Biology Instructors See Value in Discussing Controversial Topics but Fear Personal and Professional Consequences

Abby E. Beatty,[†*] Emily P. Driessen,[†] Amanda D. Clark,[†] Robin A. Costello,[†] Sharday Ewell,[†] Sheritta Fagbodun,[‡] Randy L. Klabacka,[†] Todd Lamb,[†] Kimberly Mulligan,[§] Jeremiah A. Henning,[¶] and Cissy J. Ballen[†]

[†]Department of Biological Sciences and [§]Office of Inclusion, Equity and Diversity, Auburn University, Auburn, AL 36849; [‡]Department of Biology, Tuskegee University, Tuskegee, AL 36088; [¶]Department of Biology, University of South Alabama, Mobile, AL 36688

ABSTRACT

Traditional biology curricula depict science as an objective field, overlooking the important influence that human values and biases have on what is studied and who can be a scientist. We can work to address this shortcoming by incorporating *ideological awareness* into the curriculum, which is an understanding of biases, stereotypes, and assumptions that shape contemporary and historical science. We surveyed a national sample of lower-level biology instructors to determine 1) why it is important for students to learn science, 2) the perceived educational value of ideological awareness in the classroom, and 3) hesitancies associated with ideological awareness implementation. We found that most instructors reported "understanding the world" as the main goal of science education. Despite the perceived value of ideological awareness, such as increasing student engagement and dispelling misconceptions, instructors were hesitant to implement ideological awareness modules due to potential personal and professional consequences.

INTRODUCTION

Traditional scientific training for postsecondary biology students emphasizes scientific content and practice rather than navigation of socially relevant concepts such as ethics and societal influences on science (Gregory *et al.*, 2011; Clemmons *et al.*, 2022). Previous work shows instructors prefer to teach a traditional "value-free" biology curriculum, which is perceived as unbiased (Cross and Price, 1996). However, scientific disciplines are subject to the same human biases as any other entity. Furthermore, in bypassing both conversations about these societal issues and the integration of social elements into science activities, instructors miss opportunities to encourage critical thinking, decision making, argumentation, reflective judgment, moral development, and science literacy (Zohar and Nemet, 2002; Sadler and Zeidler, 2004; Zeidler *et al.*, 2005; Sadler *et al.*, 2006; Dawson and Venville, 2010; Eastwood *et al.*, 2012).

This brings us to a central question: "Why is it important for students to learn science?" Recent advances in our thinking about the primary goals of education led to a reshaping of science teaching. Here, students are viewed as future citizens who require a science education that prepares them for a lifetime of personal and social decisions related to science (Aikenhead, 2002). More formally, the American Association for the Advancement of Science (AAAS, 2011) developed a set of standards to promote scientific literacy or skills that facilitate the use of science to make sense of issues in our daily lives, and several studies have highlighted the importance of promoting science literacy among both science majors and nonmajors (Feinstein, 2011; Feinstein *et al.*, 2013; Ballen *et al.*, 2017). One of the six core competencies described by the AAAS as the priorities of science is "the ability to understand the relationship between science and society" (AAAS, 2011, p. 15). As it is the role of higher education to foster

Molly Bolger, *Monitoring Editor*
Submitted Jun 8, 2022; Revised Apr 4, 2023; Accepted Apr 6, 2023
CBE Life Sci Educ September 1, 2023 22:ar28
DOI:10.1187/cbe.22-06-0108
*Address correspondence to: Abby E. Beatty (Aeb0084@auburn.edu).

the development of core competencies, science course content that highlights complex societal issues will lead to a more thoughtful and informed student body (Beatty *et al.*, 2021).

One broad approach that integrates societal issues into science is the use of culturally relevant pedagogy (Ladson-Billings, 1995a,b). According to Ladson-Billings (1992), this approach empowers students not only intellectually, but also socially and emotionally through the use of cultural referents. Later, Ladson-Billings (1995a) clarified that this approach rested on three criteria, including academic success, cultural competence, and critical or sociopolitical consciousness. The use of this framework has changed in the time since its inception. Ladson-Billings even wrote how culturally relevant pedagogy has "taken on a life of its own," as many of its applications in the literature are distant from her central ideas (Ladson-Billings 2021, p. 147). Gay and Howard (2000) and Young (2010) described how subsequent research using this framework focused on academic success and cultural competence while deemphasizing or omitting another major component of culturally relevant pedagogy, critical or sociopolitical consciousness, which questions and confronts injustices and systems of oppression.

Ideological awareness addresses this part of culturally relevant pedagogy as an understanding of biases, stereotypes, and assumptions that shape contemporary and historical science (Potochnik, 2020; Beatty *et al.*, 2021; Costello *et al.,* 2023). Ideological awareness confronts dominant paradigms that inform approaches to science and practice. Thus, teaching ideological awareness enables students to challenge prevailing worldviews and the status quo by thematizing topics in the classroom to incorporate socially relevant discussions. Angela Potochnik, a philosopher of science who developed the term, described how individual values have the potential to influence science in several ways. For example, values can impact research questions that are asked, hiring decisions that dictate which scientists pursue research, and the consumers of research (Potochnik, 2015, 2017). Costello *et al.* (2023) elaborated on the meaning of ideological awareness, and this topic is well covered in that extensive review. Our ambition here is to summarize its meaning and the limited empirical work that has studied the impacts of ideological awareness in undergraduate biology.

Because the term was recently operationalized, little empirical work has focused on the impact of ideological awareness on student outcomes. Beatty *et al.* (2021) showed that students preferred a biology curriculum that incorporated ideological awareness activities to a traditional curriculum, and persons excluded because of their ethnicity and race (PEERs; Asai, 2020) reported greater approval than non-PEER students. Further, when given an opportunity to name as many scientists as possible over 2 minutes, students exposed to ideological awareness modules named more women scientists and scientists of color compared with students in the control section.

Previous research has focused on socio-scientific issues, a similar but distinct approach to teaching topics at the intersection of science and society. This well-established teaching methodology (Mary and Marcus, 2003; Zeidler *et al.*, 2005; Zeidler and Nichols, 2009; Eastwood *et al.*, 2012) integrates societal issues directly into science education (reviewed in Sadler, 2004; Zeidler and Nichols, 2009). Zeidler and Nichols (2009), p. 49 describe socio-scientific issues as the use of "scientific topics that require students to engage in dialogue, discussion, and debate." Such topics are often controversial and require students to consider their moral reasoning and address the ethics of each circumstance, increasing student engagement by making examples personally relatable. Ideological awareness is distinct from socio-scientific issues, because ideological awareness does not need to be rooted in scientific knowledge. Additionally, while socio-scientific issues emphasize understanding multiple perspectives of an issue (see examples in Zohar and Nemet, 2002), ideological awareness confronts and unveils systems of oppression and biases in science. For example, consider a hypothetical lesson centered on medicine. This could be considered a socio-scientific issue lesson if the instructor and students engaged in moral debates over the costs and benefits of getting genetically tested. However, this lesson could alternatively be considered an ideological awareness lesson if the instructor encouraged students to consider how discrimination shapes medical knowledge and practices, highlighting the impact of a history of medical research centering on white, cisgendered men (Perez, 2019). Similarly, an ideological awareness lesson might discuss the impact of the absence of minoritized identities among biologists or the demographic mismatch between students who aspire to be scientists and those who occupy science roles (Wood *et al.*, 2020; Simpson *et al.*, 2021) (See Box 1 for additional examples of ideological awareness lessons.) To download full lessons, access the following link: https://tinyurl.com/IdeologicalAwareness.

