correspond with the sex they were assigned at birth (e.g., transgender, nonbinary, gender nonconforming) (Casper *et al.*, 2022; Cambridge English Dictionary, 2024). We collectively use the term "people with queer genders" to encompass the wide diversity of experiences.

[4]Intersex is a term that applies to any person with a difference from the binary male or female sex categories (e.g., XXY chromosomes, androgen insensitivity, and late onset adrenal hyperplasia) (Blackless, 2000). We used this definition to encompass the multifaceted and multitiered development of sex rather than limit this definition to one facet of sex (i.e., genitalia) (Fausto-Sterling, 2012).

[5]Hermaphrodite refers to organisms that produce *both* eggs and sperm, either **simultaneously** or **sequentially** across their lifespan (Leonard, 2018). Sequential production of gametes can be protandrous (i.e., sperm is produced first, before eggs), protogynous (i.e., eggs are produced first, before sperm), or serial bidirectional (i.e., where the order of gamete production can switch during an organism's lifetime) (Leonard, 2018). Importantly, this term does not apply to humans.

[6]Demographic information for people with queer genders is not often collected in quantitative survey research (Garvey, 2014; Garvey *et al.*, 2019), and what characteristics qualify as intersex is variable (Jones, 2018). Estimates of the number of adults with queer genders in the United States range from 0.39% (Meerwijk and Sevelius, 2017) to 1.6% of the adult population (Brown, 2022). When parsed by age group, college-aged adults in the United States more commonly identify with queer genders, with estimates ranging from 1.3% (Herman *et al.*, 2022) to 5% (Brown, 2022), for 18- to 24-year-olds and 18- to 29-year olds, respectively. Similarly, survey data taken from 18 four-year colleges/universities in the United States estimated the number of college students with queer genders to be 1.7% (n = 1526/87,966 students) (Greathouse *et al.*, 2018). The number of intersex people is estimated at 2% of live births globally (Blackless *et al.*, 2000). Collectively, based on these estimates, people with queer genders and intersex people make up between 2.39% and 3.6% of the adults in the United States. However, the actual number of people with queer genders and intersex people in the United States is most likely underreported for myriad reasons. First, while intersex status can be gleaned from genitalia at birth (Cleveland Clinic, 2019), other—more common—presentations of intersex traits are not discovered until puberty (Lindahl, 2019) or until a person has multiple unsuccessful attempts at conception (i.e., fertility issues; Cleveland Clinic, 2019). Sometimes, people never discover that they are intersex (Cleveland Clinic, 2019). Second, people with queer genders may not feel comfortable reporting their identity (Ghorbanian *et al.*, 2022). Third, the definitions and tools (e.g., surveys) used to measure the prevalence of intersex and queer gender identities vary and do not always accurately capture the entirety of these populations (Sax, 2002; Holzberg *et al.*, 2017; Ghorbanian *et al.*, 2022).

(Kosciw *et al.*, 2014). In college biology courses, students with queer gender identities faced curricula that emphasized binary sex and gender, and they struggled to form relationships with their instructors and peers, access career advancing steps (e.g., letters of recommendation, research experiences), and feel recognized (Casper *et al.*, 2022). Students with queer genders are less likely to persist in undergraduate biology majors (Maloy *et al.*, 2022) and undergraduate STEM majors (Hughes and Kothari, 2023), compared with their cisgender peers. Additionally, the portrayal of intersex people as aberrant in biology courses can harm intersex students by 1) teaching their peers that they have genetic mutations that are not survivable, 2) objectifying intersex people, and 3) delivering content about intersex people with the assumption that no one in the class is intersex (Casper *et al.*, 2024). In contrast, sexual and gender diversity–inclusive curriculum can positively influence queer students' sense of safety and belonging as well as their educational interests, and performance (Snapp *et al.*, 2015; Linley *et al.*, 2016; Kosciw *et al.*, 2020).

It is important to note that ideas about sex and gender do not just impact students with queer genders, intersex students, and—more broadly—queer students; these ideas impact everyone. Sex and gender influence each person's daily life, including how governments categorize them and the proficiencies that others may assume they have or do not have. For example, Donovan *et al.* (2019) found that students who were taught an oversimplified definition of sex (i.e., sex defined by chromosomes) endorsed common stereotypes about men and women more strongly than students where this belief was refuted. These stereotypes include beliefs that women have lower intelligence than men and low ability in science. In addition, teaching these oversimplified narratives perpetuates outdated science that will impact the way students (e.g., our future scientists and medical practitioners) will ask research questions, interpret data, and interact with collaborators and patients (Okruhlik, 1994).

Given that science is being misrepresented to justify oversimplified ideas about sex, gender, and reproduction, scientists and science educators have an important role to play, particularly in undergraduate biology courses. These courses are often unique among STEM disciplines in that examples and concepts taught in core biology courses touch on sex, gender, and reproduction. For example, students often encounter topics such as sex determination, sexual reproduction, and sexual selection early on and throughout the biology curriculum. Importantly, many students encounter sex and gender topics through biology courses: undergraduate biology degrees account for 41% of STEM degrees earned and introductory biology courses are commonly required across STEM majors (National Science Foundation, 2014). For many STEM students, biology courses may be the only place they encounter explicit conversations about sex and gender. Thus, understanding the way sex and gender are represented in biology classrooms is important and more work is needed to describe what instructors are teaching and what influences them to teach about sex and gender the way they do.

How Sex and Gender are Taught In Biology

Preliminary work in biology education demonstrates that the way sex and gender are presented is problematically oversimplified relative to the complexity in biology (Hubbard and Monnig, 2020; Stuhlsatz *et al.*, 2020; Štrkalj and Pather, 2021; Zemenick *et al.*, 2022a). Additionally, reproduction, which is inherently linked to sex in sexually reproducing organisms, is also problematically oversimplified. For example, studies on multiple biology textbooks found these books generally did not mention sexes beyond male and female, did not explain the actual continuous variation within and across sex categories, conflated sex and gender, linked anatomical features of the body to specific genders, and presented heteronormative depictions of sexual reproduction (Bazzul and Sykes, 2011; King *et al.*, 2021; Donovan *et al.*, 2024; Dunk *et al.*, 2024). This kind of representation does not acknowledge the diversity of ways sex is defined or manifested across organisms, nor represent the ways organisms with different sexes behave sexually. A study of the experiences of biology students with queer gender identities similarly found that biology teaching can reinforce ideas of binary sex and gender and—more broadly—gender essentialism (Casper *et al.*, 2022). Gender essentialism is the idea that sex and gender are the same, are fixed within individuals, and dictate differences between the categories of men and women, including preferences, behaviors, attitudes, skills, and other traits (Heyman and Giles, 2006; Coleman and Hong, 2008; Rhodes and Gelman, 2009). This simplification misrepresents the diversity of sexes and genders observed in nature and the current challenges with how to define them.

However, there have been calls and efforts at the K-12 education level, and some preliminary recommendations and research at the college level, to make curriculum more biologically correct and inclusive to students with queer genders, intersex students, and—more broadly—queer students (Scholer, 2002; Cooper *et al.*, 2020; Beatty *et al.*, 2021; Long *et al.*, 2021; Casto *et al.*, 2022; Zemenick *et al.*, 2022a,b). For example, the *Gender Inclusive Biology* framework prompts high school biology teachers to reflect on their current curricula and teaching practice using five principles for gender inclusion (Long, 2019; Long *et al.*, 2021). Similarly, Zemenick *et al.* (2022a) proposed *Six principles for embracing gender and sexual diversity in postsecondary biology classrooms* to highlight and promote the importance of teaching gender and sexual diversity as the rule in biology rather than the exception. Preliminary research tested Zemenick *et al.*'s (2022a) framework by measuring student inclusion before and after receiving a lecture in an introductory biology course that focused on sex and gender diversity as the norm in nature, finding that student feelings of inclusion among queer students were higher than their nonqueer student peers (Adams *et al.*, 2024). Similarly, Beatty *et al.* (2021) used some of the ideas from these frameworks—including providing context and acknowledging the holes in scientific understanding—to create and implement a curriculum for nonmajors introductory biology courses that addressed the biological and social constructs of sex and gender, provided biological support for gender identity, and pushed against the idea that being transgender is a mental illness. A comparison of precurriculum and postcurriculum results demonstrated that students taught with this curriculum felt more knowledgeable about the biology of societal issues and largely enjoyed and approved of the materials taught (Beatty *et al.*, 2021).

The Complexity of Sex, Reproduction, and Gender

Although society often discusses sex as a binary (Morgenroth and Ryan, 2021), sex is complicated and varies depending on the disciplinary tradition through which it is being viewed. The term sex itself is relevant to anisogamous species, or those in which gametes differ in size, and this size difference is relevant to gamete compatibility (i.e., a big gamete will only combine with a little gamete). Many organisms, such as fungi, are isogamous, in which gametes are often the same size and gamete size is not relevant in determining compatibility. Species that are isogamous have mating types[7] as opposed to sexes.

From an evolutionary tradition, sex is usually defined by gamete, or reproductive cell, size (Goymann *et al.*, 2023). Females make big gametes, often eggs, and males make small gametes, often sperm (Heesch *et al.*, 2021; Goymann *et al.*, 2023). However this difference in size is relative both within and across species, and there is no actual universal definition of sex that works across eukaryotes (Gorelick *et al.*, 2016).

For organisms with sexes, the organization of sexes in bodies, or sexual systems, happens in many ways. For example, species may be gonochoric, where individuals only *produce one of two types of gametes throughout their lifetime*; these species are dioecious (i.e., male or female) (Leonard, 2018). In contrast, other species are hermaphroditic, *producing two types of gametes throughout their lifetime* (Leonard, 2018). Thus, once the focus moves from abstract gametes to how gametes are actually present in bodies, there are already at least three sexes across taxa (i.e., female, male, and hermaphrodites). In addition to variation in sexual systems from an evolutionary perspective, there are various methods of reproduction. For example, reproduction of simultaneous hermaphroditic organisms varies across species: in some species, individuals can reproduce with both themselves or with other individuals; in other species, individuals can only self-fertilize; and in other species, individuals can only reproduce with a different individual. Additionally, the evolution of sexual reproduction is dynamic; some species have evolved both obligate and facultative asexual reproduction from sexual reproduction (Booth *et al.*, 2014; Mirzaghaderi and Hörandl, 2016; Kratochvíl *et al.*, 2020; Ryder *et al.*, 2021). Thus, not only are the concepts of sex, sexual systems, and sexual reproduction interrelated and complex, they are also evolutionarily dynamic.

Another way to consider sex is from a developmental perspective. From this standpoint, sex describes a range of characteristics, such as the chromosomes, hormones, and anatomy of an individual, including the gametes the individual produces (Fausto-Sterling, 2012; Morgenroth and Ryan, 2021). However, these characteristics do not inherently align within an individual, nor across individuals within a species, to create clear dichotomous categories of males and females, even in gonochoric species (Gorelick *et al.*, 2016; Morgenroth and Ryan, 2021). Even when focusing only on animals, research demonstrates that, on their own, anatomy, hormones, or chromosomes cannot be used to distinguish male from female consistently (Sanz, 2017; DuBois and Shattuck-Heidorn, 2021; Morgenroth and Ryan, 2021; Štrkalj and Pather, 2021). In humans, and sometimes in other gonochoric species, the term intersex is used to describe the sex of individuals who have characteristics that span those of both males and females (Blackless *et al.*, 2000; Adolfi *et al.*, 2019). Even within the categorization of intersex, there is variation with fuzzy boundaries (Intersex Society of North America, 2008). Given the complexity of how sex is characterized evolutionarily and developmentally, it is not surprising that there is no universally agreed upon definition of sex in biology, or even universally agreed upon number of sexes (Fausto-Sterling, 2012; Maney *et al.*, 2020; Meissner, 2021; McLaughlin *et al.*, 2023; Subramaniam and Bartlett, 2023).

