Empowering and Liberating: Fostering STEM Identity through Engagement with Women's and Gender Studies

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Abstract

While the importance of diverse participation in STEM is widely understood, persistent biases and complex disadvantages can thwart the thriving of students experiencing marginalization. Although many interventions within STEM have shown promise, the potential transformative impact of student curricular engagement with subjects outside of STEM has been under-examined. We report on a qualitative exploratory study of the knowledge and attitudes STEM students carry forward from a STEM-themed course in Women's and Gender Studies (WGS). Participants in the study are undergraduate STEM majors who completed a WGS course focused on critiques of scientific objectivity and the gendered and racialized history of scientific knowledge across STEM disciplines. Using focus group interviews to expand on coded student survey responses, we found that STEM students who participated in this WGS course generally considered that experience to be empowering, liberatory, and enhancing of their STEM confidence and preparedness. The provocative findings from a small sample of students warrant further study, and preliminary results suggest great potential in more fully and intentionally leveraging the wider academic curriculum to advance the involvement, agency, and flourishing of diverse STEM students.

Keywords: STEM identity, gender, race, gender studies, agency, belonging, STEM, intersectionality

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Despite the knowledge that diverse participants and perspectives are integral to "creativity, productivity, innovation, and success" (Blackburn, 2017, p. 236) in science, technology, engineering and mathematics (STEM)—and decades of research on how to best foster sustainable diversification—many STEM fields remain frustratingly homogenous in both demographics and ways of being. Strategies to promote diversity in undergraduate STEM (for systemic overviews see Tsui (2007) and van den Hurk et al. (2019)) often integrate knowledge from other fields—for example, working to change STEM educational practices by applying concepts from psychology such as stereotype threat or implicit bias. Some initiatives engage underrepresented STEM students more directly, including mentoring programs (e.g., Dasgupta, 2011), teaching "coping strategies" (Ko, 2014, p. 171), co-curricular support and living-learning programs (Inkelas & Soldner, 2011), and "cultural competence training" to help students adapt to a STEM environment (Chang et al, 2011; Whittaker & Montgomery, 2012). While each of these approaches has value, we can observe a significant omission: inclusivity strategies have not consistently connected STEM students to the study of STEM cultures, nor have they routinely leveraged the vast array of STEM diversity knowledge shaped by interdisciplinary and social science research. Offering STEM students an informed perspective on how identity and power circulate through STEM by connecting them with fields that deliver that knowledge has not been part of the STEM diversity "toolbox."

The Myth of STEM Neutrality/Objectivity

The normative disconnect between STEM learning experiences and the study of power and identity in STEM content and cultures is undergirded by the persistent myth of STEM

objectivity. As early as 1985, Evelyn Fox Keller identified science's reliance on an "objectivist ideology prematurely proclaiming anonymity, disinterest, and impersonality, and radically excluding the subject" (p. 12). The crux of this ongoing critique is not simply that unmediated objectivity in STEM research is impossible, but that implicit confidence in scientific objectivity and neutrality ensures the continuation of beliefs and practices that marginalize the very students we particularly wish to welcome and retain.

A belief in STEM objectivity has been shown to correlate with the marginalization of under-represented participants in STEM (e.g., Cech, 2013). This dynamic is complicated by an investment in depoliticization, that is, "the belief that not only *can* cultural and social concerns be bracketed out of engineering, but they *should* be" because such concerns "threaten the purity and integrity" of STEM fields as a whole (Cech & Sherick, 2019, p. 2, emphasis in original). This conceptualization configures the belief in STEM neutrality as not merely passive but actively protectionist, situating STEM fields as needing defense from the "outside" corruption of politics and ideology. We recognize Cech and Sherick's call for *re*politicization in the form of acknowledging that the culture of STEM is socially constructed and incorporating sociocultural context and critique in STEM education. If a protectionist attitude of neutrality (depoliticization) perpetuates the default settings of white, masculinist, heterosexist cultures and identities in STEM, repoliticization could have the opposite effect. Repoliticizing STEM education (e.g., Riley, 2003)—asking STEM students to learn about the ways in which gender, race, class, and other factors have both formed STEM content and shaped the experiences of those engaged in STEM—may reduce feelings of marginalization and improve under-represented students' ability to see themselves as belonging in STEM, as do-ers of STEM.