Instructors of introductory biology courses may be reluctant to teach culturally relevant pedagogy, such as ideological awareness, for several reasons. We draw upon expectancy-value theory to explore how instructors weigh the costs and benefits of teaching ideological awareness in biology (Wigfield and Eccles, 2000; Eccles and Wigfield, 2002). This theory predicts that instructors will modify their teaching if they perceive they can make those changes (expectancy), if they place value in the changes (value), and if they perceive those changes will come at a low cost to them (cost). Expectancy is one's self-efficacy (Bandura, 1997), or the belief that one is competent in a particular area. Value relates to an individual's incentives or reasons for doing an activity (Eccles and Wigfield, 2002). Cost relates to the negative results experienced by an individual for engaging

BOX 1. Definition of ideological awareness and set of examples provided to instructors during survey administration

Ideological awareness is an understanding of biases, stereotypes, and assumptions that shape contemporary and historical science. Examples of topics related to ideological awareness in the class include, but are not limited to:

1. Representation in STEM
2. Disparities in healthcare related to systemic discrimination (maternal mortality in the black population, LGBTQIA+ access to medical care)
3. The relationship between science and religion (stem cell research)
4. The history of unethical human experimentation (Nazi Germany twin experiments)

in a task, including those directly stemming from the task itself. As instructors develop or modify existing curricula, they must determine whether to choose a "path of least resistance" and maintain "value-free" biology course work or consider ways to integrate difficult societal issues into science, even if this option requires more work and is potentially professionally costly. These decisions may be driven by perceived ability to teach ideological awareness, institutional culture, concerns about equity, or other factors. We reason that, if instructors see the value of ideological awareness as outweighing the potential costs (e.g., student pushback, professional consequences), then they will be more likely to incorporate it into their teaching; but, if faculty chose to do the minimum work possible or perceive the potential costs outweigh the benefits, then they will be less likely to incorporate ideological awareness into classrooms. Because ideological awareness is a relatively new concept in the context of undergraduate biology education, no comprehensive research efforts exist to understand the motivation or reluctance of instructors to navigate ideological awareness lessons or how instructors go about teaching these topics.

Through this mixed-methods analysis, we researched a national sample of biology instructors' perceptions of ideological awareness. Specifically, we explored the following research questions.

1. What personal and contextual factors relate to instructor use of ideological awareness?
2. Why do instructors feel it is important for students to learn science?
3. How do instructors value the implementation of ideological awareness in biology education, and to what extent are instructors currently implementing ideological awareness in the classroom?
4. What do instructors report as hesitations associated with teaching ideological awareness in biology?

METHODS

To address our research questions, we performed a mixed-methods study. We invited instructors across the United States who were currently teaching or have taught lower-level biology courses to voluntarily participate in an online survey. This research was approved by the Auburn University Institutional Review Board (protocol no. 21-237).

Survey Development

At the time of this study, no research-validated survey existed to address our specific research area. Additionally, there were no existing constructs that directly answered the questions posed here. With the previously recorded low response rate of Web-based surveys, particularly in frequently surveyed population such as instructors (Shih and Fan, 2008), and the sensitive nature of the research topic (Fowler, 2014), we were prepared for a sample size insufficient for validation of latent constructs, so we designed a mixed-methods survey with open-ended responses to directly answer our research questions (see GitHub Repository Supplemental Files).

The survey underwent a series of pilot tests before implementation. Initially, all authors contributed to the development of survey items during a meeting supported by the Inclusive Environments and Metrics in Biology Education (iEMBER) Collaboration and Supported Preliminary Awards for Research Collaboration (SPARC) Award. We developed survey items using both inductive and deductive methods, according to best practices outlined by Boateng *et al.* (2018). Due to the nature of the survey, we carefully checked the survey for "threatening questions" (Bradburn *et al.*, 1978), as social norms may have influenced how participants responded. As recommended by Bradburn *et al.* (1978), we placed sensitive items toward the end of the survey, and we administered the survey both online and anonymously in order to increase response rate and honesty of responses.

Following the survey's initial development, A.E.B., J.A.H., and C.J.B. refined survey items. We discussed the survey items during a focus group evaluation with the target audience (a subset of instructors from a variety of demographic backgrounds from the southeastern United States). Then, we piloted the Web-based survey by distributing it to the iEMBER network, where we were able to collect pilot data. We then met and discussed the interpretations and responses in a focus group with iEMBER members. In response to that feedback, A.E.B. lightly modified the survey for clarity.

Previous research showed the majority of biology education research occurs at primarily white research institutions (Thompson *et al.*, 2020), so we aimed to equitably maximize our distribution efforts using several encompassing approaches in a combination of purposive and snowball sampling (Fowler, 2014). First, we sent survey links to the iEMBER, Ecological Society of America, and Society for the Advancement of Biology Education Research (SABER) listservs. Second, we sent invitations to faculty directly after extracting their individual emails from departmental webpages. To recruit instructors across a range of locations and institution types, we collected instructor emails from all schools with faculty contact pages across: all campuses with graduate programs in discipline-based education research (as reported on SABER webpage), the top 50 research institutions in the United States according to the *Nature* index, two randomly selected historically Black colleges and universities (HBCUs) per state, and two randomly selected institutions from list of all universities/colleges in the United States per state obtained from the U.S. Department of Education Database for Accredited Postsecondary Institutions and Programs; these methodological approaches totaled targeted emails to 5,781 instructors. Third, we achieved snowball sampling by requesting participants continue distributing the survey to their existing contacts.

Survey Description and Dissemination

The survey instrument opened with an information letter, detailing the purpose of the study to participants (GitHub Repository Supplemental Files). Then, the survey prompted respondents to give or deny consent for participation, including the use of responses in publication. Next, the survey provided respondents with a definition of ideological awareness and a series of examples (Box 1), and the participants had to verify that they reviewed the summary and understood the terms presented before proceeding to the survey items. These definitions, as well as examples, were accessible on the screen for the duration of the survey and were easily viewed by participants at any time, as described in Fowler (2014). Subsequently, participants answered a series of questions assessing 1) why it is important for students to learn science, 2) the perceived educational value of ideological awareness in the classroom and their current frequency of

implementation, and 3) hesitancies associated with ideological awareness implementation (see Supplemental Table 1 for specific survey questions). At the end of the survey, respondents provided details concerning their demographics and previous professional experiences. These details were used as correlative factors (see Supplemental Table 1 for the specific demographic questions we asked) that may affect an instructor's views of ideological awareness implementation. Specifically, we collected respondents' self-reported gender identity, race, and first-generation student status. Respondents were given the option to report any additional aspect of their identities they felt was underrepresented in science. Additionally, we collected information on institution type, institution location, category of current appointment, and years of teaching experience.

The survey was open for a period of 30 days, from November 21 to December 21, 2021. Over this time period, a total of 203 survey attempts were initiated. Of those attempts, 75 surveys were less than 20% complete, so we excluded them from analysis. An additional 13 surveys were ~50% complete and were used when appropriate based on the survey item. The remaining 115 surveys were 95–100% complete, resulting in a total of 128 surveys used in mixed-methods analysis.

Qualitative Analysis

After cleaning the data, eight of the authors (A.E.B., J.A.H., A.D.C., R.A.C., E.P.D., S.E., R.L.K., T.L.) worked in pairs to create categories and codes using inductive coding (i.e., the authors deduced codes from the data rather than creating codes a priori; Saldaña, 2013). To ensure consistency among coders, we completed coding in a series of predetermined steps. First, each coder examined the instructor responses for one survey prompt/question and designed a proposed coding rubric, and then coders met with their assigned partners to agree on a tentative rubric. Then, each coder independently binned the first 30–50 responses for each survey item into coding themes. Coders then met and revised the rubric based on discrepancies. Then, the individuals coded all instructor responses using the finalized rubric. Coders then met and determined the percent agreement between coding pairs (Supplemental Table 2), and they coded to consensus (100% agreement). All emerging themes, complete with descriptions and examples, are available in Supplemental Table 3 in the GitHub Repository. Of note, if a single instructor's response fit into multiple thematic codes, then we coded it into multiple themes. After we finished coding, we used qualitative content analysis (i.e., a tool used to determine the presence and frequency of certain codes within the open-ended responses; Morgan, 1993) and calculated the frequency of responses within each theme by dividing the number of responses for a specific coding category by the total data points gathered for one survey question (i.e., the total number of responses within a code were divided by the total number of responses for a question, after removal of non-response surveys and uninformative responses).