At least in humans, a discussion of the term sex also requires a discussion of the term gender because these concepts are related, although gender is not determined by sex as commonly assumed (Money and Ehrhardt, 1972; Fausto-Sterling, 2012; Hyde *et al.*, 2019; Beischel *et al.*, 2023). Like sex, gender does not have a single agreed upon definition. According to Morgenroth and Ryan (2021), society often conceptualizes gender as binary and automatically aligned with binary sex (i.e., female = girl/woman; male = boy/man). However, gender is actually a performance of a socially constructed identity category that is expressed through daily actions (e.g., gestures, movements, clothing) in response to the current societal expectations (Butler, 1988, 2004). Given that gender identity categories are created in time and space, these societal expectations are unstable and vary by culture (Butler, 1988, 2004). Building on this idea of gender as a performance of an identity category, Tate (2014) argued gender also involves self-categorization (i.e., how one identifies themself). Like some definitions of sex, these conceptions of gender recognize that many elements contribute to gender. To help capture the interrelationship of sex and gender in humans, some researchers who study gender have begun using the term gender/sex, because an individual's understanding of one cannot be disentangled from their understanding of the other (Fausto-Sterling, 2012; Beischel *et al.*, 2023).

Despite this great complexity and lack of consensus about the way sex and gender are understood in scientific research, there is a general agreement across research in these fields that sex and gender are not the same thing; at a developmental level, sex occurs across a spectrum and does not fit into a discrete binary; and, in humans, a person's sex does not determine their gender.

Theoretical Framework: Banks's Four Levels of Integrating Multicultural Content

There are many ways to think about how instructors reform their sex and gender curriculum in biology courses to focus on inclusivity. One way is through the lens of multicultural education, an approach that challenges dominant western cultural assumptions (e.g., racism, heteronormativity). A goal of multicultural education is to reform education so students from diverse groups experience education equality (Banks and Banks, 2015). To reform curriculum, Banks (2010) advocated for the integration of the variety of experiences, cultures, and histories of individuals with identities that are commonly ignored

[7]There are numerous species that reproduce sexually, such as fungi, that have gametes of the same size that differ phenotypically in other ways (Billiard *et al.*, 2011); these organisms do not have sexes but instead have mating types, which can vary from two to at least 28,000 within a single species (Heitman *et al.*, 2007; Constable and Kokko, 2018).

or marginalized by mainstream curriculums. He developed a framework for characterizing approaches to integrating multicultural curriculum into existing curriculum (Banks, 2010). One of the strengths of this framework is that it characterizes the different extents to which multicultural material is integrated into a curriculum and the extent to which mainstream ideas remain centered. His curriculum reform model focused on challenging racism and ethnocentrism (Banks, 2010), but the model has since been further adapted for other topics. For example, Moorhead (2018) adopted it to explore queer content in a high school social studies class.

Similarly, biology instructors can challenge dominant western cultural assumptions of binary sex and gender (i.e., gender essentialism) by integrating perspectives on sex and gender from minoritized communities' (e.g., people with queer genders and intersex people) into biology curricula; this benefits both individuals from these communities as well as individuals who are outside of those communities (Money and Ehrhardt, 1972; Banks, 2010; Fausto-Sterling, 2012; Morgenroth and Ryan, 2021; Casper *et al.*, 2022). For example, teaching about the diversity of sex and gender in a biology course can positively impact students with queer genders and intersex students' sense of safety and belonging and performance (Snapp *et al.*, 2015; Linley *et al.*, 2016; Kosciw *et al.*, 2020) while also accurately educating students without queer genders or intersex traits about the complex social constructs of sex and gender.

Below we describe the original four levels of Banks's framework, how they were previously adapted to focus on queer folks' experiences and perspectives in social studies, and how they can be adapted to consider students with queer genders and intersex students' experiences of sex and gender topics in biology courses. We incorporated the framework for *Gender Inclusive Biology* (Long, 2019; Long *et al.*, 2021) and *six principles for embracing gender and sexual diversity in postsecondary biology classrooms* (Zemenick *et al.*, 2022a) to assist with this alignment.

Level 1: Contributions. Level 1 focuses on highlighting contributions from a group of people such as heroes, food, and music (Banks, 2010). Moorhead (2018) extended this to acknowledging holidays celebrating queer culture, including LGBT Pride Month, LGBT History Month, and National Coming Out Day (Moorhead, 2018). In general, the *contributions* approach can have limitations as it tends to skip over the forces leading to the marginalization (e.g., gender essentialism) of the group highlighted, a main tenant of multicultural education, and can make the marginalized group seem like "an appendage" (Banks, 2010).

In science classrooms, one of the fundamental ways contributions (i.e., Level 1) are highlighted is through case studies of scientists with marginalized identities (e.g., Schinske *et al.*, 2016, Zemenick *et al.*, 2022b; Costello *et al.*, 2024). Thus, teachers could feature a scientist with a queer gender or an intersex identity in class through the use of Scientist Spotlights (https://scientistspotlights.org/spotlight-search/) or Project BioDiversify scientist profiles (https://projectbiodiversify.org/), for example, but not change anything else about their class.

Level 2: Additive. Level 2 is defined by the addition of multicultural content, themes, and perspectives to the curriculum without a change in the curriculum structure or overall goals. This approach also commonly has the limitation of centering mainstream ideas in the course overall (Banks, 2010). Examples of this level offered by Moorhead (2018) include adding first-person perspectives from queer individuals. Given that biology classes do not commonly bring in first person accounts like the humanities, we instead focus on raising topics and perspectives that have been expressed to be important by people with queer genders, such as challenging cisnormativity (i.e., the assumption that every person identifies as the gender they were assigned at birth; Cambridge English Dictionary, 2024) (Bradford and Syed, 2019; Casper *et al.*, 2022). This effort could manifest as an isolated, one-time explanation that sex is not binary or that sex does not equal gender, or this effort could include isolated examples of organisms with sexes that do not align with these mainstream beliefs about sex (Long, 2019; Zemenick *et al.*, 2022a). These one-off examples are brief and do not involve the instructor changing any other aspect of a unit.

Level 3: Transformation. Level 3 is characterized by more extensive changes to the curriculum that promote integration of perspectives and knowledge of minoritized people throughout the course rather than in isolated moments. The mainstream-centric perspective is presented as one of multiple ways a topic can be viewed (Banks, 2010). As described by Moorhead (2018), examples of "transformation" include assigned readings of queer studies books, podcasts, music, and articles, teaching students about the intersection between queer folks' experiences and society. Examples of teaching strategies in biology for this level could include restructuring a unit to emphasize the diversity of sex and gender in nature, highlighting it as the rule rather than the exception throughout the course (Zemenick *et al.*, 2022a). Instructors could also highlight the perspectives of people with queer genders and intersex people on sex and gender throughout the course, in addition to teaching sex and gender diversity as the rule (Zemenick *et al.*, 2022a,b).

Level 4: Social Action. Level 4 transcends the classroom as it involves having students take action in social settings to promote diversity, equity, inclusion, and justice (DEIJ) efforts (Banks, 2010). As an example of this level, Moorhead (2018) details one instructor's efforts, including the presentation of contemporary queer civic issues and encouraging students to take steps toward civic engagement. In biology courses, Level 4 could look very similar to these examples. Instructors could teach sex and gender topics with socially relevant case studies of people with queer gender identities and empower students to engage with these issues beyond their time in class. An example of this includes educating students about the science and social relevance of hormone therapy for adolescents with queer genders and empowering them to use their knowledge in conversations with friends and family.

The Current Study

This qualitative study builds on previous education reform efforts by investigating the queer gender and intersex inclusive

teaching strategies biology instructors are already using in their courses. Specifically, we investigated the following three research questions:

1. What journey do instructors go through to reach the point of implementing inclusive narratives in their biology courses?
2. What strategies are instructors using to create more inclusive narratives within their biology courses?
3. What obstacles do instructors describe when using these strategies?

To investigate these research questions, we recruited four college biology instructors who self-identified as caring about teaching sex and gender inclusively. Given their interest and commitment to providing inclusive learning spaces for these students, we conducted stimulated recall interviews (Calderhead, 1981; Stough, 2001; Moreland and Cowie, 2007; Fox-Turnbull, 2009; Consuegra *et al.*, 2016), where we presented instructor participants with the course materials they use to define or discuss sex and gender topics in their biology classroom, so they could explain them in relation to our semistructured interview protocol questions (see Supplemental Materials, Appendix A for full protocol).

MATERIALS AND METHODS

Positionality and Reflexivity of the Research Team

We bring a variety of viewpoints and identities to the team, and they interact with all stages of the research process (Secules *et al.*, 2021; Martin *et al.*, 2022). For transparency, we discuss our approaches and motivations here. This study arose from the shared viewpoint of the authors that biology education can and should be improved to create more inclusive spaces for students with queer genders and intersex students. In creating this study, that viewpoint was further motivated by our own gender identities (i.e., our research team includes members who identify as women, transgender, nonbinary, queer gender, and cisgender) and science and education disciplines (i.e., all researchers are in science or science education fields; this includes two professors, one research scientist, and two postdocs with backgrounds spanning biology education, biology, and chemical engineering, as well as two undergraduate students majoring in biological content areas). To move beyond simply listing our viewpoints and identities, we relate our viewpoints and identities to the present work, practicing reflexivity and analysis of the systems of power present in this study (Boveda and Annamma, 2023). For this project, our viewpoints and identities are especially apparent in the development of research questions, narrative framing, study design and methods, and interpretation.

Development of Research Questions. We are aware that, for many of the authors, our role as instructors gives us power and privilege. There is a potential for us to use our power to perpetuate gender essentialist narratives in undergraduate biology classrooms; however, we also are aware of our potential to use our power as instructors and experts on biology to disrupt gender essentialist narratives through undergraduate biology education. For this reason, we designed our research questions to investigate how biology instructors are using their positions of privilege and power to disrupt gender essentialist narratives through the implementation of inclusive curriculum. Our team's aim to create more inclusive educational spaces means that instructors for whom this is not a shared priority may not have responded to participate in the study; our research questions therefore focus on those who are already working to make changes in their classrooms.

Narrative Framing. Our direct experiences with teaching sex and gender in biology and with the marginalization of sex and gender identities in biology led us to focus on calling the community in with an invitation for collective improvement, rather than framing a narrative of calling out "bad" behaviors and speaking as if we occupy a position above the needed work. We acknowledge that we do not have all the solutions to this complex problem. Therefore, our aim is not to evaluate but rather to describe. Both our aim of description and our backgrounds as science education researchers impacted our choice of framework. We are not queer theorists or gender studies researchers, so our choice of theoretical framework does not use a critical gender lens (e.g., critical gender kinds; Dembroff, 2020) and instead focuses on pedagogy and biology. We are a part of this continuing classroom work, and in this study we emphasize pedagogy and not a discussion of what gender is.

Study Design and Methods. We selected four instructors known to at least some members of the research team. All of the interviewed participants are cisgender, heterosexual, and white biology instructors who are all striving to teach inclusively for students with queer genders and intersex students, despite not holding a marginalized sex or gender identity. These instructors have power and privilege in many ways, through their majority group identities, position as biology instructors (e.g., they have control over what they teach and how they teach it), and flexibility in their course content because the university they teach at allows this and supports DEIJ initiatives. The researcher who interviewed the participants shared many identities with them (i.e., white, cisgender, biology instructor). In at least one way, the participants had more power than the interviewer, given that the interviewer was a postdoctoral researcher at the time of the study and the participants were all faculty. However, the researcher was slated to become a faculty member. We selected this researcher as the interviewer to minimize power dynamics in an attempt to maximize participant comfort with opening up about their teaching rather than selecting a student or someone who was earlier in their career. We elected to conduct participant interviews with their course materials rather than observing them in class to negate potential feelings of being watched, evaluated, or studied while teaching. Even interviews can feel like an evaluation of oneself, so we framed our call for participants and our interview procedures from a place of curiosity rather than judgment to hopefully increase comfort of the participants.

While making undergraduate biology courses more inclusive to students with queer genders and who are intersex is the ultimate motivation behind this study, we acknowledge that no students with queer genders or intersex students from

the instructor participants' courses were involved in this study. This decision aligned with our narrative framing (i.e., focus on calling the community in with an invitation for collective improvement, rather than framing a narrative of calling out "bad" behaviors). However, other studies need to focus on including the voices of students with queer genders and intersex students to provide evidence for which teaching strategies actually make these students feel included.

