Leveraging Grant-Writing for Transforming Students' Normative Views of STEM[1]

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Abstract: Today, efforts in WAC/WID to address social issues are gaining traction. Parallel to the shift in WAC/WID is a shift in STEM. Practices in STEM are responding to larger social concerns that include recruiting more diverse populations and improving research in consideration of its value and consequence to various publics. Rather than conceive of STEM as a homogeneous group or as representing narrow interests of progress, the social context of STEM is also gaining traction, though the uptake is slower. STEM instructors often lack the knowledge to incorporate social issues into their curriculum, much less address social change through writing instruction. This article contributes to the social turn in WAC/WID STEM in two ways. First, it examines STEM students' attitudes toward science to find out how they view the social in science since its importance in STEM is increasing, but instruction is lagging. And second, given our results, we suggest grant-writing as one way to facilitate the social into STEM writing pedagogy because of its critical importance as a genre in the field.

In recent years WAC/WID has made advances in incorporating more complex views of disciplinary engagement. Whereas the focus previously was about students' enculturation into disciplinary practices (see Carter, 2007), students are now being considered in light of how a discipline intersects with race, gender identity, ability, and language ideology, to name a few (i.e., Anson, 2012; Falconer; 2019; Poe, 2013). This positive movement towards diversity and inclusion allows for the possibility of a sense of belonging while simultaneously enacting social change in a discipline as more student identities and knowledges shape it through their participation.

Parallel to the shift in WAC/WID is a shift in STEM. Researchers are now highlighting the need to address the social context in STEM education, although the uptake is slower. According to Juan Garibay (2015), two attitudes have guided STEM. The first embraces an economic perspective where workforce is the primary concern. The second, the subject of this article, is a critical perspective, where the focus is on "civic engagement and equity orientation" (p. 610).

Practices in STEM are responding to larger social concerns that include recruiting more diverse populations into STEM and improving research in consideration of its value and consequence to various publics (Henkhaus et al., 2022). STEM instructors, however, often lack the knowledge to incorporate social issues into their curriculum, much less address social change through writing instruction. As Bradley Hughes' (2020) study of early-career disciplinary faculty demonstrates, they have many more questions than answers about writing. The majority of questions faculty posed in his study could be categorized into several general themes: designing assignments (46%), writing

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pedagogy (35%) responding and evaluating to student writing (27%), and learners and learning (24%) (p. 39-40). Drilling down to more disciplinary concerns, faculty were genuinely interested in teaching disciplinary ways of thinking through writing and scaffolding assignments.

Hughes' study and others that similarly study writing in STEM are important because they highlight the normative ways in which faculty may position writing. Though most faculty would agree that it is integral to science (Emerson, 2020), many still tend to focus on writing as additive rather than transformative, underestimating writing as a tool for learning (Moon et al., 2017). Still, others teach writing based on their own learning experiences, which often do not align with writing as a process nor as an indicator of community identity (Callow & Dykema, 2022; Read, 2011). Efforts to incorporate the social into STEM writing are lagging. As Iris Ruiz and Sonia Arellano (2019) critically demonstrate, not all understand the social in science. Ruiz and Arellano present the case of a science writing professor who claimed he did not teach content and did not have to worry about diversity, thus disavowing the social power inherent in writing (p. 141). Though the social turn is upon higher education, many in STEM writing are not keeping up with attitudinal shifts in their writing instruction.

This article contributes to the social turn in WAC/WID STEM in two ways. First, it examines STEM and non-STEM students' attitudes toward science to find out how they view the social in science since its importance in STEM is increasing, but instruction is lagging. Exposure to it, therefore, is, too. And second, given our results, we suggest grant-writing as one way to facilitate the social into STEM writing pedagogy because of its critical importance as a genre in the field. WAC/WID can support STEM in its social turn by incorporating writing practices that encourage and reinforce it for students. Below, we describe our inquiry, including the theory that informs it, and then report on how students responded to our questions about science. We end with suggestions for how STEM WAC/WID practitioners might recalibrate grant-writing courses to introduce students to social issues that result from STEM work through broader impacts statements. In this way, students can begin to think about the social value and consequences of their work. Currently STEM students, at least in our findings, are more likely to hold a normative science-centered frame of reference over a society-centered frame of reference in discussing science. Socially relevant curricula may serve to enhance budding scientists' and engineers' sensibilities toward the broader impacts of their work and support their ongoing professional development while supporting social change to address various publics and their investment in STEM.