Quantitative Statistical Analysis

We performed a regression analysis to assess how measured instructor demographics and teaching style (see Supplemental Table 1 for the specific demographic questions we asked) interacted with their views of ideological awareness in the classroom. Instructor demographic variables included: institution location, instructor rank, institution type, gender, and race. Teaching style included: years teaching, class size, proportion of teaching load that is lower division, the percent of the course the instructor had developed or modified, percent of students who are PEERs, and how comfortable the instructor is addressing ideological awareness topics in the classroom. Response variables included 1) importance of ideological awareness according to instructors, and 2) time dedicated to ideological awareness in biology education. Using R v. 4.0.3., we created linear models using the nlme package (Pinheiro *et al.*, 2020) and calculated correlational statistics. All independent correlational measures are based on Pearson's correlation coefficients. Statistical significance was based on $p < 0.05$ and confidence intervals (CIs) that exclude zero.

RESULTS

The Impact of Contextual and Personal Factors

The 128 total responses used in analysis came from instructors with a variety of backgrounds and professional experiences. Participants represented institutions from 32 states (Supplemental Figure 1), and their academic appointments ranged from 2-year institutions to doctorate-awarding institutions, including faith-based and primarily minority-serving (including HBCU and Hispanic-serving) institutions of both public and private status (Table 1). Instructors reported teaching experience ranging from less than 5 years to more than 20 years in positions including: graduate student, postdoctoral researcher, staff, part-time instructor/adjunct, full-time instructor, non–tenure track faculty, tenure-track faculty, tenured associate professor, and tenured full professor (Table 1). On average, 55% of all instructional time by participants is spent in lower-level courses. Instructors reported primarily white (78.91%) and self-reported binary gender identities (85.16%). We found 63.28% of instructors reported that they did not identify as a first-generation student, 25.78% did report a first-generation status, and the remaining proportion reported that they were unsure of their first-generation status (Table 1).

We found that institutional or identity characteristics did not play a role in instructor perceptions of ideological awareness curricular materials. When we asked instructors how likely they are to implement ideological awareness, how much they valued ideological awareness, or how often ideological awareness should be used in the classroom, we found neither instructor location, appointment, institution type, gender, race, first-generation status, or years of experience teaching influenced their responses. However, we note that certain instructor identities may be statistically underrepresented (e.g., "race" and "gender"; Table 1), so we may not have had adequate sample sizes to detect present relationships between these and ideological awareness implementation.

The Importance of Science Education

To grasp the reasoning behind instructor views of ideological awareness, we first needed to understand what science educators view to be the objective of science education. When instructors were asked, "In your view, why is it important for students to learn science?," responses fell into six codes: understand the world, build science skills, combat misinformation, apply science skills, build career foundation, and encourage excitement (see coding rubric for descriptions and examples of coded responses in GitHub Repository Supplemental

TABLE 1. Self-reported demographic criteria of participant instructors[a]

Institution type	*n*	%	Years of teaching experience	*n*	%
Two-year institution	2	1.56	>5	36	28.13
Baccalaureate-awarding institution	45	35.16	5–10	35	27.34
Master's-awarding institution	39	30.47	11–20	26	20.31
Doctorate- awarding institution	69	53.91	>20	28	21.88
Faith-based institution	8	6.25	Unreported	3	2.34
Primarily minority-serving institution	8	6.25	**First-generation status**	***n***	
Private institution	32	25.00	No	81	63.28
Public institution	39	30.47	Yes	33	25.78
Unreported	5	3.91	Unreported	14	10.94
Instructor appointment	***n***		**Gender identity**	***n***	
Graduate student	13	10.16	Genderfluid	1	0.78
Postdoctoral researcher	1	0.78	Nonbinary	2	1.56
Staff	2	1.56	Woman	65	50.78
Part-time instructor/adjunct	3	2.34	Man	44	34.38
Full-time instructor	12	9.38	Unreported	16	12.50
Non–tenure track faculty	25	19.53	**Race/ethnicity**	***n***	
Tenure-track faculty	24	18.75	Asian/Asian American	5	3.91
Tenured associate professor	13	10.16	Black/African American	4	3.13
Tenured full professor	25	19.53	Latino/Hispanic American	5	3.91
Unreported	9	7.03	White/ European American	100	78.91
			Unreported	14	10.94

[a]Note that all survey items included "choose all that apply" options. Percentages are calculated based on the number of respondents who chose each option out of the total number of participants, and percentages may total more than 100%.

Table 3). A majority of instructors mentioned two main goals. Specifically, instructors described a need for students to 1) understand the world they live in (88%) and 2) to build basic science skills, such as scientific inquiry and critical thinking (40%). To a lesser degree, instructors were concerned with students' ability to combat misinformation (18%), properly apply science skills to solve problems (13%), and build a foundation for future science careers (13%), and their own ability to encourage excitement among students (1.7%; Figure 1).

Importance and Benefits of Ideological Awareness

After asking about instructors' rationales behind the importance of students learning science, we prompted them to convey their thoughts on the importance of ideological awareness to graduating students from their institutions, the percentage of time in a lower-division course that should be dedicated to ideological awareness, and the perceived benefits of incorporating ideological awareness into their courses. We detail findings from each of these categories in the following sections.

Importance of Ideological Awareness

Instructors were asked on a scale from 0 to 10: "How *important* is it for students graduating from your institution to have exposure to a scientific curriculum that addresses biases, stereotypes, and assumptions that shape contemporary and historical science?" Instructors reported a high level of importance for their students (8.19 ± 0.39; 95% CI; Figure 2A). The amount instructors rated the importance of ideological awareness in the classroom increased with both their average reported comfort with ideological awareness topics ($r_{(119)} = 0.29$, $p = 0.001$) and the degree to which they felt it was the instructor's responsibility—rather than the students' responsibility—to explicitly link those topics to class content ($r_{(101)} = 0.42$, $p < 0.001$; Figure 2A).

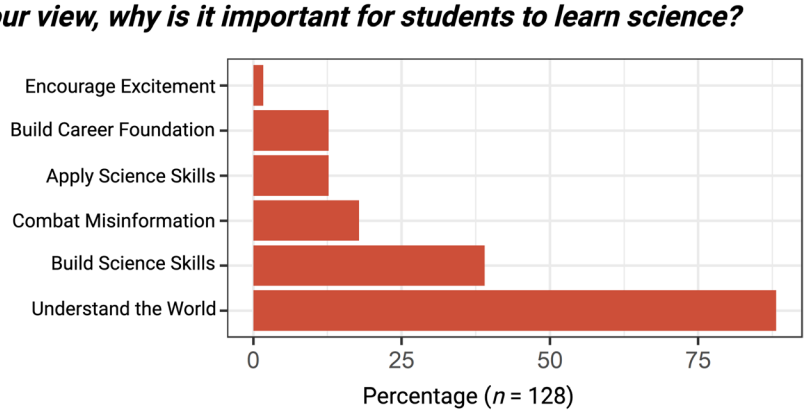

FIGURE 1. Instructors were asked to respond to the short answer prompt, "In your view, why is it important for students to learn science?" Responses were coded into categories, and response frequency is represented by increasing percentage of occurrence.