Interpretation. Our experiences also shaped this study's interpretation. Having researched student perspectives on sex and gender in biology classrooms—both in the past and in simultaneous work—we may describe faculty actions through this lens. Having student perspectives in the project team may also contribute to this, and our interpretations of the impact of instructor practices on students could be influenced and informed by talking and working with students. In interpreting and communicating our results, we developed shared values emphasizing collaboration and centering of marginalized experiences to guide our analysis and writing. We also came to the writing of this manuscript with aims of describing rather than assessing. This resulted in our overall narrative for the manuscript to encourage change and reduce harm.

In summary, our shared viewpoints and identities interacted to inspire and create this research, impacting all stages of the research process, particularly the development of research questions, narrative framing, study design and methods, and interpretation of findings. We are transparent about this interaction as it increases the trustworthiness of study, a critical tenant of qualitative research (Dodgson, 2019).

Research Design: Multiple Case Study

In this qualitative research study, we used a multiple case study approach to understand how instructors navigate the experiences of students with queer genders and intersex students from multiple contexts and perspectives. Case study–based research involves the study of a real-life process, individual, or system (Creswell and Poth, 2017). This typically involves gathering multiple sources of information, such as interviews, documents, or artifacts (Creswell and Poth, 2017). In this study, we collected course artifacts from each of the four biology instructors' corresponding courses and conducted interviews with each participant using those materials. Each instructor represents one case study, meaning we conducted multiple (i.e., four) case studies. This multiple case study approach allows us to first explore the themes and codes present in the instructors' teaching and then describe them and their interactions (Corcoran *et al.*, 2004). As previously detailed, we explored these themes and codes through the lens of *Bank's Four Levels of Integration of Multicultural Content framework* (Banks, 2010) which was additionally informed by *gender inclusive biology* (Long, 2019; Long *et al.*, 2021) and *six principles for embracing gender and sexual diversity in postsecondary biology classrooms* (Zemenick *et al.*, 2022a).

Rather than presenting all collected data, this multiple case study approach focuses on common ideas that we can use to explain the themes present when integrating inclusive teaching strategies and curriculum into postsecondary biology classrooms for students with queer genders and who are intersex (Greene and David, 1984; Harland, 2014). In line with this approach, we used reflexive thematic analysis to distill our data into themes and codes (Braun and Clarke, 2019): a process we detail in the analysis section for both the course materials and the interviews.

Context and Participants

We recruited instructors from a large, midwestern university with very high research activity (Carnegie Foundation for the Advancement of Teaching, 2021) and many ongoing DEIJ initiatives that some or all of the interviewees may have participated in. All participants were made aware that the research goals focused on inclusive teaching strategies for students with queer genders and who are intersex, and all participants self-identified as caring about teaching sex and gender inclusively. For the instructor participants, we selected four pseudonyms, Riley, Ellis, Alex, and Skyler, assigning them randomly to the four instructors. All of the interviewed participants are cisgender, heterosexual, and white biology instructors. None of them are knowingly intersex. We do not formally disclose additional demographic information to avoid identifying participants to other participants and their coworkers.

Each of the four instructors taught a different undergraduate biology course. These courses included three different types of introductory biology courses and one upper division biology course. Both majors and nonmajors courses are represented. Relevant topics from these courses include: sexual selection, human and animal reproduction (stratified into male and female reproduction), the endocrine system, sex and gender, mitosis and meiosis, inheritance, and cancer biology. This work was considered exempt from full review by University of Minnesota Institutional Review Board (STUDY00012869).

Data Collected

We collected course materials from the four participating instructors, selected examples of materials from the relevant topics, and then used these materials to conduct stimulated recall interviews with the instructors. Here, we detail our methods in obtaining and selecting the course materials, followed by our methods in conducting the participant interviews.

Course Materials. We collected course materials directly from each instructor's course website, focusing on the materials used in units about sex, gender, reproduction, sexual selection, inheritance, or the endocrine system, to explore how sex and gender were presented by the four instructor participants in their undergraduate biology courses. Depending on the materials available and the frequency of which sex and gender topics were addressed within a course, the volume of analyzable materials per course varied. After collecting the course materials, three researchers used document analysis strategies to decide whether these materials were relevant to the study and whether we should use these materials in the stimulated response interviews. One approach to document analysis involves three steps: skimming, thorough reading, and interpretation (Bowen, 2009). With this in mind, two researchers first skimmed through each of the collected course materials, selecting only materials that addressed sex and gender topics. All of the materials that addressed sex and gender topics were analyzed (see *Data Analysis* section). Next, we chose a sample of these materials, focusing on presenting a variety

of course materials to use as stimuli in our stimulated recall interviews (see *Stimulated Recall Interviews* section). Specifically, we based our choices on 1) the type of material (e.g., slides, exam questions, class activities) and 2) the range of ways the instructor discussed sex and gender. Of note, we did not observe class lectures because this method was unnecessary to answer our research questions (i.e., our intent was not to test the differences between what instructors said they did and what they actually did in class, nor was it to test the impact of actual practices on student outcomes), and we felt our methodological approach minimized instructor discomfort and maximized instructor honesty about their teaching decision-making.

Stimulated Recall Interviews. In prior literature, researchers have conducted stimulated recall interviews by 1) presenting excerpts of recordings (Calderhead, 1981; Stough, 2001; Consuegra *et al.*, 2016) or 2) having participants take photographs of their surroundings (Moreland and Cowie, 2007; Fox-Turnbull, 2009). We adapted this stimulated recall method for our present research by presenting instructor participants with the course materials they use to define or discuss sex and gender topics in their biology classroom.

When presenting the course materials, we asked instructors about the inclusive strategies they used to include students with queer genders and intersex students, their motivations and intentions to use these strategies, and obstacles to implementing these strategies (see Supplemental Materials, Appendix A for full protocol). Interviewees could answer beyond the presented course materials and were asked to reflect on their courses broadly, as the materials served primarily as a tool to start discussion. Interviews lasted approximately 60–90 min and were conducted by A.K.L. with T.H. present. We recorded all interviews and initially transcribed them using the closed caption feature of an online meeting program (i.e., Zoom; https://zoom.us/). Then, T.H. compared the transcription with its corresponding audio recording, checking and editing the transcription for accuracy. After the interviews, we returned to the course websites to collect materials we had initially missed, as indicated in the interview as relevant. We needed only to retrieve one additional relevant course material for one participant, Alex. After retrieving this course material from Alex's course website, we analyzed this in the same way we analyzed the other course materials (see *Data Analysis* section).

Data Analysis

After completing data collection, we interpreted the relevant course materials and all interview transcripts using reflexive thematic analysis, a qualitative analysis method for distilling text into codes and themes that recognizes the researcher(s) as central to interpretation, bringing subjectivity and reflexivity to the analysis (Braun and Clarke, 2019). Reflexive thematic analysis is a particularly well-suited method to analyze our data due to 1) its function in distilling text data into smaller units (i.e., themes and codes); 2) its compatibility with both inductive (i.e., data-driven) and deductive (i.e., framework-driven) coding approaches; and 3) its straightforward approach to finding themes that answer the research questions of the study (Clarke and Braun, 2017; Braun and Clarke, 2019). A code is the smallest unit in thematic analysis that still captures interesting components of the dataset. Combined, codes contribute to themes in the data. A theme captures a patterned meaning within the dataset that relates to at least one of the study's research questions (Clarke and Braun, 2017). Given that our study is informed by the Banks' (2010) *Four Levels of Integrating Multicultural Content Framework,* we used deductive (framework-driven) analysis to identify and code any mention of sex- and/or gender-related topics related to the four levels of multicultural inclusion (Clarke and Braun, 2017). However, we additionally used inductive (data-driven) analysis to identify and code any mention of sex- and/or gender-related topics that was not covered by the framework (Clarke and Braun, 2017).

According to Braun and Clarke (2006), thematic analysis follows a six-step process: familiarization with the data, generation of initial codes, collating codes to create themes, reviewing themes, defining and naming themes, and presenting the themes. First, to familiarize ourselves with the data, two researchers (K.E.W. and T.H.) read through all four interview transcripts and all relevant course materials (i.e., those that the team already identified as covering sex and gender topics; see *Course Materials* section) Second, those same researchers used inductive and deductive analysis (Clarke and Braun, 2017) to begin creating codes for the data, taking detailed notes in Dedoose (i.e., a brand of thematic analysis software). Those two researchers then conferred with the senior author (A.K.L.), who reviewed and added additional codes—using inductive and deductive analysis—with them as necessary (Clarke and Braun, 2017). The researchers often identified new codes within one participant's data (as indicated by the course materials or interview transcripts), which they then applied to the data obtained from the other participants. This was an iterative process, in which the researchers (K.E.W., T.H., J.R.S., and A.K.L.) continuously reviewed and discussed codes until they reached consensus for each code application. Third, to collate codes to create themes, E.P.D. skimmed all collected course materials and interview transcripts, took notes of themes she noticed, and then read all of the course material and transcript excerpts that supported the created codes, prompting her to edit or build on her initial themes. Then, she aligned the inductive and deductive codes with themes from the conceptual framework, and took note of codes that did not fit the framework, prompting her to create new theme(s). Fourth, to review the themes to check that they made sense in relation to the coded data and the entire dataset, E.P.D. reread all course materials and interview transcripts and then reread all of the excerpts from the course materials and interview transcripts that supported the created codes. Then, she went back to the themes she created and reread them, taking notes throughout the process and editing as needed. Fifth, to define and name the themes that appeared across the course materials and interviews, E.P.D. shared her theme summaries and collated codes with the research team (J.R.S., A.C., S.E., and A.K.L.), and the team iteratively compared these themes and collated codes as a group, coming to consensus after several iterations. Sixth, to present the themes in writing and fine-tune the overall story, E.P.D. wrote an original draft of the themes in the manuscript. All authors then edited and refined this draft, resulting in the final five themes:

(i.e., Unlearning, Level 1: contributions, Level 2: additions, Level 3: transformation, and Inclusive language) which are presented in the *Results* section.

Of note, our method of analysis (i.e., thematic analysis) is incompatible with interrater reliability for myriad reasons. It is difficult to provide meaningful interrater reliability metrics when multiple stages of feedback are built into the analysis. At any given stage, the codes and themes were changing through iterative team discussion and revisiting the data (Clarke and Braun, 2017; Braun and Clarke, 2021), so we do not present interrater reliability metrics. Instead we are transparent in our analysis section about the many rounds (i.e., over 10) of editing, coding, recoding, developing themes, and coming to consensus after lengthy discussions. Our approach aligns with prior calls to replace interrater reliability metrics with trustworthiness (e.g., transparency) (Lincoln and Guba, 1985; Hammer and Berland, 2014; Smith and McGannon, 2018).

We Provide Evidence of Trustworthiness in this Qualitative Study

This study uses qualitative methods to investigate how four undergraduate biology instructors were working to teach sex and gender topics accurately and inclusively for students with queer genders and intersex students in their courses. While validity and reliability are often standards for quantitative research (Lincoln and Guba, 1985; Stahl and King, 2020), trustworthiness is often a standard for qualitative research (Lincoln and Guba, 1985; Johnson and Parry, 2015; Rose and Johnson, 2020; Stahl and King, 2020; Adler, 2022). Here we summarize some key practices for trustworthiness that apply to our study; for a more nuanced literature review, read Adler (2022). While Lincoln and Guba (1985) penned the seminal work on the term trustworthiness, using the term to refer to the credibility, dependability, confirmability, transferability, and authenticity of the research, Adler (2022) argues the most important aspect of trustworthiness is transparency. This is due to the fact that in qualitative research, the researchers are the principal research instruments (Dodgson, 2019). For these reasons, we precisely and explicitly describe our research process and the epistemological and theoretical bases of our work through 1) detailing the theoretical framework that informed our research questions, analysis, and interpretations; 2) providing a positionality and reflexivity statement, 3) focusing on transparency of our entire research process throughout all sections of this article, and 4) including qualitative data (i.e., quotes edited solely for clarity) for readers to interpret and assess the accuracy of the analysis for themselves (Adler, 2022). Importantly, the aim of this qualitative study is not to find a representative case that generalizes findings to the instruction of other college biology instructors. Rather, the aim of the present study is to develop an understanding of the curriculum that four biology instructors are using in their classrooms and how they came to use or create that curriculum (Salkind, 2010, p. 880).