Genre as a Critical Tool in WAC/WID

Traditional models of WAC/WID, including those of STEM, have generally focused on appropriation models, where students learning to write become enculturated into disciplinary ways of thinking. This is especially prevalent in theories that emphasize community (e.g., Engström, 2015; Lave & Wenger, 1991; Wenger, 1999) through the incorporation of genre (Bazerman & Russell, 2003; Russell, 1997). Genres are a powerful means to demonstrate belonging to a community as they exemplify ways of valued thinking and practices that lead to successful performance in a discipline. Not only do genres instantiate disciplinary epistemologies, but they also demonstrate disciplinary social ontologies (Berkenkotter & Huckin, 2016). They are, therefore, inherently ideological in nature, imbued with occluded power. Carolyn Miller's landmark article on genre as social action in 1984 provided an impetus for WAC/WID pedagogy to incorporate them as a vehicle for learning community expectations and behaviors. According to Charles Bazerman (2002) "genre shapes intentions, motives, expectations, attention, perception, affect, and interpretive frame" (p. 14). Genre has been a powerful teaching tool to enact activities in STEM, from feasibility reports (Rude, 1995) to lab reports (Doody & Artemeva, 2022; Wickman, 2010), to research articles (Blakeslee, 1997; Swales, 2004; Thaiss, 2019), and now, crucially, online genres (Mehlenbacher, 2019). Ken Hyland

(2008) explains that "Genre is…. a robust pedagogical approach perfectly suited to the teaching of academic writing in many contexts as it serves a key instructional purpose: that of illuminating the constraints of social contexts on language use" (p. 543).

Genres have become a mainstay of WAC/WID, with scholars of various backgrounds providing information on how students can perform various genres in STEM. While this approach has supported student learning, it has room to more explicitly address issues of the social through newer instructional efforts. Of the 107 faculty who participated in Hughes' study discussed above, over half mentioned that National Science Foundation (NSF) proposal assignments were important for them to teach. Grant-writing—especially its broader impacts section— is a genre that can leverage social change.

Grant-writing is one of the most common genres in science, though it is not well understood by those who are new to it (Ding, 2008). It is, so to speak, the bread and butter by which STEM disciplines are funded and able to progress. It also readily aligns with the current goals of incorporating a broader and more inclusive view of the social into science. Making grant-writing materials more responsive to the social a central part of the curriculum is compatible with changing needs in STEM, as evidenced in their grant-writing protocols. Whereas scientists applying for grants years ago may not have been asked to consider their work in a social context, today they may be asked to explain how their research contributes to society. For example, the NSF now requires scientists to address the issue with an explicit question on its proposal form stating a project's broader impacts. Multiple categories exist under the rubric of broader impacts, ranging from mentoring and training students, to increasing participation of groups that have been underrepresented in STEM disciplines, to moving out of the laboratory and into the public realm, among others (Mathieu, Pfund, & Gillian-Daniel, 2009, p. 51). Intellectual merit and broader impacts in grants are now considered equally to the proposed research when reviewing proposals (see Reilly, 2021). Though primarily a source for funding innovation, foundations and organizations like NSF now require applicants to not only have a command of their disciplinary knowledge, but also a knowledge of its broader impact on society. "[A] renewed focus on the 'broader impacts of science' from funding agencies has increased the urgency to train scientists equipped with an understanding of how their work intersects with the public interest" (Alexander & TeSlaa 2020, np). As WAC/WID practices have been shifting over the past decade, it is in a supportive place to help enact social change through writing instruction.