Time Dedicated to Ideological Awareness

When instructors were asked "What percentage of each lower-division course *should* be dedicated to moral and ideological components of scientific issues?," the average instructor response was 23%

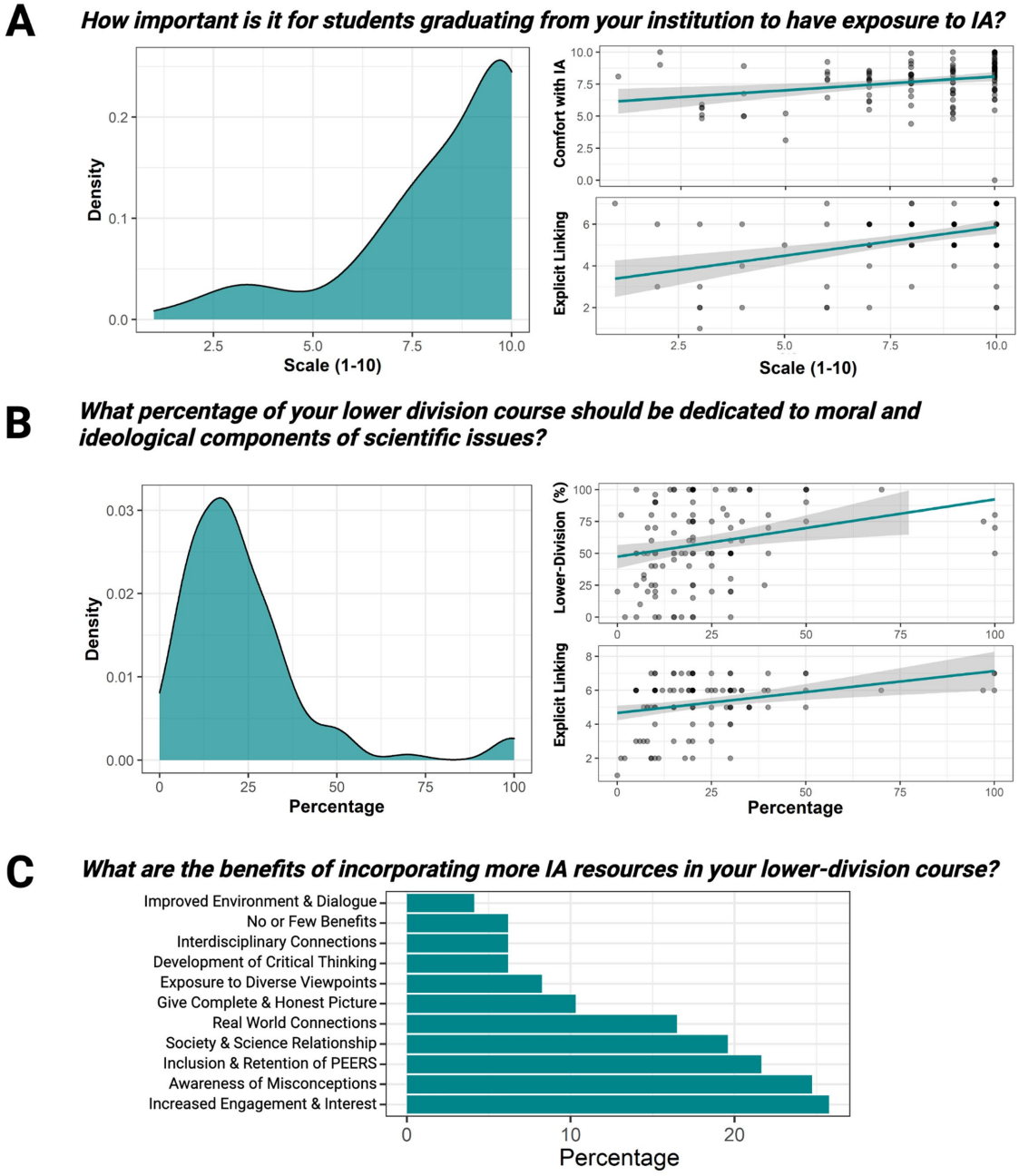

FIGURE 2. (A) Instructors were asked to rate the importance of student exposure to ideological awareness materials on a scale of 1–10. Instructors rated importance at 8.19 on average, as displayed by the density plot. This was significantly and positively correlated with an instructor's comfort level with ideological awareness and view of instructor responsibility to *explicitly link* (see "Teaching Style," Supplemental Table 1) biological and societal topics. (B) Instructors were asked to report what percentage of their individual lower-division courses should be dedicated to ideological issues, and the average response was 23.36%. This was significantly and positively corelated with increasing proportion of lower-division courses taught by participants and their views of instructor responsibility to *explicitly link* biological and societal topics. (C) Instructors were asked to respond to the short-answer prompt: "What are the benefits of incorporating more ideological awareness resources in your lower-division course?" Responses were coded into categories, and response frequency is represented by increasing percentage of occurrence (see coding rubric in GitHub Repository Supplemental Table 3).

(±1.91; 95% CI) of the time (Figure 2B). The frequency at which instructors felt ideological awareness *should* be incorporated in the classroom increased as the percentage of their classes that were lower division increased ($r_{(111)} = 0.26$, $p = 0.0004$). In other words, instructors who taught lower-level courses were more likely to report enthusiasm for ideological awareness. Instructors who reported increased value of ideological awareness topics were also more likely to report it was the instructor's responsibility to explicitly link those topics to class content ($r_{(106)} = 0.31$, $p = 0.0009$; Figure 2B).

TABLE 2. Eight of the most common codes that characterized instructors' responses to (A) "What are the benefits of incorporating more ideologically aware resources in your lower-division courses?" and (B) "What do you fear is the worse-case scenario implementing ideologically aware material in your lower-division course?"[a]

(A) What are the benefits of incorporating more ideologically aware resources in your lower-division courses?			
Code		**Description**	**Examples**
Increased engagement and interest	*n* = 25 25.8%	Mentions that students are more engaged, more motivated, and interested in content when presented with materials focused on ideological awareness	1. "When I have done it, students really are engaged. They realize that some of the things they believed about biology and science and the world aren't really true. They realize that some of what they thought was 'science' (like race is biological and there are only two sexes) is not. Some of them have gone on to educate the others around them as well." 2. "Maintaining student interest, motivation, and applicability to their lived experiences"
Awareness of misconceptions	*n* = 24 24.7%	Mentions that students become more aware of previously held misconceptions or biases as ongoing issues	1. "When I have done it, students really are engaged. They realize that some of the things they believed about biology and science and the world aren't really true. They realize that some of what they thought was 'science' (like race is biological and there are only two sexes) is not. Some of them have gone on to educate the others around them as well."
Inclusion and retention of PEERs	*n* = 21 21.7%	Mentions that students (but especially those who identify as PEERs) feel more included, more likely to persist in STEM	1. "It indicates to historically excluded students that they were unfairly excluded and are valued." 2. "I think it allows persons from PEERs groups [to be] more connected to the material and it helps involve them in the course material in a meaningful way."
Society and science relationship	*n* = 19 19.6%	Makes clear mention of how ideological awareness materials connect science and societal issues	1. "Perhaps a better understanding of the societal role of science and science education" 2. "It gives context to the problems that exist in our society and encourages students to question power and authority. In many cases, science has been exploitative. It's important for students to learn that so we can avoid making the same mistakes in the future."
Real-world connections	*n* = 16 16.5%	Mentions that students are able to connect ideological awareness to their everyday life	1. "Students will be more broadly educated and will see the relevance of what they are learning in class to their everyday lives"
Give complete and honest picture	*n* = 10 10.3%	Mentions that the ideological awareness materials provide more context or present a complete picture regarding certain concepts	1. "It will allow getting a more holistic understanding of where scientific concepts come from and why science has been dominated by the perspective of white males." 2. "Making STEM fields more inviting; greater intellectual honesty"
Exposure to diverse viewpoints	*n* = 8 8.2%	Mentions that students are exposed to various sides/perspectives of an issue	1. "VERY beneficial as long as both sides (or more sides) are offered for exposure instead of just the instructors' implicit biases. Presenting a single side causes more harm than good." 2. "One benefit is to educate the students on different perspectives and let the students ponder their own feelings on the matter."
Development of critical thinking	*n* = 6 6.2%	Mentions that students become critical thinkers who can use their knowledge to analyze various policies and claims.	1. "It builds critical ability, especially regarding targeting social policies and claims that are mistakenly presented as being based on science." 2. "A greater sense of inclusion for PEER students may be a benefit, though I sometimes sense that my PEER students feel uncomfortably singled out when they just want to be seen as 'students'. An increase in critical thinking ability."