RESULTS

Instructors provided examples of queer gender and intersex related content that aligned with the levels in Banks's (2010) framework, queer gender and intersex inclusive language, and examples of instructor obstacles to implementing queer gender and intersex inclusive teaching strategies when discussing sex and gender. For this reason, we present three subsections here to 1) present the iterative unlearning journey that instructors undertook to implement inclusive sex and gender content in their courses, 2) highlight instructor efforts toward integrating this inclusive cultural content in their classroom, and 3) point to potential obstacles to implementing this inclusive sex and gender content in undergraduate biology courses.

Instructors Take an Iterative Unlearning Journey to Implement Queer Gender and Intersex Inclusive Sex and Gender Curriculum in their Biology Courses

In our analysis, we noticed that many of the instructors described having to engage in personal reflection, unlearning, and learning prior to and iteratively throughout the process of integrating queer gender and intersex inclusive content into their curriculum. Banks' (2010) framework focuses on categorizing curriculum, rather than the instructor and their process to build the curriculum, so the framework does not characterize unlearning. However, after we noticed this theme of unlearning, we checked the literature and found that unlearning is a well-documented process. Briefly, according to the literature, the exact meaning of the term is contested (McLeod, *et al.*, 2020), but unlearning is generally understood to be an iterative process that involves correcting, reframing, or replacing some long-held ideas, beliefs, and practices, which are often difficult to uproot through the learning of new knowledge, questions, and practices (Cochran-Smith, 2003, p. 9). We further detail and describe prior literature on unlearning in the discussion section, where we use it to contextualize our findings presented here.

In our present study, this work of unlearning often involved literature searches, training, or library visits. For example, Riley detailed a book he read, which he later recommended to students in his class, to understand more about sex and gender, even when he only taught sex- and gender-related topics for one class period.

> I think one of the most recent books I read, or that I often recommend to students who are interested in the subject, is "Testosterone Rex,[8]" and I think [the author] she's a psychologist, but it is biologically tangential. So yeah, I'm primarily looking at how people are talking about it [sex and gender] in the evolutionary sciences.

Riley educated himself on sex and gender, using a book that presented these topics at the intersection of psychology and biology.

Alex described a longer journey of unlearning, beginning in graduate school and continuing through her current work as an instructor. For example, she noted taking training at one of her previous institutions as a graduate student, which taught her about teaching sex and gender inclusively.

> When I was a grad student I took Safe Space training, but it was about just in general, how to make your everyday

[8]Fine, C. (2017). *Testosterone rex: Unmaking the myths of our gendered minds*. Icon Books.

interactions with teaching gender and sexuality and sex inclusive, and I really recommended that.

Later, as a biology instructor, Alex kept seeking resources to learn further about the best ways to inclusively teach sex and gender. This included literature searches in education journals, consulting with librarians, consulting with authors of inclusive sex and gender textbooks, consulting with other instructors, and watching videos. Then, after trying out what she learned in the classroom, she revised her materials and teaching after receiving student feedback.

> I sought out some education research materials about the best way to teach sex and gender from some education journals. I actually consulted a little bit with some librarians. I talked with some other people that I work with, or have worked with in the past, about the way that they teach it. I watched some videos on how to teach it and to try to be inclusive, and I actually got feedback from some students when I taught it, revising as I get more feedback from students.

Alex mentioned she also read popular press articles and blogs from queer theorists to prepare to teach sex and gender in an inclusive manner, mentioning these articles taught her about the importance of using correct pronouns, how to address intersex development, and how to teach in a more queer gender and intersex inclusive manner.

> I did read some articles, and look at some posts from people who [study] queer theory. I read some non-scholarly material about how important it is to teach inclusively, like using a person's pronouns correctly, for example. I looked at the Intersex Society of America about some of their strategies for addressing intersex development and intersex youth, and I looked at a few resources for teaching science in a transinclusive way.

Alex's journey of unlearning spanned roles at multiple institutions, as well as a variety of resources from articles to workshops.

While Alex and Riley mentioned the unlearning they did to prepare to teach sex, gender, and reproduction in an inclusive manner, Skyler and Ellis mentioned strategies they currently use, acknowledging they have more to unlearn and relearn in the future. For example, Skyler mentioned he is in the process of thinking about inclusive language to use when teaching about sex and gender and trying to avoid using harmful language, noting it is something he is actively still learning about.

> I think it mostly makes me think a little bit more about how I say things, so I don't necessarily make it seem like, 'oh, male and female coming together, this is like the only normal, good way to do it.' I try to avoid using any language that I think might be harmful, but it's a real active area that I'm still learning about.

He highlights how he is still unlearning harmful and exclusive language, even though he has already started to avoid using language that normalizes heterosexual behaviors and excludes homosexual behaviors.

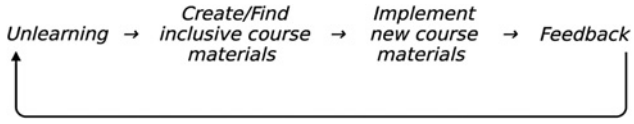

FIGURE 1. A schematic of the unlearning journey the interviewed instructors went through iteratively when modifying their courses to include queer gender and intersex inclusive teaching strategies and curriculum.

Ellis mentioned how for her, this work to implement queer gender and intersex inclusive curriculum was sparked through receiving student feedback and resources, prompting her to learn more about inclusive language when teaching sex and gender.

> Yeah so one of our [my colleagues and my] students was like, "Hey, when you talk about like a father and mother you could use these terms instead," and I was like, "Oh, you thought about this a lot," and the student was like, they were like, "Yeah I can send you some resources," and they did, and so then we looked at those and then we started looking more.

Student feedback acted as a springboard for this instructor to continue to challenge her language to be more inclusive, prompting her to continue her unlearning process.

Together, these journeys highlight the many forms that doing the work of unlearning can take. For each instructor, those journeys were important in shaping how they taught sex and gender in their course, and these journeys are ongoing. Across all instructor interviews, we noticed a journey of initial unlearning that prompted the instructor to make changes in their classroom by implementing new, queer gender and intersex inclusive course materials. Additionally across all four instructors' experiences, after implementing new course materials, there was a period of additional unlearning, and this was prompted by feedback, either from students (most commonly) or by personal reflection (Figure 1). This unlearning process was then iterated on over an extended time. Alex shared, "It's been a process for like the past 5 years, so it's not all in one go."

Instructor Efforts Toward Integrating Queer Gender and Intersex Inclusive Content

All four of the instructor participants in this study self-identified as caring about and making active strides toward queer gender and intersex inclusivity when teaching sex and gender topics in their undergraduate biology courses, qualifying them for this study. We categorized their efforts into our conceptual framework. We first present levels 1 and 2 separately with instructor teaching strategy descriptions from interview excerpts, and we follow those sections with a vignette from Ellis, the only instructor meeting level 3 and nearing level 4. Finally, we present a section on inclusive language that did not fit neatly into any of the levels in our conceptual framework.

Conceptual Framework Level 1: Contributions. Level 1 captured instructor efforts that acknowledged queer gender and intersex identities; however, these efforts were brief and non-

descriptive. For example, Alex noted that she featured relevant scientific research from scientists with underrepresented racial or ethnic identities in class, but she plans to additionally feature research from queer scientists in the future. Specifically, Alex said, "I think what I'm trying to do is incorporate some more examples of papers or data from queer-spectrum scientists as well." This is a strategy biology instructors can use in their classroom to introduce relevant science that features scientists with queer genders or intersex scientists. Examples of Level 1 include ways to make space for people with queer genders and intersex people and culture in the biology classroom in a way that does not place high demands on class time.

Conceptual Framework Level 2: Additive. This level captured additions onto the already present curriculum. These additions went beyond highlighting the contributions of people with queer genders and intersex people to science, but stopped short of course-long transformation. Specifically, we noticed two types of Level 2 integration: 1) explaining sex is not binary and 2) discussing the basis of gender identity.

Explaining Sex Is Not Binary. Instructors mentioned they teach their students that sex is not binary, ranging from discussing variability in sex chromosome combinations to directly discussing queer genders and intersex identities. For example, Skyler's course materials briefly mentioned that binary human definitions of sex and gender are incomplete. Specifically, the materials said, "Human definitions do not always adequately describe biology (happy to chat more about this)." While it does address terminology, further explanation is relegated to asking the instructor after class. Although this example alludes to queer gender and intersex identities, this material may only reach students who already express an interest, rather than educating all of them.

Similarly, Riley also communicated to his students that societal definitions of sex are limited and do not always align with biology. He also tested his students on this information, featuring one true/false prompt in his course to test whether students had learned that biological sex is not always determined by sex chromosomes: "True or False: Biological sex is always determined by sex chromosomes." The correct answer was "false," reflecting the knowledge of the diversity of biological variables contributing to one's sex characteristics. Featuring this information in a graded test question signaled that this information is important to know, rather than reserving this information for out-of-class chats with self-selected students.

Alex took engagement with the material even further. Specifically, Alex gave an explanation at the beginning of her course, explaining there is variation in sex and that sex chromosomes do not determine sex alone; In fact, there are many layers of sex, including gametic sex, gonadal sex, reproductive sex, and genital sex, and there is also a behavioral component to reproduction.

> I try to start out by saying, …these are all of the things that person has necessary for reproduction: chromosomes, gametes, and behaviors. Most people…don't have all of these because they might not have penis and vagina sex, and that's necessary for unassisted reproduction, or they might not have lactation, and that's necessary for reproduction too.

Additionally, Alex's course featured an article from the Scientific American entitled "Beyond XX and XY" (Montañez, 2017), which illustrates the factors that determine one's sex characteristics throughout development. Collectively, this excerpt and featured article illustrate the space Alex made in her class for variation in sex traits, possession of traits that allow for unassisted reproduction, and space for same-sex relationships, signaling inclusivity for a variety of individuals, including students with queer genders and intersex students.

Together, these inclusive strategies demonstrated that sex is not binary through different approaches. For example, Skyler's approach made space for the truth that the societal categorizations of sex are limiting and do not capture the variation displayed by all biological organisms, including humans. However, Skyler's approach merely hinted at this possibility without calling it out specifically, while Riley's approach specifically called out that sex chromosomes do not always determine biological sex, and he even tested his students on this information, signaling the importance of this information. Then, Alex takes a third route to addressing that sex is not binary by specifically addressing several layers of sex, in addition to the chromosomal layer of sex, demonstrating the complexity of sex. While all of these strategies made room for students with diverse sex and gender identities by challenging binary sex and gender narratives and illustrating the diversity and complexity of human sex and gender, Alex and Riley took more clear and outright approaches to making space while Skyler's approach alluded to space more discreetly.

Discussing the Basis of Gender Identity. An addition to one instructor's course was the United Nations definition of sex, gender identity, and sexuality (United Nations, 2017). After introducing this definition, Riley prompted students to discuss the intersection between biology and gender identity. Specifically, Riley's course posed a question within a team assignment to prompt students to discuss the differences between sex and gender identity and the biological basis of gender identity.

> How do you understand the difference between biological sex and gender identity? Given what you know about sex determination in humans, do you think there is a biological basis to an individual's gender identity even if [it] doesn't conform to the biological definition of sex?

This prompt asked students to apply their course knowledge to a discussion of gender essentialism. This provides a space for introducing gender identity in the undergraduate classroom, allowing for the opportunity to include queer gender and intersex topics.

Conceptual Framework Level 3: Transformation. Ellis made extensive efforts to transform her classroom throughout the course to increase queer gender and intersex inclusivity. Specifically, she implemented a variety of queer gender and intersex inclusive strategies, including an activity that prompted students to research the use of puberty blockers in adolescents with queer genders, team reflection questions that centered

intersex individuals, and exam prompts that acknowledged the variation present among and across sexes.

