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Addressing Gender Bias in STEM Graduate and Post-graduate Students Using *Equity in STEM for All Genders* Course

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Abstract
Implicit gender bias is frequently cited as a contributor to the gender disparity that persists in STEM fields, despite continued efforts toward equity. While many bias interventions are aimed at faculty, scientific trainees (graduate students and post-docs) are a powerful group with the potential to enact future change. A graduate level, synchronous online course entitled, *Equity in STEM for all Genders*, is presented as a gender bias intervention. Course participants include graduate students, post-doctoral fellows, academic staff, and faculty. The course pairs weekly discussions (synchronous and asynchronous) about gender and gender bias-related topics with experimentally validated video interventions, primary literature, and popular articles. Over three course iterations, we observed increased bias literacy and participant motivation to mitigate gender-related bias within their local STEM contexts. We provide suggestions for making this course more widely available to STEM future faculty.

Keywords Professional development · Graduate education · STEM education · Gender bias · Diversity and inclusion

Abbreviations

Cis woman	Cisgender woman
cis man	Cisgender man
trans man	Transgender man
RCT	Randomized controlled trials
VIDS	Video Interventions for Diversity in STEM
CIRTL	Center for the Integration of Research Teaching and Learning

Introduction

Gender Bias in STEM

Significant attention has been directed toward confirming the persistence of gender bias in Science, Technology, Engineering and Mathematics (STEM) fields in spite of progress in representation at the doctoral level (Hill, 2010). Indeed, research indicates that although women are more successful at acquiring graduate degrees, they remain at a disadvantage in areas that are vital to developing a successful career. For example, in the late 1990s it was found that women needed to publish three additional papers in top outlets or 20 additional papers in strong specialized journals to be rated equally to men (Christine & Agnes, 1997). This type of bias has remained persistent, with research showing more hesitation to hire women in STEM positions (Sheltzer & Smith, 2014) and lower citation rates for women first-authors (Larivière et al., 2013). Control studies have shown that these trends are not just correlational. Moss-Racusin showed that STEM faculty (of all genders) were more willing to judge as competent, hire, mentor, and pay an equitable salary to a male lab manager than an equally qualified female candidate (Moss-Racusin et al., 2012).

Lesbian, gay, bisexual, transgender, queer, (LGBTQ+) persons are also subject to bias, and as a result, disadvantage in STEM environments (Cech, 2015). Discussions and initiatives around gender equity in STEM are frequently limited to the progress of cisgender women (cis women), resulting in exacerbated isolation among scientists who do not fit within the gender binary. As a result, the climate for many LGBTQ+ scientists remains unwelcoming in academia (Bilimoria & Stewart, 2009; Patridge et al., 2013) and industry (Cech & Pham, 2017) alike. Much of the negligence around LGBTQ+ inclusion is

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not the result of explicit homophobia but implicit biases, much like those that have slowed the advancement of cis women in STEM. When discussing the way that implicit bias impacts gender equity in STEM, a more inclusive definition of gender should be in place. In this way, the interests of all gender minorities in STEM fields can be represented.

Implicit bias is pervasive at every level of the academy (Ginther et al., 2011; Houser & Lemmons, 2018; London et al., 2011; Moss-Racusin et al., 2012). Because of this, there is a need to address bias at all levels, through programming for undergraduates, hiring committees, and more extensive training for future and current faculty with an emphasis on classroom strategies.

Challenge to Enacting Change

Gender bias interventions face a host of subtle challenges to their efficacy. An effective intervention requires careful attention to the participants' backgrounds and motivations or else has the potential to do more harm than good (Legault et al., 2011; Moss-Racusin et al., 2014; Roberson, 2013). One major challenge lies in the fact that the types of biases that need to be corrected are implicit and cannot be accessed through introspection alone. They are experienced by individuals of all genders and are the result of socialization and exposure to stereotypes (Rudman & Phelan, 2008). These biases are deeply internalized, and long-established members of the STEM community who hold the power to enact change often do not recognize the biases that may motivate their own behaviors. Furthermore, while bias is found across the gender spectrum, men are more critical of the validity of gender bias research and, consequently, the necessity of interventions (Ian et al., 2015; Moss-Racusin et al., 2012). It is quite difficult to break through this barrier, and because of this, targeting future faculty for these interventions may lead to a greater potential for change.