(Continued)

TABLE 2. Continued

(B) What do you fear is the worse-case scenario implementing ideologically aware material in your lower-division course?			
Code		**Description**	**Examples**
Poor implementation	*n* = 23 24.2%	Includes being biased or wrong, or not knowing how to handle issues	1. "Students challenging me on topics that I do not have a thorough understanding of." 2. "I am always afraid that I will 'get it wrong,' i.e. bungle the content because of my own positionality or lack or experience; that professors will do more harm than good, because they are not trained in inclusive pedagogy, or they are unaware of their own biases."
Pushback from people of power	*n* = 19 20.0%	Pushback from colleagues, supervisors, administration, or leadership	1. "Backlash from other faculty." 2. "Admin pushback, I get fired."
Takes away from course content	*n* = 19 20.0%	It will be distracting/muddying science content/taking away from course content	1. "Will distract course and prevent from teaching other necessary material." 2. "There is a tremendous amount of information and many concepts they need to learn during Freshman year in order to get a good start and excel[l] in college. The worst-case scenario is they don't learn this material, do poorly, and complete college without the skills necessary to succeed."
Student alienation	*n* = 14 14.7%	Students will be left out, persecuted, or feel stereotype threat	1. "Alienating some students." 2. "I don't want science to threaten a student's identity. I don't want them leaving my class thinking that their values are wrong because science says so."
Distort scientific objectivity	*n* = 10 10.5%	Reports of lessons being too political or views of student indoctrination	1. "It would undermine students' faith in the objective nature of science—the goal we strive to achieve even when we fall short. Politicizing science leads to atrocities from both the left and the right, and is antithetical to the ideas of scientific (rationale) discuss and exploration." 2. "Pushback in regards to some individuals' views that science should be politically neutral, especially with the current attitudes towards 'critical race theory'."
Student discomfort	*n* = 10 10.5%	Students may be unresponsive, checked-out, or unengaged.	1. "Lack of student participation and lack of student engagement with the course material." 2. "An all-too-likely scenario is that my students silently 'check out', assuming that I am biased, willing to put 'ideology' over sound education."
Student complaints	*n* = 9 9.5%	Poor student evaluations, student 'pushback' only, dropping the course	1. "That the students will not be receptive, and that they will complain about the material." 2. "Students dropping the course"
Confrontational student response	*n* = 8 8.4%	Physical or verbal confrontations, disrespectful students	1. "Worst case scenario someone responds in a very aggressive, confrontational, and disrespectful manner in the class and causes a physical altercation." 2. "My worst fear would be that students would call out other students in a purposeful and hurtful way."

[a]Comprehensive rubrics used in qualitative coding can be found in Supplemental Table 3.

The Benefits of Incorporating Ideological Awareness

When instructors were asked "What are the benefits of incorporating more ideologically aware resources in your lower-division courses?," there were a number of common responses (Table 2; Supplemental Table 3). The five most commonly mentioned benefits were: 1) increasing student engagement or connection to the materials (26%), 2) addressing misconceptions or raising awareness (25%), 3) increasing sense of belonging, including the inclusion and retention of PEERs (25%), 4) increasing the understanding of the connection between societal issues and science (20%), and 5) revealing those real-world connections for students (16%) (Figure 2C; coding rubric in GitHub Repository Supplemental Table 3).

Instructor Hesitations

Participants were asked "In the lower-division biology courses you teach, how often do you address biases, stereotypes, and assumptions that shape contemporary and historical science?" For assessment of instructor hesitancy in teaching ideological awareness materials, survey participants who reported that they never or rarely (<34% of class periods) address these topics were then asked the open-ended question: "You indicated that you never or rarely address biases, stereotypes, and assumptions in

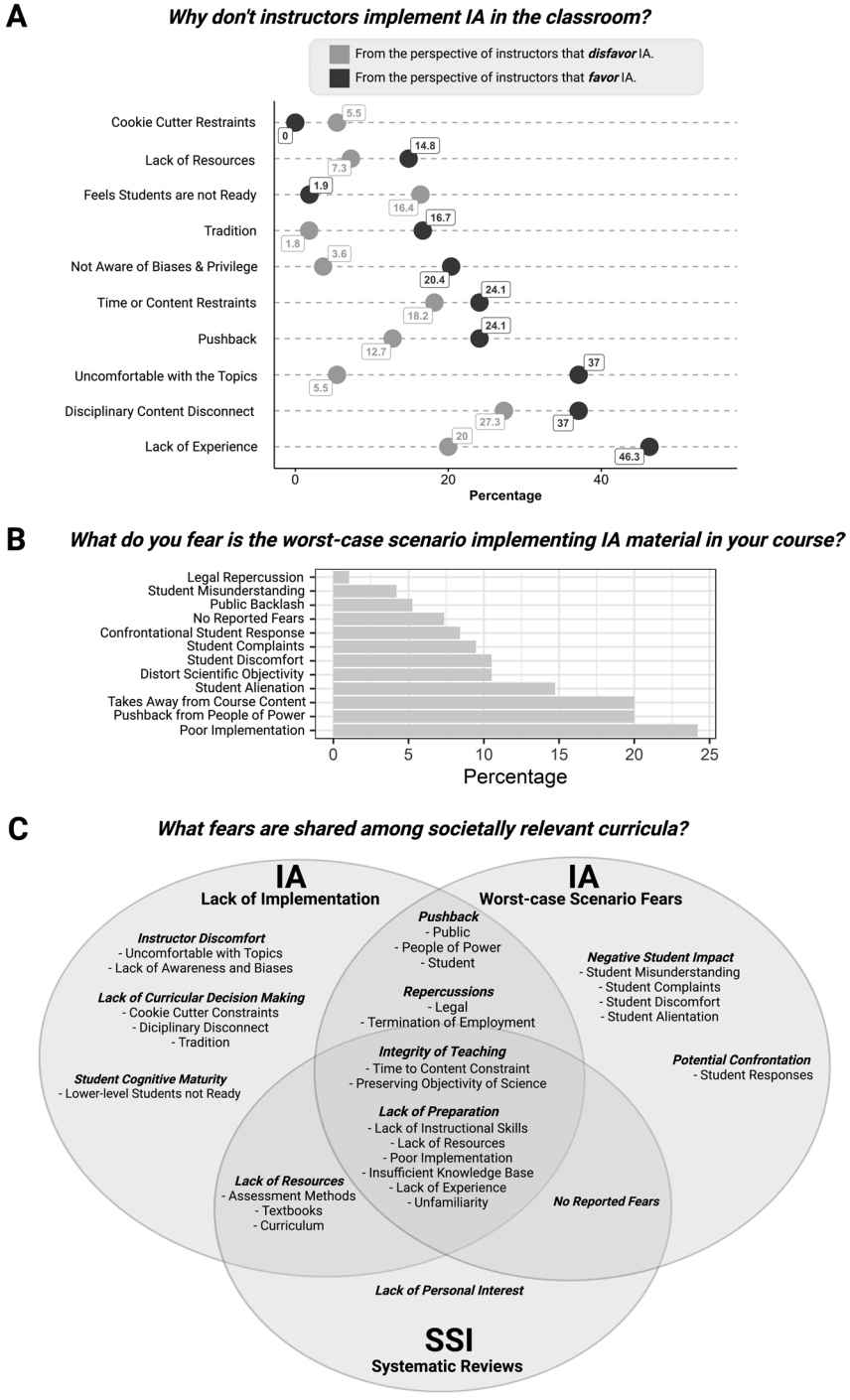

FIGURE 3. (A) Instructors were asked to respond to the short-answer prompt: "Why don't instructors use ideological awareness materials in biology classrooms?" See coding rubric in GitHub Repository Supplemental Table 3. Dot plots show the proportion of instructors responding from the perspective of *disfavoring* ideological awareness (light gray) and the perspective of *favoring* ideological awareness (dark gray). (B) Instructors were asked to respond to the short-answer prompt: "What do you fear is the worst-case scenario implementing ideological awareness material in your course?" All responses were coded into categories, response frequency is represented by increasing percentage of occurrence. (C) Venn diagram displaying the overlapping fears between socio-scientific issues (SSI) and ideological awareness curriculum based on this study and SSI systematic reviews (Nielsen, 2020; Chen and Xiao, 2021). Code definitions and examples from categories displayed in this diagram can be found in Table 2.

your course. Why do you think these topics are rarely addressed in biology classes?" (See coding rubric in GitHub Repository Supplemental Table 3). Most commonly, instructors felt there was not a natural way to discuss ideological awareness topics alongside existing core content areas (27%) (i.e., there is a "disciplinary content disconnect"). This relates to the third most commonly reported reason: time or content restraints (18%). The second most commonly reported hesitation was a lack of experience with ideological awareness concepts (20%). Finally, 16% of instructors reported lower-division students were not socially mature enough to have such nuanced discussions (Figure 3A).