For example, Ellis created an active learning activity that addressed the use of puberty blockers, drugs that suppress the release of gonadotropin, delaying puberty to treat gender dysphoria in children (i.e., the distress a child experiences due to a mismatch between their gender identity and their assigned gender; American Psychiatric Association, 2024). The activity spanned multiple classes, which allowed students to research the topic of puberty blocker used to treat gender dysphoria in children through reading a provided mandatory article (*When transgender kids transition, medical risks are both known and unknown*; Boghani, 2015) and an optional article (*Suppression of puberty in transgender children*; Lambrese, 2010), watching a video about the experiences of transgender youth, some of whom used puberty blockers, and responding to four writing prompts: 1) What specifically would suppressing the release of gonadotropin prior to the onset of puberty do for a male and female, respectively?; 2) If the goal is avoiding the onset of puberty, when would puberty blocking drugs need to be given for a male and female, respectively?; 3) Imagine that you are a parent with a child experiencing gender dysphoria. Describe several benefits and drawbacks of "puberty blockers" that the child would need to understand to give informed consent; and 4) How would you balance your responsibility as a parent with the autonomy of your child? Per the assignment prompt, the intention of the activity was to help students review reproductive hormones and their function and consider bodily autonomy and consent related to the use of puberty blockers to treat gender dysphoria in children. Ellis explained the activity in her own words.

> I wanted to talk about puberty blockers and how they fit in with hormone cycles…so I ended up creating an assignment, that was like, put yourself in this person's shoes, you're a parent, and this is your child, and we talked about informed consent. I want you to read about puberty blockers and how they work, and I want you to be able to talk about how they impact feedback cycles because that's how you understand hormones in the class. And I want you to talk about what you would tell them about how they work. And then I had them watch this video, I had them read some articles about how they work, they're basically just like here's how it works like here's the science.

Ellis's activity asked students to consider their views regarding a sociopolitical topic, using course content to inform their analysis. This activity provided an opportunity for all students to learn about the science of hormone blockers (referred to in the excerpt as puberty blockers) and critically think about their use to stall puberty for adolescents with queer genders. This topic both incorporated the voices and experiences of people with queer genders and addressed a topic that is clearly important to the community given the number of bills attempting to ban gender affirming care for youths.

Aside from using an activity about puberty blockers in her course, Ellis explained the various levels of sex (e.g., anatomical, chromosomal, and hormonal), described the nonbinary nature of sex characteristics by highlighting intersex individuals, differentiated between gender and sex characteristics, and discussed the ethics and importance of anti-discrimination laws. To further her students' knowledge on some of these lessons, she wrote queer gender and intersex inclusive team reflection questions. For example, she had her students discuss intersex infant genital surgery ethics as an assigned team reflection question.

> Intersex infants often undergo medically unnecessary surgeries to make their external genitals appear to be more female-like. Think of one possible argument FOR such surgeries and one argument AGAINST such surgeries. Relate each of your arguments to one of the pillars of biomedical ethics. (We will discuss some of your ideas more in the next class).

Even her test questions reinforced the idea that sex characteristics vary across individuals, regardless of sex. For example, the following prompt laid the landscape for several multiple choice questions that made assumptions about the defined male and female individual, and she admitted this before even asking the questions.

> Several of the multiple choice questions below refer to the two specific adult individuals ("male" and "female") that we described in class. Remember that sex characteristics vary considerably between individuals, so just think about the two specific adults we described in class to answer the questions related to reproduction.

Collectively, these teaching strategies (e.g., a student-led activity on hormone blocker use among children with queer genders, queer gender and intersex inclusive team reflection questions, and queer gender and intersex inclusive exam prompts) signal integration of this content across the duration of the course, signaling transformation (i.e., Level 3).

Inclusive Language: Beyond the Conceptual Framework. One strategy that instructors used to create more inclusive spaces for students with queer genders and intersex identities was to alter their sex- and gender-related language, providing 1) terminology clarification and explanation and/or 2) removing gendered or sexed language from their curriculum altogether

Terminology Clarification and Explanation. One way instructors grappled with exclusive language was to clarify and explain the terminology to students. For example, Riley's co-instructor would present a terminology clarification slide to students about the term "hermaphrodite" because the term came up in a popular paper on the evolution of sex that uses the word to refer to roundworms that produce both eggs and sperm and that can self-fertilize. Then, Riley would explain the term to the class.

> One of the slides he [the co-instructor] showed was that hermaphrodite warning slide… In a study that we used to cite in the course - which is a really good study of the evolution of sex - they use the term hermaphrodite in reference to roundworms, so I've felt this need to explain it.

However, after presenting and explaining the use of the term, Riley shared that a student corrected him in class suggesting he use the term "intersex" instead.

> [A student] actually called me out in class…It wasn't confrontational but as I showed that slide, [and said,] "this is why you might see this term because it's in this study and we're using it only in the context of this specific definition"…Then a student raised their hand and was like, "why don't you just use intersex?" I'm like, "That's right, I should."

In response to the student's feedback, Riley has since removed the term hermaphrodite from the course materials. As discussed later, this provides an example of how student suggestions may not be biologically accurate.

Alex provided clarification about her use of the terms "female" and "male." She presented an explanation of the use and limits of these terms at the beginning of the semester, so students would understand that while these terms are commonly used in biology, they are limited and exclusive.

> I try to start out by saying, for the class, this is my defined female…and this is my defined male, and these are all of the things that person has necessary for reproduction: chromosomes, gametes, and behaviors. Most people who are female don't have all of these because they might not have like penis and vagina sex, and that's necessary for reproduction unassisted, or they might not, you know, have lactation, and that's necessary for reproduction too.

Alex's explanation of the terms "female" and "male" addresses diversity first in a simple and brief way that makes space for people with queer genders and intersex people. Together, Riley and Alex's terminology clarification and explanation was necessary due to the limitations and complexity of commonly used biological language, especially language used in other resources (e.g., the popular evolution of sex paper presented in Riley's class). Riley demonstrated responsive engagement to student feedback regarding the clarification and explanation of the term hermaphrodite, even though the students' feedback included biologically incorrect information.

Removing Gendered or Sexed Language. Another way instructors created more inclusive spaces for students with queer genders and intersex identities was to alter the language they used when teaching sex and gender topics. For example, Ellis provided many examples of removing gendered or sexed language both in her interview and through the course materials she provided. For example, she noted she edited the open source resource she uses for her course, replacing exclusive language with more queer gender and intersex inclusive language.

> We are kind of in a continuous state of rewriting for that. One area that I know that both me and [my co-instructor] are interested in updating is the chapters that are about hormones, sex characteristics, and reproduction. Some things are updated really well but the entire [resources] feels very under construction to me. So, yeah, it's a moving target.

Other than editing, Ellis provided a variety of instances where she used language that was either not gendered, or both not gendered and not sexed. As an example of language that was not gendered, Ellis posed a question in class that described a set of sex characteristics as "male" and asked about a symptom an adult male would have if a hormone receptor became insensitive due to a mutation.

> Suppose an adult with male sex characteristics had a mutation that made their FSH receptors insensitive to the hormone. In other words, their body makes FSH but is not able to respond to it. Which symptom are they likely to have?

This question endeavored to describe sex characteristics rather than draw an assumption regarding the adult's traits by gender alone. Instead of using gendered language (e.g., referring to a male as a "man"), Ellis avoided assumptions and inaccuracies by using sexed language.

An example of language that was neither gendered nor sexed was in another question she used in class that focused on a characteristic of an individual who produced sperm, while another focused on a person who had testes and took synthetic testosterone: "When can sex with a sperm-producing partner cause pregnancy[?]" and "If a person with testes takes a large amount of synthetic testosterone, we might expect all of the following EXCEPT which one?" Admittedly, Ellis stated she has tried to move away from using sexed language at all.

> We've kind of shifted away from what I would call sex and even using the terms, male and female, and using terms like egg-producing and sperm-producing just because it doesn't align in the way that students will expect it to, or at least there's a bigger range then students expect. I think that's kind of a broad challenge with anatomy and physiology beyond just sex.

Collectively, these excerpts highlight the variable ways in which instructors addressed language to create more inclusive spaces for students with queer genders and intersex identities in their undergraduate biology courses. Specifically, Riley plans to remove the term "hermaphrodite" and focus on the terms "small gametes", rather than "male" and female," while Ellis already uses substitutive terms for "male" and "female" (i.e., "egg-producing" and "sperm-producing").

Summary of Instructor Work Toward Inclusion for Students with Queer Genders or Intersex Identities. Collectively, the work done by these four instructors to teach sex and gender topics in their undergraduate biology courses in an inclusive manner ranged from briefly featuring a scientist with a queer gender in their course materials (Level 1) to centering queer gender and intersex inclusivity throughout the duration of the course by teaching diversity first, using exam questions to reinforce the importance of accurate sex and gender biology content, and assigning students to educate themselves on puberty blocker use in children with gender dysphoria (Level 3). In addition, instructors changed their use of sexed and/or gendered language to some extent in their course. These efforts showcase several different strategies to create queer gender and intersex inclusive undergraduate biology classrooms.

Obstacles to Instructor Implementation of Queer Gender and Intersex Inclusive Content

These instructors faced the challenges of 1) potential isolation of students with queer genders and intersex students; 2) lacking first-hand knowledge of queer gender and intersex sociopolitical topics due to positionality; 3) scarcity of queer gender and intersex inclusive sex and gender resources; 4) opposition from co-instructors; and 5) shortage of available time. When looking at curriculum reform efforts, these obstacles are commonly faced (see *Discussion*) with the exception of the first and second obstacles (i.e., isolation of students with queer genders and intersex students and positionality, respectively). For this reason, we describe the first and second barriers more thoroughly in this section compared with our brief description of the third, fourth, and fifth.

Obstacle 1: Potential of Isolation of Students with Queer Genders and Intersex Students. When discussing sex and gender topics inclusively, instructors expressed a fear of isolating students with queer genders and intersex students, especially in group settings in the classroom. This fear was generalized and did not stop instructors from making curriculum changes in their course. This generalized fear could impact the confidence of instructors at any point in the unlearning process.

As an example of the fear of potentially alienating or creating an uncomfortable environment for students with queer genders and intersex students, Ellis reported concern with how students interacted with one another regarding sex and gender topics in class, citing the difficulty of monitoring these discussions in large classrooms (i.e., during implementation of new course materials).

> … I worry about their interactions because I think that interaction is super important, they learn so much from each other, and when we are talking about lived experiences… I also don't want negative or disrespectful interactions happening within the groups and I always worry it's going to happen just because it's really hard to monitor.

This highlights the role other students play in students with queer genders and intersex student inclusion in the classroom. This role may be larger or smaller based on the format of the class. For example, if the course format incorporates the commonly used active learning practice, group work, then the possibility of negative student interactions increases compared with a course format that focuses on students listening to the instructor lecture or working alone.

Ellis mentioned having a fear of potentially isolating students with queer genders and intersex students as well; however, her fear was not directed toward student interactions, her fear was aimed at her own ability. Specifically, Ellis expressed concern over her own ability to properly explain the variation of sex characteristics so as not to isolate students with queer genders and intersex students, because that was counter to her goal.

> I was concerned that I would get pushback - not from people who are like, "gender is the same as sex," - I wasn't concerned about that. I was concerned about my ability to explain sex characteristics and what sex is…

This excerpt demonstrates Ellis's commitment to explaining sex characteristics and sex in a queer gender and intersex inclusive way, even though she did not feel completely confident in her ability to do so.

Together, these excerpts highlight the tension that may exist in the classroom between creating inclusive spaces for students with queer genders and intersex students in undergraduate biology courses while also educating students who may be resistant to conceptions of sex and gender as variable and nonbinary. These excerpts also demonstrate the variable causes of the fear (i.e., student interactions vs. instructor explanations).

Obstacle 2: Lacking First-hand Knowledge of Students with Queer Genders and Intersex Student Experiences Due to Privileged Positionality. Instructors explained that due to not holding a queer gender or intersex identity themselves, they had a lack of first-hand knowledge of queer gender and intersex sociopolitically relevant topics and experiences; this contributed to some fear or anxiety surrounding their ability to address sex and gender inclusively. While this fear did not prevent instructors from participating in the process of change, it did serve as an obstacle that could impact any stage of the unlearning process.

As an example of the obstacle of positionality, Riley acknowledged that because of his own positionality, discussing sex and gender topics such as queer gender or intersex identities has lower stakes for him than for students with queer genders or intersex students whom society forces regular negotiating of their sex and gender.