The Power of Reaching Graduate and Post-Doctoral Populations

In most of the validated STEM bias interventions, the intended subjects have been faculty members (Carnes et al., 2015; Devine et al., 2012; Jackson et al., 2014). Indeed, this population has the greatest power to enact change within departments and reaching this population is crucial to making progress toward mitigating bias. However, limiting the audience to current faculty alone limits the potential impact of effective interventions. The power of scientific trainees (graduate students and post-doctoral fellows) is often overlooked but has the potential to affect the future of STEM departments.

By intervening early, at this crucial juncture in their professional training, it is possible to allow graduate students and post-docs to identify incidents that are motivated by bias. Importantly, biases are already beginning to develop through systematic exposure to the structures that promote them (Knobloch-Westerwick et al., 2013). In addition, even if intervention is not possible due to power structures within a department, students' awareness can ensure that they do not continue biased patterns when they are in positions of power in the future. Since the faculty and departmental change-makers all exist within this group, it is vital to reach them before it becomes much more difficult to break biased habits. Once they are in positions with sufficient power to enact systematic bias, they will have the tools to identify and mitigate it. Targeting this population been effective in efforts around improved pedagogy in the sciences (Ebert-May et al., 2015), and it stands to reason that awareness of bias can "break the cycle" in a similar way.

In addition to the potential impact of scientific trainees as future change-makers, exposure to literature about the existence of bias is often a validating and empowering experience for graduate students and post-docs. The mental health crisis among STEM graduate students and post-docs is well-documented (Teresa et al., 2018), and one of the pervasive causes is a lack of autonomy and constant self-doubt. Realizing that situations that individuals may have encountered personally are the result of real, documented phenomena can go a long way toward improving mental health.

Effective Existing Interventions

Despite these challenges, over the last several years, academic institutions have made great progress in developing interventions to address bias at every level, spanning from general best practices for search committees to the existence of discipline-specific societies for underrepresented groups. For example, institutional training programs like the Women in Science and Engineering Leadership Institute (WISELI) at the University of Wisconsin-Madison offers extensive resources to combat bias at the hiring level and beyond (Sheridan et al., 2010; University-of-Wisconsin-Madison, 2008) Institutional and systemic resources like these are crucial to progress; unfortunately, they depend on the user independently navigating them and drawing conclusions in an unstructured way. For a phenomenon as insidious as implicit bias, a more structured intervention is often necessary to dismantle underlying assumptions, misunderstandings, and beliefs underlying certain behaviors (Carnes et al., 2015; Gil et al., 2021).

Additionally, of the existing STEM gender bias interventions, few have been systematically evaluated to establish their effectiveness at reducing gender bias. To date, only a small number of gender bias interventions have been validated in randomized controlled trials (RCTs) (Moss-Racusin et al., 2012), and all of these were directed at STEM faculty specifically.

One of the most promising interventions generated in the last several years comes from a collective interdisciplinary effort among researchers and artists at several institutions. Video Interventions for Diversity in STEM (VIDS) is an evidence-based intervention that incorporates high-quality videos to illustrate and explain sources and instances of gender bias in STEM (Hennes et al., 2018; Moss-Racusin et al., 2018; Pietri et al., 2017). VIDS incorporates the experience of professional biologists, expertise of academic psychologists, and the production skills of a professional playwright, actors, and filmmakers. The final result is an impactful, entertaining, and engaging intervention that can be employed in a variety of settings. Further, the design has allowed for a double-blind RCT to validate its effectiveness.

In each VIDS module, a video featuring an expert interview explaining research that has been done to confirm and explain the existence of gender bias in STEM is paired with a video illustrating a situation where that type of bias plays out. Research around this pairing indicates that each component fulfils a unique role in affecting participants' perception of gender bias. Specifically, among the general population, VIDS increased bias literacy, which is characterized by awareness of bias, knowledge of gender inequity in academic settings, feelings of efficacy at being able to notice bias, and recognition and confrontation of bias across situations (Pietri et al., 2017). Subsequent research investigated the effects of each component independently and the impact on STEM faculty compared to the general population (Moss-Racusin et al., 2018). Overall, the impact of the intervention has shown to be substantial and persistent over time.