Next, we report results of the same question from instructors who *favor* the use of ideological awareness materials ("You indicated that you address biases, stereotypes, and assumptions in the classroom more than 33% of the time. However, we often got responses indicating faculty rarely teach these relationships. Why do you think these topics are rarely addressed in biology courses?"; see coding rubric in GitHub Repository Supplemental Table 3). Instructors who use ideological awareness more than 33% of the time reported that these topics are rarely addressed primarily due to a lack of experience or knowledge of ideological awareness topics (46%), discomfort with the topics (37%), and a disciplinary content disconnect (37%). They also suggested ideological awareness is not implemented because of perceived fears of time and content restraints (24%) and potential pushback (24%; Figure 3A).

In addition, instructors were asked, "What do you fear is the worst-case scenario implementing ideologically aware material in your lower-division course?" Of 95 coded responses, instructors indicated several common fears (Figure 3B, Table 2, and coding rubric in GitHub Repository Supplemental Table 3), and 7% of respondents reported that they did not have any fears. We discuss those reported by more than 10% of instructors here. Patterns arose in responses that indicate general fears related to 1) quality and perception of implementation, 2) student response, and 3) reactions from people in positions of power. The most common instructor report was the fear of poor implementation by faculty (24%). This category included mentions of instructor biases, presentation of incorrect information, and lack of proper

training to handle any issues that arise in response to ideological awareness in the classroom. Instructors also often reported they were afraid that these discussions may lead to student alienation (15%) or make students uncomfortable in the classroom (11%). Additionally, instructors reported that taking time to teach ideological awareness topics may take away from course content (20%), and distort perceptions of the objective nature of science (11%). Finally, instructors commonly reported a fear of pushback from people in positions of perceived power (e.g., administration, other faculty, parents) or the risk of termination (20%) (Figure 3B and Table 2).

Through this analysis, we found that instructor reported fears or hesitancies were often the same as the reasons why they did not implement ideological awareness (Figure 3C). Instructors were likely to report fears of pushback and repercussions and also reported those fears as reasons to not implement ideological awareness in the classroom. This is not uncommon, as previous studies often cite a fear of repercussion as a reason instructors avoid controversial topics (Lusk and Weinberg, 1994; Byford *et al.*, 2009; Fredman *et al.*, 2015).

Additional worst-case scenario fears unique to ideological awareness implementation included negative student impacts and potential confrontation with students (Figure 3C). Interestingly, instructors commonly report fears of student discomfort and alienation, particularly for PEERs; however, a previous study showed that PEERs were actually *more* likely to report enjoyment and approval of ideological awareness materials in the biology classroom (Beatty *et al.*, 2021). While this finding is promising, more research is necessary to ensure that all students participating in a curriculum feel protected, included, and valued.

DISCUSSION

We found that biology instructors valued ideological awareness in curricula and believed substantial class time should be devoted to it. However, they also reported several hesitancies and worst-case scenarios that align with previous research on controversial issues linked to science topics. We explain our findings through an expectancy-value theoretical framework, which predicts instructors would allocate effort into teaching ideological awareness if they perceived they could effectively navigate the topics in class (expectancy), if they valued ideological awareness in biology (value), and if they perceived teaching ideological awareness would come at a low cost to them (cost). In the following sections, we highlight our main results and place them in the context of the broader literature.

Contextual and Personal Factors Do Not Predict Use of Ideological Awareness

We found that institutional and identity characteristics (e.g., institution location, gender, experience teaching) did not predict the likelihood that instructors would implement ideological awareness in class, how much instructors valued ideological awareness, or instructor views on how often ideological awareness should be used in the classroom. This was contrary to our expectations, given previous literature on instructor practices found institutional and identity characteristics predicted the likelihood of implementation of active-learning instructional approaches. Specifically, Yik *et al.* (2022) showed contextual factors (e.g., class size and setup), personal factors (e.g., experience in discipline-based education research or education training), and teacher thinking (e.g., growth mindset and satisfaction) predicted the use of active-learning instructional approaches (i.e., less time spent lecturing). Additionally, using expectancy-value theory to guide our interpretation of results, we predicted generational proxies (e.g., experience teaching) to impact the value that instructors place on teaching ideological awareness. For example, we expected graduate student instructors to place higher value on the importance of changing curricula to incorporate ideological awareness. Similarly, we expected that instructors with identities that have experienced marginalization in science (e.g., on the basis of race or gender) would be more likely to implement ideological awareness in class. Because our sample size did not allow us to thoroughly examine demographic variables such as race and gender, future work is needed to investigate the impacts of these factors on curricular changes.

To explain why these factors did not predict ideological awareness implementation in our study, we looked to previous research that delved into how and why instructors chose to use innovative approaches. Those studies focused less on institutional and identity characteristics and more on factors that contributed to individual decision making. For example, Lane *et al.* (2020) found instructors who used evidence-based instructional practices predominantly shared this knowledge with others who also used evidence-based practices. As an extension of our current work, we could combine survey and social network analysis to determine to whom ideological awareness users speak and whether "secondary diffusion" (Lane *et al.*, 2020) represents an effective strategy to disseminate ideological awareness teaching innovations. Additional mechanisms that lead to instructional changes in prior work include exchanges among colleagues about teaching experiences, personal evidence obtained over time (Andrews and Lemons, 2015), and co-teaching experiences (Henderson *et al.*, 2009). Other research focused on commonly cited barriers for faculty to participate in pedagogical change, which included a lack of time, inadequate training, low incentives, and a professional identity that might interfere with a willingness to engage (reviewed in Dancy and Henderson, 2010; Brownell and Tanner, 2012). We suggest that more nuanced personal and social factors likely contribute to instructors' perceptions of ideological awareness and instructor likelihood of implementation, more so than coarse demographic or institutional descriptors.

The Importance of Learning Science

We found that "understanding the world" was the most common response to our question about why it is important for students to learn science. Instructor responses coded within this category mentioned understanding how science shapes aspects of their lives; promoting open-mindedness; becoming scientifically literate, informed citizens; and developing the ability to combat misinformation.

> "Science is the basis for understanding the world we live in from the very basics of life to modern science and understanding of disease processes."

> "Teaching students science is important for them to learn about the world around them. It provides practical knowledge of how to evaluate resources and use critical thinking to understand complex phenomenon."

Instructors described the importance of learning science as helping students understand the world, particularly in how it shapes their lives. This is similar to worldwide education reform efforts that have worked toward promoting scientific literacy to prepare students for a life of evidence-based decision making. For example, in England, science curricular reform encompasses five broad foci, including a social, individual, political, or economic emphasis (Ryder and Banner, 2011). The United Nations Education, Scientific, and Cultural Organization has laid out similar objectives for its education system aimed to support students as they transform themselves and the societies in which they function (UNESCO, 2016). Similar calls have been made in Europe (Osborne *et al.*, 2008), Australia (Ross *et al.*, 2012), and Malaysia (Osman and Marimuthu, 2010). Within the United States, the AAAS (2011) listed "understanding the relationship between science and society" as one of six core competencies of science education. This view of science as a vehicle to help students understand and navigate the world is incomplete without making connections to larger societal issues.