To fully embrace a social turn in STEM writing, we reconceptualize genre as a powerful tool to leverage change. Current reforms in WAC/WID that address the social have focused on issues of assessment, linguistic diversity, programs for under-represented students and readings that represent marginalized communities (Bushnell, 2020; Falconer, 2022; Kareem, 2020; Inoue & Poe, 2020). These newer practices critically extend traditional approaches to WAC/WID by enacting social change in classroom practices that can be taken up in STEM. Genre, now a staple of disciplinary pedagogy, can be added to the list of practices to shift current conversations in STEM. As Dorothy Winsor (1999) stated years ago "If four engineers behave a certain way and get others to behave in a certain way, then the companies for which they work take one form rather than another." (p. 220). As social practices transform, so do genres, and as genres transform, so might social practices.

Approach and Method

Approach

We selected Nature of Science (NOS) on which to base our inquiry. NOS is an approach to science pedagogy that explores how students understand scientific activities by adopting a critical model of inquiry, what Renée Schwartz and Norman Lederman (2008) term a "human endeavor" (p. 727). One of NOS's foci is to improve students conceptual and contextual understanding of science (Sandoval, 2005; Schwartz, Lederman, and Crawford, 2004). A second foci of NOS is to create an awareness of the social dimensions of science so that students address science as more than strictly a cognitive endeavor. Combined, the two foci provide a more informed view of science and its practitioners' relationship to society. According to the National Science Teaching Association Website, "[NOS] enhances students' understandings of science concepts and enables them to make informed decisions about scientifically-based personal and societal issues." NOS draws attention to not only the intellectual pursuit of science, but also its contingencies, particularly its social aspects. Inherently, NOS allows for a more inclusive view of science where STEM social consequences can be reflected upon. William McComas, Michael Clough, and Hiya Almazroa (2002,) have identified characteristics of NOS, which we have collapsed into four categories: 1) the purpose of science; 2) features of scientific knowledge; 3) features of scientific practice; and 4) features of human influence in science (p. 6-7). Features of scientific practice has long been a framework for those in STEM WAC/WID as it addresses evidence, appropriate arguments, and written communication. Features of human influence in science as represented in the STEM social turn, is now increasingly important, but has not been fully explored by researchers. In particular, human Influence addresses issues of science's cultural embeddedness as well as the social and historical circumstances that give rise to the ideas pursued and their uptake by scientists (p. 7). STEM is fundamentally human-based and contextual, and open to transformation under shifting conditions. Grant-writing, in particular, incorporates the social though the requirement of its broader impacts statement, and can capitalize on human Influence to transform practices.

Methods

We collected our data at the University of Utah, considered the flagship institution of the State. At the time of writing, the majority of students are white (70%) and come from within the state (60%). We recruited 36 undergraduate students in upper-division writing courses at our university to participate in our inquiry. The students represented a variety of disciplines, from accounting and Asian Studies to biology and physics. Of the 36 students, 19 were STEM and 17 were non-STEM students. Our sample was purposive in that we aimed to compare STEM students and non-STEM students' perceptions. All STEM students mentioned in interviews they would seek a career in their major. There was 1 first-year student, and 6 sophomore, 15 junior, and 14 senior students. Students were given $15 to honor their time, which averaged one hour.

The students completed a written questionnaire that asked them open-ended questions regarding science: 1) What is science? and 2) What is the role of science? A third question, "What is your view of science?" was asked in an interview to provide more in-depth information on students' views. Questions were purposefully open-ended to allow students to answer without manipulating their responses. Responses to questions provided a snapshot of their view of science and allowed us to discern differences between STEM and non-STEM students and the degree to which they mentioned society and how they did. All three questions were coded separately through a process called themeing. According to Gery Ryan and H. Russel Bernard (in Saldaña, 2013), "themes can be found in repeating ideas, participant or indigenous terms, metaphors and analogies, transitions or shifts in topics, similarities and differences of participation expression, linguistic connectors, and theoretical issues suggested by the data" (p. 180). For example, the student response, "Science is the study of the natural world through experimentation and observation," was coded as method. Or, another response, "To advance man's [sic] understanding of the universe and put that understanding to use by finding useful applications of the knowledge we gain" was coded as advancement. Agreement between raters was high.[2] In the following sections, we briefly describe our findings and then discuss genre as an intervention to improve social attitudes.