STEM Identity Formation in the WGS Context

The literature on STEM diversity strongly suggests that a robust "STEM identity" can be a critical element of STEM student persistence (e.g., Kuchynka, 2017). Components of identity formation have classically included a sense of inner agency, a commitment to certain self-representations and roles, an acknowledgment of these roles by others, and a commitment to core values and a value-laden worldview (Erikson, 1968; Gee, 2000-1). The process of STEM identity formation is constructed through relationships and social interactions (Eccles, 2007; Binning et al., 2020) and influenced by context (Tan, 2007).

Connections between successful STEM identity development and promotion of STEM diversity are well-established. Research emphasizes the importance of students' active engagement with the sociocultural contexts of STEM, especially relative to STEM fields' long histories of implicit and explicit bias in terms of gender, race, and other aspects of identity. Carlone (2003; 2007) has suggested that attention to STEM identity formation can offer new ways to understand the process of enculturation into the community of scientific practice, as well as make science education more equitable by acknowledging the social construction of science and helping students recognize their own agency. Cech (2013) noted that "we cannot begin to change cultures and climates in engineering without cultural space for frank discussions about how … inequalities are (re)produced" (p.3). Subramaniam (2014) has studied student identities within a culture of STEM characterized by norms and unwritten rules. The tension between Cech's call for "frank discussions" and Subramaniam's identification of "unwritten rules" indicates a need to introduce sociocultural issues while simultaneously exposing not-so-neutral cultures of STEM.

Reflecting on the work of black feminist theorists Patricia Hill Collins (1993) and bell hooks (1994), we suspected that students who engage with critical theorizing around identity, power and practice might feel empowered by acquiring the ability to name systems of power and oppression, and that this ability might support their identity formation and sense of belonging in STEM. It seems plausible that students who rigorously examine the intertwined workings of identity, power and social/knowledge systems will be less inclined to see challenges or struggles in STEM work as the result of individual inadequacy and more inclined to attribute some obstacles to systemic factors outside of their own intelligence and effort.

We consider a Women's and Gender Studies (WGS) course an ideal platform from which to explore these questions. Those experiencing marginalization can be empowered by naming the oppression and theorizing about it (Yosso, 2005). Such naming and theorizing—explicitly understanding one's experience as connected to broader systems of oppression and comprehending how such systems are directly linked to the production/dissemination of knowledge—is understood by feminist scholars as central to both liberation and learning (Rich, 1979; hooks, 1994; Berger & Radeloff, 2011). Because they focus on critical theorizing around identities, privilege, and oppression, WGS courses are engaged in precisely this kind of work. WGS explicitly links the experience of social identities to systems of power, focusing on entrenched asymmetries of power that are falsely posited as merit-based, and closely examining the processes through which such asymmetries become naturalized. WGS also intentionally makes identity itself more fluid, positing that the experiences and effects associated with identity are highly contextual and always changing. WGS courses are also inherently interdisciplinary and often designed for learners from all disciplinary backgrounds. WGS thus offers a multi-dimensional view of STEM history, cultures, processes, and content.

Emerging research indicates great value in qualitatively examining the experiences of the STEM students who have opportunities to build critical reflection skills and engage in informed systemic analysis of identity and STEM cultures. Qualitative explorations indicate that an engagement with feminist principles and other intentional counter-narratives may help women in STEM better comprehend and explain the obstacles they face in STEM (e.g., Margolis & Fisher, 2003). Sparks (2017) suggests that "develop[ing] more qualitative studies that help reveal how identity as a STEM student is formed" may help address marginalization and attrition (p. 170). In this vein, Secules et al. (2018) used individual interviews with women in STEM to foster narrative agency and encourage critical theorizing about their experiences. The study finds that such qualitative theorizing often echoed the tenets of feminism, for example, that "naming one's own oppression" positively developed students' agency and self-determination. Through opportunities to critically reflect on STEM and practice narrative theorizing, a student may arrive at the realization that it is STEM cultures, not STEM students, that need transformation. We note the example of one institutional transformation project using a critical feminist lens: Oregon State's ADVANCE seminar in which faculty, staff, and administrators examine systems of power and privilege (Shaw et al., 2019).