Previous research indicates that both narratives and expert interviews are useful persuasive tools (Green & Brock, 2000; Pornpitakpan, 2004). The narrative and expert interview components of VIDS were created with this in mind, and VIDS' ability to successfully enhance gender bias literacy, support these design considerations (Pietri et al., 2019). Key components of bias literacy are increased awareness of gender bias in STEM, general knowledge about societal gender inequities (Carnes et al., 2012), and feelings of self-efficacy to positively change and recognize gender bias (Carnes et al., 2015). Interventions designed to enhance these key elements of bias literacy may be an effective way to address gender bias in STEM (Carnes et al., 2012). With this in mind, we *hypothesize* that engaging graduate students and post-doctoral scholars as part of a sustained experience (e.g., semester-long graduate seminar) that pairs weekly discussions (synchronous and asynchronous) about gender and gender bias-related topics with VIDS, the primary literature, and popular articles, will have positive impacts on both their bias literacy and motivation to mitigate gender-related bias within their local STEM contexts.

To address this hypothesis, in this paper, we discuss using a graduate level, synchronous online course entitled, *Equity in STEM for all Genders*, as a gender bias intervention. The course paired weekly discussions about gender and gender bias-related topics with video content from the VIDS project. The course had positive effects on both participants' bias literacy as well as their motivation to act. We provide suggestions for making this course more widely available to STEM future faculty.

Gender Bias Intervention Course: *Equity in STEM for all Genders*

Overview and Hypotheses

The course *Equity in STEM for all Genders* was created to increase gender bias awareness among individuals in academic STEM contexts. The students were primarily graduate students and post-docs in STEM departments with a few early career faculty and staff also enrolled. The course used validated bias intervention tools (VIDS) (Hennes et al., 2018; Moss-Racusin et al., 2018; Pietri et al., 2017) and supplemented this with reading primary literature, online text-based and verbal discussions, and active, applied improvisational exercises to explore situations where bias in enacted and practice strategies to mitigate it.

Additionally, in constructing the course and the discussions therein, issues of gender were approached in an inclusive way that avoids reinforcing the gender binary. Many gender bias interventions focus only on the experiences of cis women versus those of cis men, and this discussion is insufficient to encompass the struggles of all individuals in STEM around issues of gender. With this in mind, the course instructors were intentional about integrating their personal identities into the course. In the first offering of the course under study, one instructor was a cisgender man and the other a cisgender woman. The female instructor also identified as queer. In the second and third offerings under study, the queer-identified, cis woman instructor was the same but was joined instead by a co-instructor who was a transgender man (see Table 1). The diversity of gender identities in each offering provided students with a variety of perspectives and a more gender-inclusive environment for students to navigate discussions. Sharing these aspects of identity early on in the course allowed subsequent discussions to be couched in the context of differing, gendered experiences. The instructors' unique experiences in STEM helped facilitate learning through class discussions for students from all different perspectives. Further, the visibility of the instructor's minority

Table 1 Features of 2018–2020 Course Offerings

Year	Student enrollment	Instructor 1 Gender identity	Instructor 2 Gender identity	Final assignment
2018	25	Cisgender woman	Cisgender man	Job application materials
2019	16	Cisgender woman	Transgender man	Proposal for institutional change
2020	42	Cisgender woman	Transgender man	Proposal for institutional change

status identity (LGBTQ+) allowed for students to feel more comfortable sharing aspects of their own identities.

Given the content of the course, we hypothesized that participation in the course would significantly impact participants across the following dimensions: (a) increased awareness of bias for women and LGBTQ+persons in STEM, (b) decreased modern sexism, (c) increased awareness of male privilege in STEM, (d) increased knowledge of gender equity, (e) improved behavioral intentions to create a better environment for women and LGBTQ+persons in STEM, (f) improved individual self-efficacy to combat gender bias in the classroom, and (g) increased belonging in STEM. The hypotheses were investigated using validated instruments described herein. Below, we provide additional information about the course objectives, context, and structure.