Instructors Value the Implementation of Ideological Awareness

We addressed three questions that related to 1) the perceived importance of teaching ideological awareness, 2) the amount of time that should be dedicated to ideological awareness, and 3) the perceived benefits of ideological awareness (Supplemental Table 1). Instructors perceived ideological awareness as highly important for their students, and on average, reported that 23% of class should be committed to teaching ideological awareness. Reported benefits of ideological awareness included increasing student engagement, addressing misconceptions, and improving student understanding of connections between societal issues and science (see Supplemental Table 3 for representative survey responses).

Research on the implementation of socio-scientific issues (i.e., controversial issues linked to the development of science that are similar but distinct from ideological awareness; Zeidler and Nichols, 2009) demonstrated their. The importance of the socio-scientific issues promoted student reasoning, perspectives, emotions, and the development of their value system (Reis and Galvão, 2004; Lee and Witz, 2009). Similarly, previous work in Denmark and the United States showed teachers believed teaching socio-scientific issues could promote critical thinking and the development of opinions that related to scientific information (Sadler *et al.*, 2006; Tidemand and Nielsen, 2017).

The perceived benefits of ideological awareness and previous research concerning teacher perceptions of socio-scientific issues overlapped with the recommendations and core competencies put forward by the AAAS (2011). For example, participant responses suggesting a benefit of incorporating more ideological awareness resources would *increase the understanding of the connection between societal issues and science* as well as *reveal those real-world connections for students.* This aligns with the AAAS recommendation that instructors "relate abstract concepts in biology to real-word examples on a regular basis, and make biology content relevant by presenting problems in a real-life context" so that students have the ability to understand the relationship between science and society. A BioSkills Guide can assist instructors as they enact the core competencies, including "Ability to Understand the Relationship between Science and Society," with measurable learning outcomes (Clemmons *et al.*, 2020, 2022).

In addressing the amount of time that should be dedicated to ideological awareness, we found instructors thought about a quarter of a course should be spent on these topics. While this reflects the perceived importance of ideological awareness according to these instructors, we did not measure the actual amount of time they implemented ideological awareness materials in their courses. A natural extension of our work would be to catalogue and measure the amount of time biology instructors *actually* spend addressing societal or ideological awareness-related topics, similar to research cataloging active-learning practices using Classroom Observation Protocol for Undergraduate STEM (Smith *et al.*, 2013; Stains *et al.*, 2018).

Instructor Hesitations Range from Personal to Political

Timing and Preparation. Instructors in our study reported that ideological awareness is rarely addressed in biology classes due to reasons that are well documented in the socio-scientific issues literature. For example, Oulton *et al.* (2004) conducted focus groups with primary and secondary school science teachers in the United Kingdom concerning hesitations in teaching controversial topics in schools, including bullying, drug and alcohol awareness, evolution, racism, sex education, and euthanasia. When asked what constraints the teachers would face if they were to ideally implement one of these activities, the most common response related to time. That is, implementing the new activity would require time that they did not have. Based on a survey, the researchers found that 65% of the primary and secondary school teachers do not receive formal training in teaching controversial issues. Further, 36% of these teachers felt "not well prepared" to teach controversial issues. Expectancy-value theory predicts that instructors will modify their teaching if they perceive they are capable of making those changes. Even if instructors value ideological awareness, they may opt out if they have low self-efficacy in their ability to teach these tough topics. These findings underscore how instructors may lack experience, knowledge, and time, which may increase their hesitance to discuss ideological awareness topics.

Curriculum Relevancy. Instructors in our study believed hesitancies to implement ideological awareness in introductory biology courses could be due to its lack of relevance to the biology content.

> "I find it difficult to connect the content I teach in lower division courses to these issues. I teach lab courses that primarily hone students' observational skills.; thought to belong in social science rather than science classes."

According to a systematic literature review of 20 studies on the implementation of socio-scientific issues in the classroom, there were a range of teacher challenges or hesitancies; however, a disconnect between the biology content and socio-scientific issues was never mentioned (Chen and Xiao, 2021). The coded responses in our study suggest the reported

disconnect may be due to the perception that: 1) content in some introductory biology classes (e.g., parts of a eukaryotic cell) do not lend themselves to the implementation of ideological awareness content as well as others (e.g., genetics and the fact that the concept of race is not genetically based but rather based on specific phenotypic traits), and 2) ideological awareness is a topic best saved for humanities classes. In response to the first idea, we contend that some connections with biology content are more straightforward than others. A repository of ideological awareness teaching materials could help instructors see the connections between a range of biological content and ideological awareness topics (e.g., see https://tinyurl.com/IdeologicalAwareness; Beatty *et al.*, 2021). In response to the second idea, we argue that most science students are not exposed to ideological awareness topics in their humanities classes, as the amount and nature of humanities courses required of science students vary. In fact, leaving the job of educating science students about ideological awareness topics to humanities instructors creates the possibility that many science students will never learn them in their formal education. This is reflected in previous literature and among our participants: In a study by Tripp *et al.* (2020), 25% of science students who engaged in a writing task targeting their interdisciplinary knowledge did not mention non-STEM (science, technology, engineering, and mathematics; e.g., humanities) domains in their written essays. As further evidence, we cite the high percentage of biology instructors surveyed in our study who are not comfortable teaching ideological awareness because they themselves have no experience.

> "I think these topics are rarely addressed due to lack of education on the subject. I started addressing systematic racism in the classroom as I learned more about it. When I first heard of racist curriculum, I thought biology was exempt. As I learned, I realized how deeply ingrained it is. The first topic I broached as an instructor was the white-centered concept of lactose tolerance. I received so much positive feedback that I started incorporating more."

Additionally, leaving this task to other disciplines is a missed opportunity for biology instructors to meet one of the core competencies put forward by the AAAS (2011), as noted earlier. That is, instructors are missing a natural opportunity to allow their students to learn how to relate abstract concepts in biology to real-world examples on a regular basis and to make biology content relevant by presenting problems in a real-life context.

Student Cognitive Maturity. Another reason we found instructors rarely address ideological awareness in biology classes is the idea that students lack cognitive maturity (i.e., they are not ready).

> "I think for most people at this level of education they can't fully appreciate or comprehend these topics as they don't have enough scientific background knowledge. Additionally, there isn't really enough time to cover these topics and they are only partially related to fundamental biological knowledge."

This finding has similarly been mentioned in the socio-scientific issues literature. For example, Ekborg *et al.* (2013) recruited 70 secondary school teachers in Sweden to implement one of six example cases of socio-scientific issues. Subsequently, the authors surveyed 55 of the teachers and interviewed a subset of those surveyed ($n = 7$) about how teachers chose content, organized their work, and experienced the students' interest and learning. Findings demonstrated teachers were concerned that *students* lacked science knowledge, habits of learning, or were "too young, [and] had difficulties with understanding the task or difficulties in focusing on specific questions [related to socio-scientific issues]" (Ekborg *et al.*, 2013, p. 610).

The assertion that college-aged students are not mature enough for or capable of maintaining conversations centered around ideological awareness is disputed across fields. Previous studies have expressed success in engaging students in difficult discussions. For example, a study with elementary-aged children, primarily students of color, led by a white woman instructor, successfully implemented curriculum discussing political viewpoints during the 2016 presidential election (Payne and Journell, 2019). While in this case parents lodged two complaints against the instructor for not providing "positive information" about President-elect Trump, students responded well to the political discussion, sharing their own viewpoints and expressing their concerns following election day (Payne and Journell, 2019). Studies have shown that when children and adolescents are given the opportunity to challenge their prior experiences, they are able to "try on" different roles and identities from the conversation, re-form their views, challenge existing stereotypes, and gain practice with independent voicing of thoughts (Hauver *et al.*, 2017). While the elementary-aged student is considered to be within the formative years, students who have not been exposed to such materials by secondary education should be given the opportunity to develop these abilities and are comparatively more cognitively mature than elementary-aged children. Students benefit from a structured environment in which they are given the opportunity to challenge their existing views (suggestions for implementation can be found in Schinske *et al.*, 2016; Brandt *et al.*, 2020; Beatty *et al.*, 2021; Simpson *et al.*, 2021).