This exploratory study thus seeks to investigate how an elective STEM-focused WGS course may influence students' understanding of cultural shaping of STEM disciplines and may impact their perceptions of their experiences as (marginalized) STEM students. We pose the research question: What knowledge, methods, attitudes, and beliefs are STEM students likely to carry forward from WGS exposure?

Methods

Data were collected from students who participated in WGS 250: Gender and STEM, a semester-long, STEM-focused Women's and Gender Studies course with no prerequisites. This elective course can be taken by any student to fulfill college distribution requirements but is not a required course for any major. Our investigation involved two instruments: an end-of-semester survey completed by all WGS 250 students; and follow-up focus groups with underrepresented STEM majors who took WGS 250. Our study was exempted from IRB approval by the College's IRB after its review.

Of the 72 total students enrolled in WGS 250 over three course offerings, 51 were declared or intended STEM majors at the time they took the course. We analyzed the survey responses of these 51 students, who consisted of 46 women (31 of whom identified as white) and 5 men (4 of whom identified as white). Students in STEM majors who had completed the WGS 250 course but had not yet graduated ($N = 25$) were invited to participate in focus group sessions, and 10 chose to participate. All 10 identified as women; 7 of these 10 identified as white; 6 of these 10 identified as members of more than one underrepresented group (LGBTQ+ status, racial and/or ethnic identity, disability, and/or national origin in addition to gender). The 10 focus group participants consisted of 5 engineering and 5 natural science majors.

The course exit survey posed two open-ended questions: (a) What effects, if any, did your WGS class have on your personal experience as a STEM major?, and (b) What effects, if any, did your WGS class have on your perspective on your academic field itself?

Facilitated focus groups "shift the balance of power away from the researcher toward the research participants," comprising a feminist methodology appropriate to our research questions (Wilkinson, 1999, p. 221). Informed consent was obtained in writing before any questions were

posed. Discussions were facilitated by one author and a faculty colleague, neither of whom had served as an instructor for any WGS class. Focus group facilitators provided copies of the WGS 250 reading list for reference, and posed the same two primary questions, with follow-up questions as necessary.

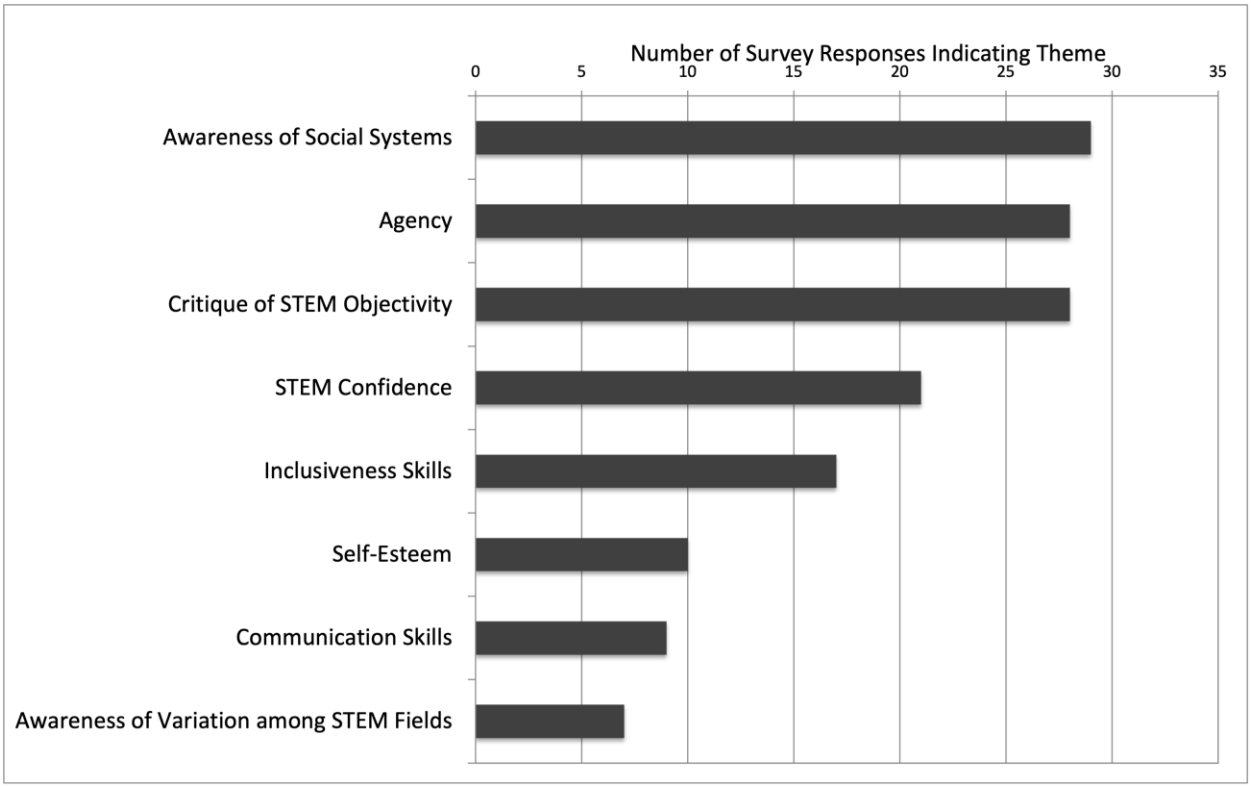
With participants' consent, the discussions were audio recorded and the recordings transcribed by a third-party service. Facilitators reviewed these transcriptions for accuracy. Our coding of survey and focus group responses was an inductive analysis. Each author performed the process independently to establish reliability of the codes and themes (Saldaña, 2015). Our professional and personal identities are relevant to this work. We are: (a) a mechanical engineering educator who co-directs our college's center for Inclusive STEM Education, and (b) a scholar of WGS and of Victorian literature whose research has included NSF ADVANCE projects focusing on institutional transformation. We are both white women, one (b) a member of the LGBTQ+ community. Our institutional context, Lafayette College, is an undergraduate-only liberal arts college, a historically white institution whose academic offerings include six engineering majors.