Course Objectives

The learning objectives of the course (as they are experienced by the students) include the following:

- Increase awareness of gender bias
- Recognize gender inequities in professional environments and classrooms
- Develop strategies to confront bias in everyday situations
- Apply principles broadly and specifically to teaching and learning situations
- Gain exposure to and engage with individuals who have successfully overcome gender bias in STEM contexts
- Develop self-efficacy around addressing gender bias
- Develop a modern vocabulary around gender and use it to discuss what gender equity looks like in STEM

Overall, it is our hope that our students leave the course both capable of identifying instances of bias within their local STEM context and empowered to intervene appropriately and productively.

Course Context

The course was offered through the CIRTL (Center for the Integration of Research, Teaching and Learning) Network; it was open to graduate students, post-doctoral fellows, faculty, and academic staff at both CIRTL-affiliated and outside institutions. The class met in a synchronous online format (Hokanson et al., 2019; McDaniels et al., 2016) through the BlackBoard Collaborate platform once a week for 2-h sessions. Students have the option take the course for credit or no-credit, depending on the way the individual institution incorporates CIRTL courses into their local course offerings. In no circumstance was the course mandatory. Three years of course offerings are under study in this report, described in Table 1.

The CIRTL Network is a collaboration among 42 research-intensive universities (R1: Doctoral Universities – Very high research activity in the Carnegie Classification of Institutions of Higher Education). The mission of the network is to prepare future STEM faculty to be excellent educators and to complement the research training they receive. Since approximately 2009, the Network has offered synchronous online courses about diversity issues in college teaching, and the *Equity in STEM for all Genders* course builds on this foundation. CIRTL's programming is built on three core concepts: Teaching-As-Research—the idea that a graduate students' disciplinary research skills form the foundation to being able to ask and answer questions about student learning. Learning communities emphasizes the importance of bringing students together for shared learning and discovery. Finally, learning through diversity positions diversity as a classroom asset and challenges instructors to leverage their students' diversity to better promote learning for all students.

The students in the course were recruited exclusively through CIRTL e-mailings and advertisements, attracting a diverse group of interested students. Across the three cohorts studied, over 13 STEM disciplines were represented from over 30 different institutions nationally and internationally. Further, student background spanned across gender identities (cis man, cis woman, trans man, and nonbinary) and racial demographics. In the 2019 and 2020 cohorts, the highest enrollment came from Howard University, a historically Black college, further enriching and challenging the discussions around gender and race.

Course Structure

The course curriculum across the three course offerings remained generally consistent. The course began with an introductory week to establish community and introduce the learning objectives. This was followed by 6–8 weeks of topic-based discussions and a final week with a panel of successful scientists across the gender spectrum speaking to their success and/or expertise in the topic of gender bias in STEM. The weekly topics included the following: (a) gender and classrooms, (b) gendered language, (c) gender and competence (impostor phenomenon), (d) gender identity and sexuality (LGBTQ + experiences in STEM), (e) gender norms and expectations, (f) gender and parenting, (g) signalling threat and intersectionality, and (h) gender barriers and leadership. The course concluded with a panel of experts ranging from successful women in STEM to LGBTQ + STEM advocates to transgender STEM education experts. The goal of this final panel session is to provide expertise beyond the experience of the instructors and to empower students by showing them individuals who have overcome the biases revealed through our course.

Typical weekly assignments took the following form: (a) read 1–2 peer-reviewed articles on a topic around gender bias in STEM, (b) watch the corresponding VIDS addressing the same topic (one situational narrative video, one expert interview video), (c) post a response to a discussion question on the course learning platform (Moodle), and (d) respond to classmates' posts. During most weeks, the instructors would pull pieces of the discussion from the asynchronous discussion boards in the online platform to facilitate class discussion and delve deeper into the nuances that were identified. Occasionally, the in-class activity would involve role-play or applied improvisation activities to practice strategies to mitigate biased incidents in real time.