> I don't perceive any value in how I'm talking about this stuff [sex and gender topics], because I don't have to; whereas, they [students] very well might…

In particular, Riley noted that his privileged identity allows him to not perceive direct personal benefit from engaging in topics that challenge dominant sex and gender narratives, because his positionality affords him the privilege of not needing to. Similarly, Alex elaborated on her lack of personal experience with queer gender and intersex sociopolitically relevant topics contributing to a lack of knowledge in how to teach these topics, citing a generational difference and growing up knowing no one who openly held a queer gender identity.

> It's something that I'm definitely still learning about because it's just so different from what I was exposed to… I am still concerned that I am not always doing it the right way.

Because Alex's identities mean that she has not directly experienced the varying types of marginalization people with queer genders encounter—in addition to homogeneity in the communities she grew up in—she feels a disconnect. That disconnect is a source of fear and concern that complicates implementing change in her course. Together, these excerpts illustrate how these instructors are noticing their privileged positionalities and ultimately interrogating their relationships

with the experiences of people with queer genders and intersex people. They are considering how this dynamic affects their course content and the student experience; however, that dynamic presents an obstacle to incorporating queer gender and intersex inclusive teaching strategies and curriculum, and instructors had difficulty addressing how the privilege their positionality gives them shows up in their classrooms.

Obstacle 3: Scarcity of Queer Gender and Intersex Inclusive Sex and Gender Resources. The four instructors in our study used resources from a wide range of disciplines and media. Aside from student feedback, regularly reported resources used by instructors were websites, books, colleagues, popular press news articles, peer-reviewed journal articles, and textbooks. Additionally, instructors relied on educational videos, inclusivity training, opinion articles, blogs, first-person accounts from people with queer genders and intersex people, information from queer gender and intersex advocacy organizations, and conference presentations. Instructors most commonly reported obtaining resources from biology and education disciplines; however, there were additional mentions of obtaining resources from other disciplines, including history, anthropology, psychology, and queer studies.

Despite the types of resources sought and obtained, instructors requested more resources. Specifically, the instructors described a lack of resources displaying range and variation in sex and gender, especially those that are easily understood by students. This scarcity of queer gender and intersex inclusive sex and gender educational resources ultimately impacted their ability to create/find inclusive course materials to implement in their courses.

Obstacle 4: Opposition from Co-instructors. Instructors described difficulty implementing changes in their course when their co-instructors held different ideas, understandings, and/or definitions of sex and gender.[9] This opposition from co-instructors created difficulties for the participants in this study, causing them to either have to work around the instructor to implement the queer gender and intersex inclusive materials or not implement the materials. Both direct opposition and a lack of support from co-workers can work as obstacles toward the inclusion of queer gender and intersex inclusive sex and gender materials in biology courses.

Obstacle 5: Shortage of Available Time. While instructors may understand the significance of teaching sex and gender in a queer gender and intersex inclusive manner, they may not have enough course time to implement these topics in a way that does them justice. Specifically, we noticed that a shortage of time prevented the instructors in our study from being able to 1) go as in-depth as they would like to about queer gender and intersex inclusive sex and gender topics during the course and 2) edit their queer gender and intersex inclusive materials based on student feedback (i.e., causing the instructor to not complete an unlearning cycle that includes student feedback).

[9]We do not provide direct quotes from participants in this section to avoid identifying the participants and creating uncomfortable situations for them with their co-instructors and other coworkers.

DISCUSSION

Through a multiple case study analysis, we found that the four participants made efforts toward teaching sex and gender inclusively in their undergraduate biology course, going through an iterative unlearning process despite citing several obstacles throughout. Here, we discuss the 1) implications of depending on student feedback to continue the process of unlearning, 2) level of queer gender and intersex inclusive curricula integration, 3) potential challenges of leaving sociopolitically relevant queer gender and intersex topics open for debate, 4) complex topic of "inclusive" language, and 5) obstacles to curricular change.

The Implications of Depending on Student Feedback to Continue the Process of Unlearning

To even begin thinking about changing the way they teach sex and gender, instructors first had to understand that certain ways of teaching sex and gender are inaccurate or make some students feel excluded. Previous literature demonstrated that binary sex and gender messaging made students with queer genders feel invisible and unimportant in their biology courses (Casper *et al.*, 2022); however, many common biology and anatomy and physiology course textbooks strictly mention "male" and "female" sexes, conflate sex and gender, and assume gender based on human anatomical characteristics (Bazzul and Sykes, 2011; King *et al.*, 2021). The instructors interviewed in this study were aware of exclusive messaging for students with queer genders and intersex students in biology courses and worked to make their courses more inclusive by unlearning and modifying their courses.

Unlearning is a process that involves correcting, reframing, or replacing some long-held ideas, beliefs, and practices, which are often difficult to uproot through the *learning* of new knowledge, questions, and practices (Cochran-Smith, 2003, p. 9). This is an iterative and lifelong process that is key in enabling instructors to respond to the demands of a changing world. In the context of the present study, biology instructors must unlearn the deeply rooted gender essentialist narratives that have biased sex and gender topics in society, so they can learn more accurate and inclusive ways of teaching sex and gender topics and implement those practices in their courses (Cochran-Smith, 2003; McGuigan and Kern, 2016; McLeod *et al.*, 2020). One instructor reported having already spent 5 years unlearning gender essentialist narratives and implementing queer gender and intersex inclusive curriculum in her biology course, and she still wanted to make further changes to improve her course. This beautifully demonstrates the iterative process and lifelong commitment that unlearning requires. While a lifelong commitment to unlearning can seem daunting, we share this information to comfort instructors that they do not—and will not—have to know everything about queer gender and intersex inclusivity before they start to implement inclusive content in their course. In fact, based on both participant interviews and the unlearning literature, biology instructors will continually learn how to be more inclusive of students with queer genders and intersex students by simply trying to be more inclusive in the first place (i.e., starting to change their curriculum to become more queer gender and intersex inclusive) and reflecting on this process. Our goal is

to encourage instructors to start this lifelong process to uproot gender essentialist narratives in their biology courses.

This process (i.e., the unlearning process) hinged—in part—on student feedback. In fact, the instructor participants mentioned student feedback to their sex and gender curricula spurred reflection, unlearning, learning, and modification of course materials. Student feedback was clearly valuable to these instructors, and student feedback is additionally an integral part of the *Gender Inclusive Biology Framework* (Long, 2019; Long *et al.*, 2021). Specifically, the fifth principle in the framework is *student agency*. The principle of *student agency* promotes: 1) the collection of student input and feedback on class lessons, language used in the class, and classroom culture, and 2) teacher solicitation of students' topic interests. Long (2019) argues student agency promotes student engagement with the material. Broadly, student agency is additionally an important component of critical multicultural education (Banks, 2010), directly countering the traditional norm of schooling where students are socialized to indiscriminately accept what they are told by their instructor, their institution, and their society (Hahn, 1998; Ladson-Billings, 2004; Banks, 2004a; Banks, 2004b).

While considering student feedback may promote student sense of agency (Long, 2019), relying on students as a crucial resource for sex and gender inclusivity presents two potential harms beyond the risk that students may provide biologically incorrect feedback. First, relying on students with queer genders and intersex students to advocate for correct and queer gender and intersex inclusive sex and gender terminology presents a problem called the minority tax (Rodríguez *et al.*, 2015). The minority tax is the extra burden of time and resources placed on minorities in the name of efforts to represent and advocate for their communities (Mahoney *et al.*, 2008; Sánchez *et al.*, 2013; Rodríguez *et al.*, 2015). Williamson *et al.* (2021) proposed several ways to avoid overtaxing minorities, including getting the majority group—in this case people who do not identify with a queer gender or as intersex—to share efforts in diversity initiatives.

Second, relying on students for correct and queer gender and intersex inclusive language is only effective in classrooms where students already feel comfortable and safe to express their concerns. However, when exclusive language is used in the course or displayed on course materials, students may feel uncomfortable approaching the instructor to provide feedback, ultimately causing them to provide no feedback (Harnish and Bridges, 2011). This could be a false signal to instructors that everything is going well in their course because no students have provided feedback to suggest otherwise. With this in mind, instructors should listen to student concerns and seriously consider their feedback, but they should not rely on students as the driving force of change within their courses.

Alternatively, we recommend that instructors welcome student feedback while additionally continuing to reflect and educate themselves on these topics. One way to elicit student feedback in a low-stakes manner is anonymously, potentially via online form responses or an in-person student feedback jar; such methods may be more accessible compared to depending on students to address the instructor face-to-face. Another method of obtaining student feedback includes the use of presurveys/postsurveys to measure the efficacy of the curricula in regards to communicating scientifically accurate and inclusive narratives to students, quantifying potential changes in student attitudes and content knowledge.

Aside from checking out the resources we provide at the end of this discussion to encourage reflection and learning on how to teach sex and gender accurately and inclusively, it can be helpful to create and/or join a community of practice focused on collaborative unlearning. Communities of practice consist of a group of people that have a common interest (e.g., teaching sex and gender inclusively) who meet frequently to improve their practice (Wenger, 1999, p. 73). Similarly, you could join or develop a community that practices being honest and vulnerable with each other about their unlearning process (Loveless *et al.*, 2016). For an example of teachers using this method to evaluate their teaching practice, see Andrzejewski *et al.* (2019). When practicing unlearning collaboratively, McLeod *et al.*'s (2020) set of five principles for collaborative unlearning can guide expectations (p. 187): First, instructors should anticipate discomfort (e.g., regret, vulnerability) during the process of unlearning because changing habits and ways of thinking and knowing is difficult but necessary; Second, instructors should make room for and be informed by personal contexts, rather than just focusing on the professional; personal contexts intersect and interact with professional contexts; Third, shift the importance away from who is a novice and who is an expert in the group, a classically ingrained binary in institutions of higher education, toward the unlearning encounter itself. Unlearning is the ultimate goal, and this can be informed by all members of the collaborative group. Fourth, instructors should be open to new ideas and methods; and Fifth, instructors must accept the ongoing mix of un/learning (McLeod *et al.*, 2020). To learn more about these principles of unlearning, read McLeod *et al.* (2020). Engaging in a community of practice or a vulnerable unlearning community practice—in addition to continuing the individual unlearning journey—will allow instructors to still incorporate student feedback but become less dependent on it.

All Levels of Queer Gender and Intersex Inclusive Curricula can be Useful

While there are different strategies and degrees of integration of queer gender and intersex inclusive content, our intent in categorizing the level of integration was not to label some instructor efforts as less than, while simultaneously labeling other instructor efforts as more than. Rather, our intent was to understand the varied ways in which instructors integrate queer gender and intersex inclusive content in their biology curriculum, the journey it took for each of those instructors to get to that place, and the potential obstacles they faced with their past or future levels of integration.

The Level 1 strategy one of the participant's proposed to use in her class (i.e., featuring queer scientists) has demonstrated positive impacts on student affect in prior literature but should be considered carefully to avoid further marginalizing the highlighted group. For example, the impacts of featuring a profile of a scientist with a queer gender from Project BioDiversify (https://projectbiodiversify.org/) or Scientist Spotlights (https://scientistspotlights.org/) have been

tested and found to increase the extent to which students relate to scientists (Schinske *et al.*, 2016; Brandt *et al.*, 2020; Yonas *et al.*, 2020; Zemenick *et al.*, 2022b; Metzger *et al.*, 2023; Ovid *et al.*, 2023; Costello *et al.*, 2024) and diversify student perceptions about who participates in science (Yonas *et al.*, 2020). Students who shared the same excluded identities with the featured counterstereotypical scientists related most strongly (Costello *et al.*, 2024).

However, simply featuring a scientist with a queer gender or an intersex scientist on their own, without contextualization, has limitations: 1) queer gender and intersex identities can be concealed (i.e., not readily apparent from outward appearance) (Rood *et al.*, 2017), so these identities would need to be announced in order for students to make the connection that the scientist being featured identifies as queer gender or intersex; 2) the obstacles faced by the scientist due to their marginalized identities need to be explained to students in order for them to understand the full impact of that scientist's experience; and 3) placing focus on one identity of a scientist can lead to tokenization. Both Scientist Spotlights and Project BioDiversify address these potential limitations by centering the scientist's research and full personhood (e.g., hobbies, interests, family), only announcing the marginalized identities of the scientist thoughtfully and in a relevant way through the scientist's own acknowledgment of these identities and explanation of these identities have been received by society in their experience. While Level 1 (i.e., contributions) strategies have been criticized for skipping over the forces leading to the marginalization of the highlighted group or individual (Banks, 2010), some of these materials acknowledge these forces. However, the instructor who uses these resources factors into the level and impact of the lesson as well. Both the materials and the instructors need to include thoughtful introduction of the scientist such as avoiding language such as "intersex scientist" or "transgender scientist" Simplifying a person down to one identity may other or tokenize the scientists, and students, with intersex and queer gender identities, rather than creating and inclusive space for them (Kirova, 2008).