STEM and Non-STEM Responses

In this section we report on what we found striking in students' responses. Though there was some overlap in themes between STEM and non-STEM students, the tenor of their responses was often unique. Priorities for the groups seemed to differ in ways that demonstrated STEM students' lack of awareness of the social, leading us to believe they may have less sophisticated understandings of what broader impacts in grant-writing means.

Students' Responses to "What is Science?"

Two themes were evident across both groups–– method and discovery–– often reflecting a stereotype of science where method is a way of discovering a "world out there." Science students were much more likely than non-science students to emphasize method over discovery, whereas non-science students emphasized discovery over methods. Eighty nine percent of science students' responses indicated science as a method, and 79% included the theme of discovery. For example, a STEM student responded that "Science is a systematic approach to examining and understanding natural phenomena." Likewise, another STEM student said, "Science is the study of the natural world through experimentation and observation." A high percentage of STEM students (74%) included both in their response, as demonstrated in this response: "Science is the discovery of the world through measures of evidence."

Non-STEM students, on the other hand, emphasized discovery (65%) over method (53%), and in combination only 41% mentioned both method and discovery in their responses, a 33% difference between group responses (74% vs. 41%). Non-STEM students, unlike STEM students, defined science saying, "It is the discovery of how the world and universe works" or "Science is the steppingstone to find factual evidence is our everyday lives." Interestingly, non-STEM students also defined science by its distinct disciplines. "Science is physics." There was no mention of science as creative, inferential, tentative, cultural, or social. Students in both groups situated science as seeking knowledge and regularity in the universe through empirical methods. Table 1 includes examples of the top three themes and the number and percentage of students who mentioned them in their responses.

Table 1: "What is Science?"

Theme	Description	Total Responses N=36	STEM Responses N=19	Non-STEM Responses N=17
A Method	Defines science based on its methodology or discusses certain aspects of how science should be conducted	26/72%	17/89%	9/53%
A Discovery	Defines science as searching for and understanding new phenomenon and how they work	26/72%	15/79%	11/65%
A Discipline	Defines science as a field of study	6/17%	1/5%	5/29%

Students' Responses to "What is the Role of Science?"

Twenty of the students wrote responses that indicated the role of science is to understand the natural world through learning and gaining more knowledge about it. Of those, 63% of STEM majors (12 of the 19) prioritized understanding in the pursuit of knowledge while 8 of the 17 non-STEM students did (47%). Table 2 shows the top three themes and how the two groups responded.

Non-STEM students were more likely to emphasize its role is "to improve life" than science students (59% and 47% respectively), whereas STEM students were almost twice as likely to discuss the role of science in terms of advancing society (47% and 24% respectively). STEM students responded: "To advance man's [sic] understanding of the universe and put that understanding to use by finding useful applications of the knowledge we gain." Others thought of it as a means to be a process in ever-increasing knowledge: "The role of science is to allow for exploration. It allows us to keep reaching new highs and potentials." Those who mentioned improving life tended to mention it in the abstract (life), as this student did: "[To] increase our knowledge of the world and universe usually allowing for technological advancements to improve life." Non-STEM students explained the role of science was to improve life, but in the context of real lived lives: "To better understand (and in turn, manipulate) our universe, and to better the lives of those in it," and "To increase our knowledge. Find better ways to improve the lives of human society and increase the lifespan on Earth."