In the 2018 course offering, the final assignment asked students to create a selection of professional materials (e.g., CV, cover letters, personal bio, teaching philosophy statement, or diversity statement) with a gender equity focus and collaborated with an assigned classmate to peer review each other's materials. The objective of this activity was to bring in the deeper understanding of subtle bias and to turn a closer eye toward how bias might play out in self-promotion. A few of the students who were in positions where they were writing letters of recommendation for undergraduate students and mentees also submitted these as part of the assignment. This correlated directly with one of the weekly topics about gendered language in letters of recommendation and the use of agentic and communal language in describing students of different genders (Madera et al., 2009). The materials were also reviewed by the instructors at the end of the term, and feedback specifically focused on biased language was provided to the students.

In 2019 and 2020, the final assignment focused on generating a proposal for institutional change. The goals of this assignment was for students to (1) identify policies, incidents, and protocols that are informed or influenced by gender bias within their local contexts; (2) apply strategies that have been collaboratively identified in class to a local context to enact change; (3) analyze power structures within institutions and identify where change-making can take place; (4) assess positionality within an institutional structure and what change can be made within a current position; (5) practice leveraging the vocabulary and analytic lens around gender equity in career development contexts; and (6) evaluate and provide feedback on a classmate's assignment to gain perspective on how bias can be perceived from various positions. Each student was asked to submit a draft halfway through class and review a classmate's draft. One half of a class session was dedicated to breakout sessions where peer review partners discussed both the draft of the assignment itself as well as the problem that was identified and its potential solutions. In this way, students were able to both write about the gender bias they identified and experienced but also discuss and collaborate with one another about solutions. These breakouts were well-received by the students (as communicated in chat conversations in the large group that followed), and many students articulated that it was refreshing to discuss the frustrations they encountered in a safe and anonymous context.

Evaluation Overview

As mentioned previously, we aimed to evaluate this course as a potential intervention to encourage graduate students and postdocs awareness of gender bias, to reduce sexism, and to promote belonging in STEM contexts. To assess the course's efficacy's addressing these goals, we had students in the class complete a serious of measures before and after taking the class. The assessment instruments and evaluation results are described in detail below.

Evaluation Methods

Procedures

Students enrolled in the course were invited to participate in a survey-based evaluation of the course. Specifically, an e-mail link was sent to the students via the course website at the start of the course, which redirected students to an online survey. This survey first presented students with a consent form discussing the purpose of the research and of the survey. If students consented to participate, they completed the "Time 1" evaluation measures (described below). At the end of the course, students were again e-mailed a link to the survey, and completed the "Time 2" evaluation measures. There were additional course evaluation questions that were asked at "Time 2", but the majority of the survey was identical.

Measures

For all measures used, we averaged participants' responses to survey items, such that higher scores indicate more of the measured construct. Participants rated their agreement with survey items on 1 (*strongly disagree*) to 5 (*strongly agree*) scale. Detailed information about the surveys is available in Table 2, including example items, number of items in each scale, and the reliability at Time 1 and Time 2. To test our hypotheses, we used previous validated measures, all of which have been employed to test the effectiveness of the VIDS intervention. Consequently, these measures were well suited to evaluate a course incorporating VIDS. In particular, to examine whether the course increased awareness of gender bias in STEM broadly and decreased sexism (i.e., testing hypotheses a–d), we used scales assessing awareness of gender bias in STEM (Pietri et al., 2017), modern sexism (Moss-Racusin et al., 2018; Swim et al., 1995), awareness of male privilege in STEM (Case, 2007; Pietri et al., 2017), and general knowledge about gender inequity (Pietri et al., 2017; Shields et al., 2011).

We also aimed to explore whether the course would improve students' motivation to enact change and thus measured their behavioral intentions to create equitable environments for women in their STEM classes and broadly (i.e., testing hypothesis e). To test this possibility, we used the same behavioral intentions employed by Moss-Racusin et al. (2018), which were validated among STEM faculty. We assessed changes in behavioral intentions broadly, combining all the items in the scale. Moreover, we divided the measure into four sub-scales to assess specific behavioral intentions, including, intentions to create an inclusive classroom, intentions to mentor women, intentions to seek additional information about gender bias, and intentions to support inclusive policies. Although these measures did not examine actual behaviors, previous work has demonstrated that behavioral intentions can be predictive of future actions (Webb & Sheeran, 2006).