We acknowledge these resources that highlight scientists from marginalized sex and gender identities address two fundamental components of multicultural education to varying degrees: 1) the forces leading to marginalization of people with queer genders (i.e., the coverage of this ranges from not at all covered to robustly covered), and 2) the amount of information coming from first-person accounts (i.e., all materials have at least a few first-person sentences from the scientist with a queer gender identity or intersex identity, but some of the resources have more information than others). This is important to note because some of the more robust accounts—those that concretely and robustly cover the forces that lead to marginalization and highlight the first-person perspective of the marginalized scientist—could be classified as a Level 2 inclusive teaching strategy. However, in our study, the interview participant who mentioned featuring scientists in her course did not refer to particular scientist profiles or resources, so we categorized this activity conservatively as Level 1.

The Level 2 strategies used by instructor participants (i.e., explaining sex is not binary and discussing the basis of gender identity) allowed instructors to teach more accurate science that also acknowledged the existence of people with queer gender identities and intersex traits. While these strategies are useful and important in their own right, they do not address the forces that lead to the marginalization of the group highlighted, a critical tenant of multicultural education (Banks, 2010). To extend one of these Level 2 strategies further, instructors could take the strategy of explaining that sex is not binary by introducing the multiple layers of sex and then expand on this strategy by assigning students to complete the Howard Hughes Medical Institute activity on the sex verification of athletes (Bonetta and Julian, 2018; see Supplemental Table S1 for hyperlink).

It may be that in an undergraduate biology course that only touches on sex and gender topics for one class period, Level 1 (contributions) or Level 2 (addition) may be what is practical for many instructors, particularly based on their social, cultural, and institutional contexts. In some state and local contexts, instructors may not feel safe or even legally allowed to discuss topics that promote diversity, equity, and inclusion. For these instructors, short examples that stick to the science of sex may be their best options. In these cases, Level 2, which does not require discussion of personal identity, may actually be easier to implement than Level 1.

The Level 3 strategies used by one of the participants (i.e., a combination of activities centered queer gender and intersex perspectives across the curriculum rather than during just one lesson) tied biology to sociopolitically relevant topics, allowing the instructor to teach science accurately while also addressing the forces that marginalize queer gender and intersex identities. If the instructor connected these activities to social action, then we would have classified her efforts as Level 4 (i.e., social action). However, none of the instructor participants in this study promoted social action in their courses.

Even in the case of a biology course that focuses on sex and gender topics for the entire semester, it may be that the highest level of inclusive content reached is Level 3 (transformation) and not Level 4 (social transformation) due to politics, the degree to which the instructor has participated in unlearning, and/or the course's specific learning objectives (Banks, 2010). First, encouraging students to take social action, such as vote or protest legislation in one direction or another may be viewed as furthering the instructor's own political agenda, a topic that is hotly contested in society and the media (Greene and Paul, 2021; Walton, 2021). Second, speaking on social issues may make biology instructors uncomfortable due to concerns of student pushback and/or feeling uninformed (Beatty *et al.*, 2023), and both of these concerns were voiced by instructors in the present study as well. Third, the learning objectives of the course are likely to dictate whether or not an instructor chooses to strive for social transformation in their course. For example, if an instructor teaches a course where one of the learning objectives is social action or diversity, equity, and inclusion, then it may be more relevant to strive for social transformation in that course compared with a course where none of the learning objectives or content approach sex topics (e.g., biochemistry).

With this in mind, the level of queer gender and intersex inclusive curriculum integration hinges—in part—on the degree to which the instructor has participated in their own unlearning process and become more comfortable with being uncomfortable. For an instructor starting out on this unlearning

journey, it may be that Level 1 or Level 2 is a good starting place for them. In time, with continued practice and unlearning, the instructor could maximize inclusion by integrating queer gender and intersex inclusive content in their class at Level 3 and Level 4. We note that any step toward teaching sex and gender in an inclusive manner is a move toward positive change. It is important to acknowledge those efforts while simultaneously encouraging continued growth and advancement.

Leaving Sociopolitically Relevant Queer Gender and Intersex Topics Open for Debate Presents Potential Challenges

Some inclusive strategies used by the instructors in this study relied on open-ended questions and student discussion in groups. Active learning strategies such as group work are commonly used in postsecondary biology classrooms (Driessen *et al.*, 2020) with positive impacts on overall student performance (Driessen *et al.*, 2024). However, including group activities—such as those concerning gender-affirming care like hormone blockers—may open opportunities for both benefits and harm. Group settings give space for students to challenge gender essentialist beliefs and foster support and inclusivity for students with queer genders, but they could also provide a chance for students to discriminate against students with queer genders, potentially adding to the already higher rate of discrimination and harassment faced by students with queer genders in college compared with their cisgender peers (Dungan *et al.*, 2012). This is a prime example of how additive content (Level 2) when posed through open-ended queries could both increase and/or decrease queer gender inclusivity in the classroom (Banks, 2010). While there is a potential for variation in the degree of queer gender and intersex inclusivity for open-ended questions in classrooms that have reached Level 3 (transformation) and Level 4 (social action) as well, it is less likely to occur since these levels do not typically skip over the forces leading to the marginalization of the highlighted group as do strategies in Level 2 (Banks, 2010). For example, in Ellis's class, which reached Level 3 integration, her students learned from first-hand accounts from people with queer genders and intersex people, gaining insight from individuals in the marginalized groups themselves.

Previous research on queer student experiences with group work in undergraduate biology courses has revealed negative experiences. Henning *et al.* (2019) documented that students who identify as queer felt group work negatively impacted their enjoyment of their introductory biology course. Similarly, interviews with queer students from one active learning classroom that commonly used group work revealed some students had negative interactions with other students when they shared their queer identity in class (Cooper and Brownell, 2016). Despite the harms experienced when revealing their queer identities however, some of these students felt the need to come out to their group members anyway in order to avoid misidentification (Cooper and Brownell, 2016). This presented a toss up between being misgendered by group members or being called "inappropriate" by group members for disclosing a queer identity (Cooper and Brownell, 2016). While these studies certainly apply to—and feature—students with queer genders, it is important to disaggregate experiences of students with queer genders and intersex students from those experiences of students with other queer identities. It will be similarly important to disaggregate the experiences of students with queer genders and intersex students from each other because—although there are shared goals/issues (e.g., bodily autonomy)—each group faces distinct socio political struggles (InterACT Advocates for Intersex Youth, 2021).

To help mitigate negative experiences with group work, special consideration should be given to student identities in group composition. A prior study in an active learning introductory biology course—that allowed students to choose their own groups—reported that Black students created groups with other Black students and women students created groups with other women students (Freeman *et al.*, 2017), citing homophily (i.e., the idea that individuals are likely to relate to others who are similar to themselves; Tatum, 1997). With this in mind, instructors could allow students to self-select into their own groups. However, as identifying with a queer gender often requires individuals "come out" (Cooper and Brownell, 2016; Human Rights Campaign Foundation, 2023), forming a group where all students identify with a queer gender—or at least one where students with queer genders feel safe—would be difficult to do for themselves in a classroom. This presents a unique challenge for students with queer gender identities.

One potential solution to this challenge is for the instructor to assign students with queer genders and intersex students to a group where they are less isolated; grouping students with queer genders together and grouping intersex students together with the group either including additional—or being entirely composed of—students with queer genders or intersex students. For example, Dasgupta *et al.* (2015) found that having same-gender peers in small group work supported women's motivation and participation. Similarly, Casper *et al.* (2014) found that women in small groups with another woman experienced fewer microaggressions than women whose other group members were all men. In theory, placing students with queer genders and/or intersex students in the same group in class may have similar outcomes to creating women-dominant groups. However, we need to assess this approach for potential harms before fully committing to using it with this particular group of students (i.e., students with queer genders and intersex identities). Specifically, we hypothesize this approach could potentially present two harms, including 1) negative student feelings associated with being segregated by the instructor and 2) students being uncomfortable with revealing their identities to the instructor. To prevent harm, we recommend future research investigate this potential solution with careful explanation to the students with queer genders and intersex students as to why it is being investigated. A universal solution to managing group assignments in regards to students with queer genders and intersex students may not exist as individuals' identities are complex and multifaceted. Further, each classroom contains a different makeup of students. Ideally, instructors should engage with the multiple and interacting identities each student holds, rather than simply focusing on a single facet of identity, but the practical application of this approach will likely vary classroom to classroom.

Language is Complicated in Biology and What is Determined as "Inclusive" Language is Not Universal

All instructors changed their use of sexed and/or gendered language to some extent in their course. Specifically, we noticed that instructors in our study focused on inclusive language, replacing gendered language (i.e., woman) with sexed language (i.e., female) in their courses and/or replacing sexed language with trait-focused descriptions (e.g., sperm-producing partner). These changes aligned with calls advocating for "inclusive language" when teaching sex and gender topics in biology (Long, 2019; Hales, 2020; Long *et al.*, 2021; Zemenick *et al.*, 2022a). For example, Hales (2020) recommended alternatives for commonly used terms or phrases, including alternatives for "female anatomy/organs," "male anatomy/organs," "biologically female," "biologically male," "mother or biological mother," and "father or biological father (p. 3)." An example of one suggested alternative, rather than saying "female anatomy" is "egg-conducting and gestational organs" (p. 3). We note that removing language alone does not necessarily convey an inclusive narrative on its own and it does not serve to facilitate conversations about sex and gender. However, when the language choices are explained, and—even better—paired with queer gender and intersex inclusive sex and gender lessons, these language changes can facilitate productive conversation about the diversity of sex and gender in biology courses.

We need to acknowledge that not all of the language changes used by instructors in the present study were biologically accurate. Specifically, one instructor planned to replace the term "hermaphrodite"—from his lesson on hermaphroditic roundworms—with "intersex," as his student suggested. As discussed earlier, the term intersex only applies to specific individuals in gonochoric species (Blackless *et al.*, 2000; Adolfi *et al.*, 2019) while the term hermaphrodite refers to a specific state and is the biologically accurate term for organisms that produce *both* eggs and sperm, either simultaneously or sequentially across their lifespan (Leonard, 2018). There is currently no word that replaces the complexity of reproductive systems captured by the term hermaphrodite (see Supplemental Materials, Appendix B for more information). This example of the term hermaphrodite highlights the tensions of language in science and science classrooms, balancing scientific accuracy and inclusivity. Instead of replacing the term hermaphrodite with the term intersex to signal inclusivity—a replacement that is biologically incorrect, likely enhances misunderstanding, and may isolate students from accessing research on these terms—instructors could explain the tension that exists with the term hermaphrodite, especially when it comes to the intersex and queer gender communities. For example, instructors could detail both the historical and present incorrect use of the term hermaphrodite to refer to intersex humans and the harm this incorrect use has caused to members of the intersex community. This would provide an opportunity to educate students on societal misunderstandings of intersex individuals and define the term hermaphrodite and the scope of its correct use. When constructing these conversations, it is also important to note that the term intersex is not universally accepted either (Costello, 2016; Viloria and Nieto, 2020). Engaging students in a conversation about the complexity of language and harmful and incorrect co-opting of biological language can provide fruitful engagements with biology as a practice, and open pathways for students into a wide range of biological fields.

Alternatively, if instructors do not want to or are unable to delve into this complexity, they could simply discuss the diversity of organization of gametes in individuals, naming characteristics: for some species an individual only produces eggs or sperm or no gametes; in other species, an individual produces both eggs and sperm; and in other species individuals produce only eggs, only sperm, or both simultaneously; and, for some species, the types of gametes an individual organism produces can change over time. These descriptions still inform students on the accurate and complex nature of the diversity of reproductive systems, without naming the term (i.e., hermaphrodite).