Results

Seven major themes emerged from the exit surveys through our coding analysis. Figure 1 shows the specific frequencies with which each of these themes were identified by STEM student exit survey responses.

Figure 1

Frequency of STEM student survey responses identifying particular themes after WGS 250



Note. Frequency various themes emerged in end-of-semester responses of $N = 51$ STEM majors

In both survey and focus group responses, the three most commonly represented themes were the same. Participants expressed most strongly and frequently that their WGS coursework helped them develop: (a) an awareness of social systems that enabled a shift in understanding of their experiences from individual to systemic; (b) agency and control through knowledge tools; and (c) a critique of STEM objectivity and more critical view of STEM as culturally contextualized and influenced. Representative responses for each of these themes follow.

Awareness of Social Systems

Focus Group Participant 1: I think it just made me a lot more aware of possible biases that people would be experiencing and, kind of, experiencing that power that goes along

> with putting names to things where maybe you had had a bit of a feeling like, "Oh, maybe that's just me that I'm not feeling confident in this" or, "I feel like I have to do x, y, z" to compensate. But actually putting a name to it and realizing that a lot of these experiences are shared with women in STEM was empowering, so you're able to actually put words to feelings and make it feel more real.
>
> Participant 2: There were some other females that I knew in the class, and a lot of us had conversations about that outside of lecture on how we all really identified with that term of imposter syndrome and how there's never a word to go along with it beforehand, but once we learned about this term, it really clicked.

Responses to the WGS 250 exit survey also described the value of learning to identify challenging personal experiences as understandable social phenomena. Participants reported finding this comforting and reassuring: "This class has shown me that I am not crazy."

Agency

> Participant 2: [WGS can] impact how you interpret things and possibly your own behavior as well.
>
> Participant 5: But if you know why you don't feel like you belong, then it's easier to do something about it and possibly change your surroundings or talk to someone about it or --I don't know --just take it less personally, I guess, and understand that...things are structured in a way to make you feel like you don't belong, it's not that you don't belong.
>
> Participant 4: I know I do talk to my classmates differently now, when we discuss things that are… of this nature.
>
> This theme was closely related to that of increased STEM confidence, which also emerged in the class exit surveys. "I compete more with men to prove stereotypes

wrong," wrote one respondent. "I feel more capable to take on courses I might have felt intimidated by."