Instructor Discomfort. Another instructor hesitancy included discomfort with implementation of ideological awareness in their biology courses. According to the socio-scientific issues literature, teachers expressed their concerns and discomfort about discussing social, moral, and ethical issues in the classroom at the primary-school (Zangori *et al.*, 2018) and secondary-school levels (Bryce and Gray, 2004; Sadler *et al.*, 2006; Day and Bryce, 2011; Hancock *et al.*, 2019). Teachers alleviated their discomfort through discussion with teams of other teachers implementing socio-scientific issues in their classes (Hancock *et al.*, 2019). While teams composed of other science instructors or non-STEM humanities scholars might reduce discomfort, a potential challenge is that even humanities scholars do not uniformly have training to facilitate lessons in ideological awareness. From a study on pre-service social studies teachers (Nganga *et al.*, 2020), instructors of humanities disciplines reported little to no training in teaching controversial topics. The lack of training on the proper implementation of ideological awareness topics is multidisciplinary, and therefore a clear action point as we move toward a more societally relevant curriculum.

Potential Student Harm. Instructors listed several worst-case scenarios that might arise from implementing ideological awareness materials in their courses, including poor implementation that could cause harm to students.

> "I am always afraid that I will 'get it wrong,' i.e. bungle the content because of my own positionality or lack or experience; that professors will do more harm than good, because they are not trained in inclusive pedagogy, or they are unaware of their own biases."

This is understandable and has been well documented in the socio-scientific issues literature as well. For example, Levinson (2004) conducted a pilot study with instructors and students from secondary and postsecondary institutions and identified characteristics of student–student and student–teacher interactions in the teaching of bioethical issues. Examples of bioethical issues included genetic engineering, in vitro fertilization, and animal experiments. While the teacher intended to have an open dialogue in the lessons, the teacher's narrative actually tended to inhibit ethical debate. Additionally, Levinson (2004) noted instructors created few opportunities for ethical discussion and those that arose had no science underpinning the lessons, suggesting that addressing ethical issues in the dynamic of the classroom is both complex and difficult. Thus, instructors in our study are justified in their concern of potentially implementing ideological awareness materials poorly to their students; however, whether or not students experience harm that instructors fear has not been investigated.

Instructor concern and hesitations can be addressed through systems of support at different levels. For example, providing properly vetted materials along with formal training makes ideological awareness implementation more feasible for novice instructors. Additionally, collaboration among colleagues that includes curricular discussions and a foundation of emotional support can address several instructor hesitancies that relate to poor implementation. For an example of a successful collaboration, see Hancock *et al.*, (2019). Networks of support are essential as ideological awareness implementation becomes more common in biology education.

Pushback. Instructors were also concerned about potential repercussions for implementing ideological awareness materials in their courses such as pushback from people in power, confrontational student responses, and legal repercussions. Systemic or institution-level responses to concerns—related to teaching ideological awareness or any experimental pedagogy—include considerations of existing opportunities for reflection and/or administrative protections to assuage the fear of pushback. Examples include rewarding instructor growth and self-reflection (e.g., Krishnan *et al.*, 2022) and a commitment to base educational decisions on evidence, foster continuous teaching improvement, and promote inclusion and diversity (Corbo *et al.*, 2016; Andrews *et al.*, 2021; Krishnan *et al.*, 2022).

Even in a generally supportive teaching environment, it is important to acknowledge that instructor reservations and worst-case scenario fears are not unfounded. Beyond retaliation or pushback from students and parents are fears of termination and legal action (Fredman *et al.*, 2015; Nahmad, 2008). Taken together through the lens of expectancy-value theory, potential costs to the instructor such as discomfort, fear of harming students, or professional consequences may be enough to prevent instructors from incorporating ideological awareness in their class, even if they see value in teaching these topics and are confident in their ability to do so.

Recommendations for Future Research

Several novel ideas and questions emerged during the interpretation of our data. While our focus here was instructor perceptions of the value or potential costs of teaching with ideological awareness, future work would benefit from investigating and understanding student perceptions. In fact, similar questions we addressed here could be asked of students to advance our understanding of similarities and differences between instructor and student perceptions (i.e., "Why is it important to learn science?," "What are the benefits of ideological awareness, and to what extent are students exposed to it?," "What are the costs?"). Second, understanding the impact of ideological awareness on students across institutional contexts (e.g., geographic, institutional type) and classroom contexts (e.g., introductory biology, upper-level genetics) would assist in developing activities that are most relevant for different student populations. A third future direction could explore how to assess students' interdisciplinary knowledge. Though beyond the scope of the current study, a challenge for future research will be to develop assessments that are specifically designed to measure whether and how students think in an interdisciplinary way as the result of interdisciplinary course content (Tripp *et al.*, 2020).

Limitations

We acknowledge several limitations in our study. First, despite our efforts to survey as many biology instructors as possible, our sample size was a fraction of our distribution efforts. This means there is a possibility that the individuals who responded are not representative of the national population of undergraduate biology instructors. Further, our participant pool was partially made up of individuals who were already implementing ideological awareness, were interested in implementing ideological awareness, or had strong beliefs that students graduating from their institutions should be exposed to ideological awareness content. Their unique perspective may add extra value concerning benefits of and importance of ideological awareness to student development; however, it will likely differ from the perspective of novice instructors. We were also unable to obtain adequate representation from community colleges, which is a broad challenge for biology education research (Schinske *et al.*, 2017; Thompson *et al.*, 2020; Creech *et al.*, 2022). Community colleges educate 41% of all undergraduates in the United States and the majority of some demographic groups such as Native American (56%) and Hispanic (53%) students (American Association of Community Colleges, 2021).

Another limitation of the research includes the potential that instructors interpreted our questions in different ways, which may have impacted our results. For example, the question "What are the benefits of incorporating more ideologically aware resources in your lower-division courses?" could be

interpreted by an instructor as "What are general benefits that could occur?" or "What benefits have I personally observed in my courses?" Similarly, the question "Why do you think these topics are rarely addressed?" could be interpreted as "Why are these topics not addressed generally" or "Why do I not include these topics in my class?" Finally, while we defined ideological awareness throughout the survey, there are many ways to implement this teaching in the classroom, which likely differed across respondents. Future research will profit from gathering additional evidence of validity.

CONCLUSION

Ideological awareness supports one of the core competencies in *Vision and Change*, for students "to understand the relationship between science and society (AAAS, 2011, p. 15)." Instructors recognized the value of ideological awareness in the classroom and suggested a significant proportion of class time be dedicated to its integration. However, instructors also reported discomfort in teaching ideological awareness modules and expressed several common fears and worst-case scenarios. Given their importance in developing critical thinking and teaching sociopolitical issues in science, we offer several recommendations to address instructor concern and hesitations through systems of support.

Data Availability

All survey instruments, deidentified data, analysis code, and supplemental images can be found in the GitHub repository: https://github.com/aeb0084/National-Instructor-IA.

ACKNOWLEDGMENTS

We would like to thank the Ballen lab for providing valuable feedback during the drafting of this article. We thank the iEMBER group for assisting with survey development and the iEMBER network for participating in survey piloting. We also acknowledge two anonymous reviewers who provided excellent feedback on versions of the article. Finally, we would like to thank the National Science Foundation for providing funding to A.E.B., J.A.H., and C.J.B. (NSF-DUE-2120934) and the iEMBER network (NSF-RCN-UBE-1919654).

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