Obstacles to Curricular Change were Typical, Aside From the Fear of Isolating Students with Queer Genders or Intersex Identities and Concerns About the Positionality of the Instructor

Instructors in this study faced the challenges of 1) potential isolation of students with queer genders and intersex students; 2) lacking first-hand knowledge of queer gender and intersex sociopolitically relevant topics due to positionality; 3) scarcity of queer gender and intersex inclusive sex and gender resources; 4) opposition from co-instructors; and 5) shortage of available time. When looking at curriculum reform efforts, these obstacles are commonly faced (Seidel and Tanner, 2013; Miller and Metz, 2014; Andrews and Lemons, 2015; Walter *et al.*, 2020; Beatty *et al.*, 2023) with the exception of the first and second obstacles (i.e., isolation of students with queer genders and intersex students and positionality, respectively). For this reason, we focus on discussing only the first and second obstacles in this section.

First, the potential of isolating students with queer genders and intersex students impacted instructors primarily through the vehicle of fear, from a variety of sources such as instructor missteps, student interactions, and complex classroom needs. We affirm the real fear of doing harm, and we also invite feedback and iteration as a necessary part of the implementation process. Harm mitigation is of utmost importance, and at the same time pedagogy will not be perfect on the first try; this can be an opportunity for instructors to be honest about their concerns and to be dynamic in how they incorporate student voices in improving their teaching. Furthermore, educational institutions can provide more space in performance evaluations for instructors to take the risks of making changes and receiving needed student feedback. The burden of fixing exclusionary practices should not rest on those whom they are marginalizing, but centering their voices and input can be an important avenue for changing curriculum.

Second, instructors expressed awareness that their *positionality* complicated their efforts to implement change in their classrooms, and moving forward toward action proved challenging. This is where we recommend instructors engage in a process of reflexivity: both becoming aware of their positionality (i.e., what social location their identities place them in, with respect to the goal of queer gender and intersex inclusivity) and moving further to reflect on how that positionality impacts our educational choices (Secules *et al.*, 2021;

Martin *et al.*, 2022). Positionality with dominant sex and gender identities does not inherently disqualify people without a queer gender and nonintersex people from teaching about sex and gender; instead, reflecting on how our positions impact our teaching allows us to move forward to reduce harm with empathy and awareness of power dynamics. Through understanding that everyone occupies different spaces within and outside of the social construction of gender—and its intersection with other identities—we can better recognize both privilege and marginalization.

All people, not just those who identify with queer genders or as intersex, hold some experience of gendered assumptions as they operate in the world; where key differences can arise is that some hold identities that are minoritized, resulting in their lived experiences being different than those with more dominant cisgender identities (Kearns *et al.*, 2017). Cisgender identity can then provide the privilege of not experiencing that oppression nor having society force them to engage as directly with their gender on a regular basis (Kearns *et al.*, 2017), as multiple instructors in this study expressed. For this reason, the work of unlearning is especially important for those who hold privileged identities.

Instructor Resources

Given instructor requests in the interviews for more inclusive and accessible sex and gender teaching resources, we have compiled a list of resources (used and known by the authors of this study) here—in the form of articles, activities, books, and podcasts—for instructors and researchers who are interested in participating in the journey of unlearning binary ways of teaching sex- and/or gender-related topics and integrating queer gender and intersex inclusive teaching strategies in undergraduate biology courses. See Supplemental Table S1 for links to both the resources we describe below as well as articles on unlearning more broadly.

For an article on how to signal inclusivity in genetics courses for students with queer genders, we recommend reading Hales (2020). Hales (2020) provides detailed queer gender inclusive teaching strategies for depicting and describing inheritance of traits. These resources can be applied to similar content and terms in courses outside of genetics courses as well. Similar relevant resources for genetics courses include Hubbard and Monnig (2020) and Stuhlsatz *et al.* (2020).

For an article on how to teach sex and gender topics more inclusively and accurately in postsecondary biology classrooms, we recommend reading Zemenick *et al.* (2022a). Zemenick *et al.* (2022a) detail six thoughtful principles instructors can use to teach sex and gender topics in postsecondary biology: 1) highlight biological diversity right away, presenting it as the rule, rather than the exception; 2), provide the social and historical context of science, making clear links between biology topics and societal issues; 3) use inclusive terminology; 4) teach the true process of science, revealing it is oftentimes iterative and nonlinear; 5) present a range of role models, avoiding tokenizing individuals; and 6) create a culture of respect and inclusion in the classroom (pgs. 483–490). Zemenick *et al.* (2022a) apply these principles in three different examples, addressing sexual reproduction, sex determination or differentiation and sexual dimorphisms, and sexual selection (pgs. 485–487).

For a thought-provoking read on how sex is shaped by the very culture in which science is conducted, read Fausto-Sterling (2012). In her book, Fausto-Sterling addresses three key dualisms: 1) sex/gender, 2) nature/nurture, and 3) real/constructed. This book could enlighten instructors on the connection between sex and gender and society, revealing the impact of societal norms and narratives on people with queer genders and intersex and—more broadly—queer people.

For an educational podcast, check out the new six-part podcast *Science* series on books that explore sex and gender. In this series, with the first episode released in May 2023, Angela Saini interviews Malin Ah-King, author of, "The Female Turn: How Evolutionary Science Shifted Perceptions About Females." This podcast may interest and enlighten postsecondary biology instructors given the blend between biological background and theoretical perspectives provided during the podcast (Saini and Ah-King, 2023).

These resources are certainly not exhaustive, and they are additionally not meant to be gone through as a checklist. More plainly, uncovering exclusive language and harmful mainstream narratives is difficult work and involves noticing and unlearning these narratives individually and then making structural and actionable changes. This may not simply be done through reading articles or books or listening to a podcast.

Considerations

There are several considerations to make when interpreting our findings. First, all participants were cisgender, heterosexual, and white. Given both their majority group identities and identities as biology professors, they hold greater positions of power in society compared with people with queer genders and intersex people and they hold positions of power over their students (e.g., persons with disabilities, racial minority) (Caruthers and Carter, 2012; Crenshaw, 2013; Boveda and Annamma, 2023). The participants noted that their lack of identifying as a person with a queer gender or as an intersex person acted as a barrier causing generalized concern of doing harm to their students further indicating the importance of unlearning. However, instructors largely reported reading biology resources to unlearn, so it is important to consider the additional need for instructor education around feminist and queer theory.

Second, in the present study, the data are from a cohort of four instructors from the same university, which is located in a state that is considered a "safe haven" for gender affirming care (Orrick, 2022) because it is one of the few states to protect trans health care (Ferguson *et al.*, 2023). Additionally, all participants are from the same unit, and this unit has engaged in DEIJ initiatives. The participants also self-identified as working to teach sex and gender topics in a way that is inclusive, and those who are not seeking such curricular change may not have responded to participate in the study. There is evidence of binary sex and gender curriculum being a predominant narrative for teaching biology in higher education (Casper *et. al.*, 2022), and this is not an experience our study explored.

Third, though our study's goal is not representativeness or generalizability, there are likely experiences of biology instructors we did not observe in this study. Such experiences could

include those of instructors who are not working to teach more inclusively or who are trying to teach sex and gender in a queer gender and intersex inclusive way in states like Florida and Texas where recent legislation acted against DEIJ efforts *and* the freedoms of people with queer genders (Kyaw, 2023; Trans Formations Project, 2024). For example, instructors who teach inclusively in those states may cite legislation or fear of administrative or parent pushback as additional or more noteworthy obstacles than the ones mentioned in the present study. In fact, when it comes to curricular reform, Woodbury and Gess-Newsome (2002) created the teacher-centered systemic reform framework, noting that reform policies need to center teachers as agents of curriculum reform. According to this framework, whether an instructor participates in the reform hinges on the relationships between the general context of reform, instructor personal factors (e.g., demographics, teaching experiences, teaching preparation, continued learning efforts), teacher's thinking, contextual factors (e.g., broader culture, institution, department, subject area, and classroom contexts), and instructor's practice in the classroom (Woodbury and Gess-Newsome, 2002).

Fourth, there are people—including biologists—who disagree with our recommendation to use certain language in biology classrooms (e.g., hermaphrodite). For example, The Ecology and Evolutionary Biology Language Project (https://www.eeblanguageproject.com) hosts a repository of biology-related terminology identified as harmful and suggested replacements. One of the terms on that list is the term hermaphrodite, and one of the suggested replacements for this term is intersex. While we do not recommend this swap of language in the context the instructors were teaching (i.e., teaching about hermaphroditic worms) due to the scientific accuracy and social impact of terms (see Supplemental Materials, Appendix B), we acknowledge that the discussion of what is inclusive and what is not inclusive is an open and active area of debate. It is important to consider that ours is one of many perspectives all from individuals trying to find the intractable balance between accuracy and inclusivity.

Fifth, we were not originally aware of unlearning as a theme rooted in literature (e.g., Cochran-Smith, 2003; Loveless *et al.*, 2016; Andrzejewski *et al.*, 2019; McLeod, *et al.*, 2020). Unlearning was a theme that we noticed in our data; however, we did not use unlearning as a framework at the outset of the experiment, so we did not design our interview questions to better understand this unlearning journey. This limited our ability to understand the role that metacognition—an important component of reflecting on one's own learning and therefore an important component of the process of unlearning (Taylor, 2010; Kennelly and McCormack, 2015; Tuononen *et al.*, 2023)—potentially played in the instructor's process of unlearning. Additionally, we did not ask instructor's specifically what about gender essentialism they unlearned. This is an area of research that is important to continue in order to understand what resources could help instructors unlearn gender essentialism in the context of undergraduate biology education and teach more inclusively to their students with queer genders and intersex students.

Sixth, we did not actually test the impact of these teaching practices on student measures of inclusivity (e.g., sense of belonging) or scientific accuracy, so these teaching strategies are not evidence-based as intersex or queer gender inclusive strategies. Preliminary research is beginning to test strategies for inclusion and scientific accuracy (e.g., Adams *et al.*, 2023, 2024). This is an important growing area of research that will have great implications on instructor continued learning concerning queer gender and intersex inclusive teaching practices.

Future Directions

Repeating this study at a larger, national scale at more institutions and with more instructors will be important to garner findings that engage with a wider range of instructor experiences and to evaluate differences of approach to teaching sex and gender topics inclusively between regions and institution types. Additionally, conducting lecture observations will allow an expanded understanding of how faculty are teaching sex and gender beyond their own reports and the course artifacts. Discussions with students—who have queer gender identities or intersex traits—and scientists, regarding their perspectives and experiences in the context of biology education, will also be valuable in informing approaches to teaching sex and gender topics inclusively. Another helpful future direction for research includes the use of presurveys/postsurveys to measure the efficacy of potentially promising curricula in communicating scientifically accurate and queer gender and intersex inclusive narratives and shifting student attitudes. Together, instructors could leverage these broader findings to alter undergraduate biology curricula toward greater inclusion of students with queer genders and intersex students and to more accurately represent the scientific understandings of sex and gender based on the needs identified by both faculty and student studies.

Moreover, future research is needed to 1) investigate the relationship between the definitions of sex and gender that faculty personally report and those employed in their courses and 2) interrogate the lecture slides with terminology clarification and explanations that define sex and gender-related language across the courses examined in this study. These types of future studies will be important in understanding how biology faculty define and present sex and gender in their courses. Juxtaposing those definitions with conceptual understandings of sex and gender in queer studies and other disciplines could broaden our perspectives on how to be inclusive of students with queer genders and intersex students in biology classrooms.

CONCLUSION

In conclusion, we encourage biology instructors to consider their current teaching practices for the topics of sex and gender. We provided resources as a place to start this evaluation. For any instructors unsure about starting the process of reforming their sex and gender curriculum to focus on diversity and inclusion due to concerns of doing harm to their students during the instructor's unlearning process, we argue that the present harms of teaching in a binary manner do more damage than an instructor who is willing to try to be inclusive and try out new teaching strategies. Previous literature has demonstrated there are multiple factors that improve queer students' perceptions of campus climate, including supportive faculty,

staff, and students (Garvey *et al.*, 2015; Garvey, *et al.*, 2018). Additionally, a positive campus climate is related to improved academic and social outcomes for queer students (Pitcher *et al.*, 2018).

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