Table 2 Evaluation measures and reliabilities

Scale	Example item	Number of items	Time 1 Reliability	Time 2 Reliability
Bias literacy				
Awareness of gender bias in the sciences	Women in science fields often face discrimination based on their gender	8	$\alpha = .87$	$\alpha = .92$
Awareness of male privilege in the sciences	Men have privileges that women do not have in USA	7	$\alpha = .86$	$\alpha = .62$
Knowledge of gender equity questionnaire	Men tend to receive larger raises than women	21	$\alpha = .90$	$\alpha = .90$
Modern sexism	Society has reached the point where women and men have equal opportunities for achievement	8	$\alpha = .85$	$\alpha = .78$
Self-efficacy				
Self-efficacy to combat bias	I believe that I, as an individual, can help stop gender bias in the sciences	3	$\alpha = .64$	$\alpha = .67$
Self-efficacy to notice bias	I feel confident in my ability to recognize instances of gender bias	2	$\alpha = .69$	$\alpha = .88$
Bias is fixed/cannot change	People have a certain amount of gender bias and they really cannot do much to change it	3	$\alpha = .80$	$\alpha = .89$
Behavioral intentions				
All behavioral intentions	(*See below for examples*)	18	$\alpha = .94$	$\alpha = .92$
Intentions to mentor women	I intend to provide career development and research support for female students	6	$\alpha = .91$	$\alpha = .88$
Intentions to create inclusive classrooms	I intend to create an environment that ensures both female and male students feel welcome in my classroom	6	$\alpha = .86$	$\alpha = .93$
Intentions to seek additional information	I intend to learn about and find resources to increase women's representation in the sciences	2	$\alpha = .69$	$\alpha = .49$
Intentions to support inclusive policies	I intend to support retention initiatives for women in science	4	$\alpha = .89$	$\alpha = .82$
Identity-safety in STEM				
Belonging in STEM	I belong in the sciences	8	$\alpha = .80$	$\alpha = .85$
Trust and comfort in STEM	I can myself in a science classes and research labs	4	$\alpha = .68$	$\alpha = .81$

We also were curious whether students would feel self-efficacious to combat gender bias and notice gender in their classes (e.g., hypothesis f). Thus, we included indices assessing their self-efficacy to combat bias in the sciences (Hennes et al., 2018), self-efficacy to notice gender bias (Pietri et al., 2017), and perceptions that bias is a fixed construct that they cannot change (Hennes et al., 2018; van Zomeren et al., 2013). Our hope was that the course would increase perceptions of self-efficacy and decrease beliefs that bias is a fixed construct that cannot be altered. Finally, we examined students' general feelings of belonging and identity-safety in STEM using a measure of belonging in STEM (Good et al., 2012; Pietri et al., 2017; Walton & Cohen, 2007) and trust and comfort in STEM (Pietri et al., 2017; Purdie-Vaughns et al., 2008) in order to test hypothesis g.

Participants

Below, we describe the information about the students who completed the above surveys across the 3 years the course was offered.

2018: Fifteen (of 23) students who were enrolled in the course completed the evaluation surveys. Of the students who completed the survey, 10 identified as female (1 transgender female) and 5 identified as male (1 transgender male). At the beginning of the course, students were informed of the research study and encouraged to complete the pre-survey if they were willing to participate. At the conclusion of the course, the post-survey was likewise administered to course participants.

2019: The structure was the same, but course enrolment was smaller (7 of 15 students completed both pre- and post-course surveys). Among the students that completed the surveys, 4 identified as females and 3 identified as males.

2020: The structure was the same as the previous studies. Twelve of 42 students completed both the pre- and post-course surveys. Among the students that completed the surveys, 9 identified as females and 3 identified as males.