Critique of STEM Objectivity

In the course exit survey, one student wrote, "I'm aware that not everything I learn in the science classes I take may encompass the full story, but instead was culturally shaped." Another said, "It has led me to be more thoughtful analyzing what I have been taught and the way my major is structured." "I became somewhat disillusioned re: the 'purity' of STEM, recognizing the various biases," one student wrote, acknowledging that the previous emphasis on the "neutrality" of STEM had set their expectation that it should be so. This theme was strongly present in our focus group interviews as well:

> Participant 1: looking at how the biases of the person who's making that program can reach into an algorithm was very interesting. And there was a lot on the design process in engineering. That's something that I feel like will be directly affecting me in the workplace later in thinking about who's on the design team… Is this "the average person on the design team" or "the average person" that we're looking at?
>
> Participant 3: [WGS] gave me a more critical view and a critical lens to view my field through, to question what I was being told in other classes.
>
> Participant 4: all throughout your childhood, you're raised in a sort of way that science and STEM in general are very concrete and they're coming from this like total truth and sort of infallible. But this class made me aware that it's so changing, based off of society's values at the time.
>
> Participant 3: the view that physicists and mathematicians have of physics as the most objective science of basically the law of the universe, when it's greatly influenced by the

> economy, wars, and --etc. really just is like, "Whoa. Definitely check what you're learning against what people's personal motives are."

In addition to reifying these themes from the exit surveys, focus group conversations suggested emergent themes for further exploration: (a) perceived disadvantages of "feminine gender performance" in STEM, and (b) opportunities and challenges related to integrating a WGS class into the curricular experiences of STEM majors.

Concern around feminine gender performance refers to the perception that presenting social cues denoting conventional femininity may trigger disadvantageous associations in STEM contexts (e.g., being "unserious").

> Participant 2: [I was] noticing that when I went to grab a highlighter, I hesitated. … Eventually [I] realized oh wow, that's ridiculous. No one's judging me for a pink highlighter, (laughter) or I hope not.
>
> Participant 1: If they are, that's on them not on you.

In both exit surveys and focus groups, students who had taken WGS 250 recommended that other students should also take this or similar courses. This was consistent with the results of other survey instruments (Rossmann & Armstrong, 2021). Focus group facilitators asked whether there was a "right time" to take such coursework. Participants described feeling that WGS prepared them for further STEM courses and experiences, but expressed concern that too-early exposure to a systemic perspective on systemic dis/advantage might have been overwhelming.

> Participant 1: You come in [to classes like WGS 250] with your solidified biases, and they kind of get worn down as you go on."

> Participant 2: [Students should take WGS early enough to have the chance] to apply it in the kind of smaller ecosystem that is college before trying to applying it to a bigger area [at work], like to impact how you interpret things and possibly your own behavior as well.
>
> Participant 5: If I had taken this class like my first or second semester, I would have just been so depressed, like so deeply depressed, and not gotten as much as I could out of it as I did taking it later. I just didn't have the confidence in my environment to be able to use this class, as a freshman.

Relatedly, discussions addressed how STEM students from overrepresented groups might respond to WGS concepts and theorizing. Participants spoke of a "stigma" associated with such classes and of "resistance" among their straight white male STEM peers. They ascribed these attitudes to fears of "emasculation," "awareness of unearned privilege," and the techno-chauvinism that values "hard" technical classes over liberal arts and general education coursework.

Discussion

Students who engaged with critical theorizing around identity, power, and practice reported feeling agency from the act of naming systems of power and oppression and, as a result, feeling empowered to act in opposition to such systems. Some respondent comments suggested that this strengthened their sense of belonging in STEM. To quote one focus group participant, "it's not that you don't belong," it's that "things are structured in a way to make you feel like you don't belong." Some students attributed an improved sense of belonging in STEM directly to their WGS course: "This class has made me feel more at home in the STEM field than any of the 15+ STEM classes I've taken."

The combination of students' reported sense of agency (to address bias, stereotyping, and other systemic issues) and STEM confidence point to WGS having a positive impact on these students' STEM identity development. Our participants articulated a desire to disprove others' stereotypes and assumptions—heightened by their new understanding that such biases are systemic, and not personal—that they found motivating. This is consistent with prior research suggesting that effort to "show the doubters" or prove others wrong may be a means to critique oppression and drive success (Rodriguez et al., 2017). Our study also suggests an impact of WGS coursework on STEM identity stereotypes: students exposed to WGS frameworks felt confident in their atypicality and liberated to "break the mold."