Table 2: "What is the Role of Science?" N=36

Theme	Description	Total Responses (N=36)	STEM Responses (N=19)	Non-STEM Responses (N=17)
To Understand the World	Science should be used to learn and gain more insight and knowledge about the world	20 (56%)	12 (63%)	8 (47%)
To Improve Life	Science should be used to benefit human life	19 (53%)	9 (47%)	10 (59%)
To Advance Society	Science should be used to advance society and create new things	13 (36%)	9 (47%)	4 (23%)

Overall, STEM students were more apt to seek understanding of the natural world to further scientific knowledge while non-STEM students claimed the role of science was to increase knowledge for the purpose of improving the quality of life and society. STEM students' views also consider society but in terms of material advancement, taking us from one level to the next, increasing the idea of life over time. STEM students' responses tended to reflect a natural world that can be used as a resource. Non-STEM students' views reflected a belief that the purpose of science is to improve human existence.

Students' Responses to "What is the Your View of Science?"

For the last question only 35 participants' interview responses were analyzed (one non-STEM student was not included due to a lack of recording comprehensibility). In looking at their interviews, STEM and non-STEM students had a greater spread of responses. We elaborate themes in the order of prevalence for each group, but only for their top five responses (for which 30% or more of the students mentioned.) See Table 3 for the STEM and non-STEM student responses.

Table 3: STEM and Non-STEM Responses to "What is Your View of STEM?"

STEM Responses		Non-STEM Responses	
Theme	**N=19**	**Theme**	**N=16**
Personal	9 (47%)	Understanding	8 (50%)
Field of Study	7 (37%)	Improvement of Life	7 (44%)
Advancement	6 (32%)	Products	7 (44%)
Methods	6 (32%)	Personal	6 (37%)
Products	6 (32%)	Advancement	5 (31%)

What stands out in the responses is the different emphasis many categories received by STEM and non-STEM students. There was overlap in three of the five most prominent responses, with STEM and non-STEM students including them to different degrees. STEM students noticeably prioritized the personal (47% vs 37%), field of study (47% vs. 37%), and methods (32% vs. 19%), while non-STEM students noticeably prioritized understanding (50% vs. 26%), benefit to improve life (50% vs 21%), and products (44% vs 32%). Advancement (32% vs 31%) responses were comparable between the groups.

STEM Student Responses

Personal

STEM students identified more with science than non-STEM students through personal experiences (47% vs 37%). Many participants expressed an affinity toward science in relation to the personal experiences they had, though those experiences were diverse. For example, some STEM students thought of science as, "something [they] like to do and have fun doing it," or said they "love" it because "it's kinda what [they] do," relating their affinity towards science because of their immersion in it. Others when discussing science, related it to personal experiences with their families. A STEM student stated, "I mean, growing up I talked with my dad, you know. We'd always have a lot of scientific kind of discussions..."

Non-STEM students also had personal connections to science. One student's parents were engineers, so STEM loomed large in her life. Other students had unsuccessfully attempted science: "I think science is great and I think if people can do it that's fantastic. I can't do it ... been there done that tried that." Another non-STEM student went so far as to have the word "science" tattooed on her shoulder, a personal reminder of her "love" of it.

Others may have related to science personally because they felt they were science minded. For example, a non-STEM stated, "I think I'm a seeker of knowledge. I view scientists as people who are curious and smart and seekers of knowledge. Not that I'm a scientist, but I am a seeker of knowledge and I think science does that." Here, the student related personally to science because he saw both scientists and his own self as seekers of knowledge. Relating personally to science provided strong positive feelings, a sense of connection.

Field of Study

STEM students were almost twice as likely to mention a scientific field of study in the interview than non-STEM (37% vs. 19%). STEM students either mentioned a specific scientific field or discussed science as a discipline. Said a STEM student, "when I say science, I mean just the study and research of things and the actual implementation of it being engineering and medicine." Another said "I view science like a field— a profession that is very important to society." When zeroing in on specific areas of science, medicine and engineering were the two most frequently mentioned. A pre-med/engineering student explained, "I think it's the most important field... engineering, cuz I think it's the field that produces the most for our society." Interestingly, all of the STEM majors, with the exception of one, mentioned their own specific discipline in the context of their connection to science. Non-STEM students did not, like STEM students, mention specific disciplines, but mentioned medicine and engineering as important. A non-STEM student, for example, claimed, "I think for the last century biological science helps human beings a lot... to change the world, especially medicine."