Results

To test our hypotheses and evaluate the benefits of course, we first ran mixed model ANOVAs on all the outcome measures, with time (Time 1 vs. Time 2) as our within subjects variable and course (courses 1, 2, 3) as our between subjects variable. There were no significant interactions with course (all $p > 0.059$), and we found a consistent pattern of results across the three classes. Thus, we removed course from the model and ran within-subjects t tests to test for changes in scores from Time 1 to Time 2. The full results for each measure are available in Table 3. We found a significant increase in many of the outcome measures, with the majority of effect sizes being medium to large effect sizes (Cohen's d ranged from 0.37–1.23; see Table 2). In particular, supporting hypotheses a–e, there was a significant increase in awareness of gender bias in the sciences ($d = 0.83$, $p < 0.001$), awareness of male privilege in the sciences ($d = 0.48$, $p = 0.008$), and knowledge of gender equity ($d = 0.95$, $p < 0.001$), and significant decrease in modern sexism ($d = 0.45$, $p = 0.014$). Moreover, in support of hypotheses e and f, there was a significant increase in all behavioral intention subscales ($ds = 0.37$–0.63, $ps = < 0.001$–0.037) and self-efficacy to combat ($d = 0.81$, $p < 0.001$) and notice bias ($d = 0.90$, $p < 0.001$). Although beliefs that bias is fixed decreased from Time 1 and Time 2, this difference was not significant ($d = 0.34$, $p = 0.055$). Finally, we did not find evidence that supported hypothesis g and saw no changes in belonging ($d = 0.13$, $p = 0.441$) or trust and comfort in STEM ($d = 0.05$, $p = 0.793$). (Tables 2 and 3 to be included here. Tables located at the end of the file.)

Discussion

Impact of the Course

Overall, the course was quite successful at increasing bias literacy and motivating participants to mitigate gender-related bias within their local STEM contexts. Notably, *both* measures of bias awareness *and* measures of self-efficacy and behavioral intentions to promote change improved over the course of the semester. The results indicate that the participants in all three cohorts left with greater intention and motivation to address situations that they encountered in the future. This is particularly promising given the position that most participants hold (potential future faculty in their given fields).

While most of the impacts of the course appear to be positive, it is important to consider the potential unintended impacts that often arise from bias awareness interventions. In prior work, it has been found that interventions that increase bias literacy and highlight gender inequities can stimulate social identity threat in women (Pietri et al., 2019). In this work, it was found that VIDS interventions resulted in lower sense of belonging in the sciences, greater negative affect and greater self-reported social identity threat among women compared to control groups. While we did not see this negative impact on our population, we also did not observe any improvements in "sense of belonging" and "trust and comfort in STEM". The lack of significant advancement in these categories is likely due to similar mechanisms that are described in the prior work.

Table 3 Changes from Time 1 to Time 2

Scale	Time 1		Time 2		Changes from time 1 to time 2		
	M	SD	M	SD	*t*(33)	*p*	Cohen's *d*
Bias literacy							
Awareness of gender bias in the sciences	4.10	0.53	4.51	0.47	4.84	<.001	0.83
Awareness of male privilege in the sciences	4.00	0.64	4.29	0.44	2.82	.008	0.48
Knowledge of gender equity questionnaire	3.95	0.42	4.30	0.39	5.53	<.001	0.95
Modern sexism	1.65	1.18	1.47	0.43	-2.61	.014	0.45
Self-efficacy							
Self-efficacy to combat bias	3.72	0.57	4.23	0.44	4.71	<.001	0.81
Self-efficacy to notice bias	3.32	0.79	4.16	0.66	5.23	<.001	0.90
Bias is fixed/cannot change	1.89	0.56	1.66	0.70	-1.99	.055	0.34
Behavioral intentions							
All behavioral intentions	4.24	0.52	4.57	0.37	3.95	<.001	0.68
Intentions to mentor women	4.14	0.63	4.49	0.49	3.69	<.001	0.63
Intentions to create inclusive classrooms	4.39	0.53	4.72	0.41	3.18	.003	0.55
Intentions to seek additional information	4.38	0.56	4.60	0.47	2.17	.037	0.37
Intentions to support inclusive policies	4.07	1.18	4.43	0.47	3.46	.002	0.59
Identity-safety in STEM							
Belonging in STEM	3.52	0.60	3.48	0.63	0.78	.441	0.13
Trust and comfort in STEM	3.58	0.64	3.56	0.77	0.27	.793	0.05