These preliminary results highlight the value of providing STEM students with a more critical view of STEM "neutrality." In fact, some participants resented having been presented with the myth of a neutral, depoliticized STEM, and suggested that WGS knowledge could "weaponize students" to reveal the truth behind that myth. Participants in both exit surveys and focus groups used the language of clarifying vision for their WGS experience: glasses, lenses, and veil-lifting were all common themes. Our participants perceived themselves as having been unknowingly constrained by an uncritical view of STEM, and felt empowered by a more contextualized one: "WGS provided a really useful lens through which to look at STEM critically. It made me think more critically about the studies I read, my own biases, and how I can design better," said one engineering student. This is consistent with the work of Erin Cech and with Evelyn Fox Keller's notion that the myth of STEM objectivity perpetuates exclusion and marginalization. In addition to the impacts reported by our participants from historically marginalized and excluded identities, we note that courses like WGS 250 can help shape what

counts as STEM for all students, and thus contribute to the transformation of the culture and biases of STEM.

Limitations and Groundwork for Future Study

Our findings suggest the potential value of guiding STEM students through an interrogation of specific STEM histories and (problematic) ideologies using critical feminist frameworks. Given the promising outcomes self-reported by students who had that experience, further study is warranted on the dis/advantages of connecting STEM students with such coursework. Further study that includes pre-WGS assessment instruments could enrich understanding of perceived impacts, perhaps providing direct evidence for what is implied by students' post-WGS responses.

We note that STEM students in WGS 250 are self-selecting for participation in the class; this may indicate a pre-participation bias in terms of personal interest or knowledge around social justice, anti-racist or feminist issues. Exit survey data could be more generalizable if the class were required, or STEM students took it randomly. Similarly, focus group participants are self-selected and our *N* is small, which could also limit the generalizability of our results. Focus group data on changes in student perspective are self-reported and could therefore be affected by social desirability bias and/or confirmation bias, as well as by study demand characteristics. In future work, pre-testing may confirm to what degree reported changes in students' STEM identity formation are attributable to the course.

Learning persists when lessons are scaffolded, reinforced, and progressively developed over time. One course cannot stand as an inoculation against the challenges of the cultures of STEM, for any student. Being able to name a hazard does not render it harmless and recognizing culture-based obstacles as systemic does not remove them from the culture. Particularly if

(when!) a student's STEM classes reinforce a depoliticized, "neutral" view of STEM, the takeaways from WGS or other contextualizing coursework may diminish. We also recognize that it would be both ethically and practically in error to expect students to be the key drivers of change in STEM.

Related to these limits of a single-semester intervention is the critical issue of intersectionality. While the readings in WGS 250 are linked to issues of both gender and race, and often to issues of sexual identity or sexual behavior, a single course is insufficient to enable students to deeply appreciate the ways in which identities are mutually constitutive and contextual—that is, intersectionality within the specific cultures of STEM (Crenshaw, 1989; Armstrong & Jovanovic, 2015). It is critical for students to develop more prismatic or dimensionalized lenses with which to understand multiple identities; for example, to examine their own privileged identities as well as their marginalized ones. The students in our study generally linked an aspect of their identity currently underrepresented in STEM to their STEM identity. The intellectual and personal demands that attention to intersectionality makes likely exceed the fifteen-week semester.

Exposure to and engagement with WGS concepts and methods may support diverse STEM students—it may even, as some of our study participants suggested, be necessary—but it is not sufficient. Partnerships linking STEM with WGS and other social science disciplines could effectively "repoliticize" STEM classrooms with liberatory pedagogical methods, critical theorizing, and contextualizing of STEM methods and products through cultural, gender, ethnoracial, privilege/power, and other lenses. It would be powerful for some of the work of understanding and transforming inequitable systems, cultures, and practices to take place in the

STEM context, including critical reflection and recognition of the social construction, and thus the mutability, of the culture of STEM.

Conclusions

We offer this study as an opportunity to begin to advance a wider, data-driven exploration of this approach to fostering STEM diversity. Our qualitative exploration found that STEM students felt empowered, provided with a sense of agency and a strengthened, more expansive sense of their own STEM identity. These findings suggest that coursework on identity and power, coupled with understanding of STEM's non-neutrality, may be perceived by some STEM students as empowering and liberatory, and may correlate with their sense of belonging and STEM identity development. These preliminary findings suggest that there is great value in deeper study of the influence of WGS coursework on STEM students.

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