All measures were on 1 (*strongly disagree*) to 5 (*strongly agree*) scales. For these analyses, we combined all three courses. There were 15 students in class 1, 7 students in class 2, and 12 students in class 3. For class 2, four students completed time 2 immediately after the class ended, and three students complete the survey 6 months after the class ended. We ran additional mixed-model ANOVAs, including class as a variable (e.g., with time as the within subjects variable and class as the between subjects; 2 [time 2] by 3 [class] design). We did not find any significant interactions class, all *ps* > .059. Thus, we collapsed across all three classes for our primary analyses

Implications and applications

The recent development of STEM-specific evidence-based gender bias interventions is promising as a marker of resources to progress toward equity in STEM fields. Progress toward this type of change is always slow, however, and ensuring these resources are effective with the appropriate population is critical. As a follow-up to the initial development of the VIDS intervention, the impact of VIDS on STEM faculty was specifically investigated to ensure the effectiveness of the intervention on the relevant population (Moss-Racusin et al., 2018). The intervention was found to have significant effects on STEM faculty, but it is important to also consider the potential, as detailed in this article, of targeting developing scientists, as the next generation of faculty in STEM fields.

As new faculty get hired into departments and industries, the conversations around processes and protocols changes. If the incoming population of decision-makers is aware of how to check their own biases and trained to identify incidents that are motivated by bias, they are in a greater position to establish a status quo that combats these incidents. Further, although this population has been exposed to institutional bias, it is likely not as deeply internalized as it is in the faculty population.

Limitations and Future Directions

Among the measured impacts of the course, "trust and comfort in STEM" and "sense of belonging" had the most modest improvements, a phenomenon that has precedent in other gender bias interventions, noted above (Pietri et al., 2019). In the aforementioned study, the integration of "identity safe cues" was shown to alleviate the negative effects on sense of belonging and trust and comfort in the sciences. The identity-safe cues included in the study included (1) the presentation of a positive female scientist role model and (2) explicit suggestions that gender bias can be overcome. Because this course focuses heavily on inclusion of gender minorities beyond the categories of male and female, we believe that our focus on instructor identity as well as our end-of-class panel discussion function as identity-safe cues in category (1). It is perhaps because of these components that our course participants did not experience the severity of decline in belonging that are reported in other interventions. Identity-safe cues in category (2) were not as heavily emphasized. In future iterations of the course, including more explicit messaging about the capability of overcoming gender bias may further maximize progress in the areas of belonging and trust and comfort in the sciences.

An additional limitation of the present study is the small number of participants that take the class each year. As additional cohort data are accumulated, the consistency of the results becomes more compelling. Continuing to measure the impact of the course as it is offered every year will strengthen the confidence in the trends observed. During the course of writing, submission, and review of this manuscript, an additional cohort of data has been added to the analysis, and the effects have held consistent both within and across cohorts. Larger populations of participants would also allow different populations to be studied separately (results could be analyzed by gender, age, race, region, institution, or position in academia). As other institutions adopt the course, it may also be offered in an in-person format or asynchronously. A comparison of different modalities of the course would highlight the most effective facilitation of the intervention.

Conclusion

Gender bias in STEM is a persistent problem encountered by individuals at all levels and of all gender identities. As more robust interventions are developed to target this type of bias, it is important to consider the best way to harness their impact. In our course, *Equity in STEM for All Genders*, we combine the power of evidence-based bias intervention (VIDS) and emphasizing instructor identity to target future STEM faculty in the field. Through discussions that draw on real experiences in STEM training and education, participants gain the awareness of gender bias that they need to productively contribute to strategies to mitigate it throughout their careers.

It is our hope that the participants of our class will continue to be change-makers in their respective STEM contexts, raising awareness about the bias they identify and proposing strategies to intervene. We also hope to continue to develop this course to continually improve its impact.

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Author Contributions SK and DGD instructed the 2018–2019 cohort of this course. SK instructed the 2019–2020 and 2020–2021 course with another instructor. EP analyzed and interpreted the survey data from students in the course. The authors read and approved the final manuscript.

Availability of Data and Materials The datasets generated and/or analyzed during the current study are available in the Open Science Framework repository, https://osf.io/jrukm/?view_only=532767423c7c4818a301c66cef6276b8.

Declarations

Ethics Approval This research has been declared as exempt by the Institutional Review Board of Northwestern University.

Conflict of Interest The authors declare that they have no conflict of interest.

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