Advancement

For STEM students, advancement of society (32%) appeared to be slightly more salient in their interviews than it was for non-STEM students (31%). Many students acknowledged how science has the ability to benefit society, but more so in terms of what it contributes to the progression of humanity. A science student boasted that, "We'd still be living just like in the Stone Age probably." Another expressed that "it advances us as a species. I feel like science is a good way of doing that." Many students discussed advancement in terms of its contributions to humanity as medical interventions, such as vaccines and technological inventions such as electricity. A non-STEM student credited science by noting its novel expertise, "I think it helps our society advance in a way that without science, we wouldn't be able to."

Method

STEM students discussed method as a part of their view of science more than non-STEM students in their responses (32% vs. 19%). STEM students discussed method as being central to science. They were likely to include information about science consisting of facts that are testable. "You can prove them and show them experimentally, and you can repeat the experiments and show that no matter who you are that this is a fact, and this has been built up over centuries by, or by millennia, by countless individuals...doing this work," explained a STEM student. Or it provides "actual hard evidence of stuff around us," said another. One STEM student lauded science for its logic. According to this particular student, theories are considered, tested, and results are found. Finally, another enjoyed proving things, finding correlations and causation. Non-STEM students were more likely to make general comments about methods, such as "When I say science, I mean just the study and research of things."

Non-STEM Student Responses

Understanding

STEM and non-STEM students discussed science in terms of its ability to gain understanding of phenomena, but non-STEM students did so at almost twice the rate of science students (50% vs. 26%). Many non-STEM students nodded to some of the phenomena science seeks to understand about the world. For example, a non-STEM student said science "[tries to] make meaning of the world around us." Others expanded, mentioning, "…how the world works, how humans evolve, and in medication...an understanding of life." One non-STEM student even focused on truth-seeking when saying, "Science for me is a study about...you find the truth, you want to know what exactly that thing is, you want to know how things really work." Instead of focusing on how science leads to understanding, others claimed that we need to understand science itself. A non-STEM student stated, "I think the better understanding we have about science, and all that makes up the science world, the better off we are."

Improves Lives

All 12 students, whether STEM or non-STEM responded similarly in discussing how science improves lives. The difference was that non-STEM students responded at a higher rate (44 % vs. 26%). For non-STEM students, comments included improving lives, improving society, and increasing lifespans. One non-STEM student focused on how science helps the environment when saying, "I think that it can be used to help increase the quality of life for all sorts of organisms on this planet and on a larger scale." A few non-STEM students mentioned how science helps through technology: "Because we do use technologies and science can help us there." Similarly, another non-STEM student commented that science is "making certain things easier." STEM students responded comparably, exemplified in the statement that science leads to "...improving the quality of life, new technologies, new methods for treating diseases, new methods for prolonging life and increasing the quality of life."

Products of Science

Thirteen students discussed science in terms of the products it creates, with non-STEM students mentioning it more than STEM students (44% vs 32%). In the words of a STEM student, science contributes to new ways of doing things: "...new technologies, new methods for treating diseases, new methods for prolonging life and increasing the quality of life. I think science contributes to all of that." By far the most common product participants discussed was medicine. For example, a non-STEM student, said, "...because of science we are able to cure diseases." Another non-STEM student also mentioned medicine as a product of science, but, like several other participants, also discussed technology. He stated, "I mean, I'm driving a car, I'm going on vacation in a plane. I'm getting vaccines that keep me from getting sick. I'm calling my wife on my phone. Yeah, I mean science is awesome."

Similar to this participant, other participants listed specific products of science and their importance or limitations: energy and electricity (positive) versus atomic bombs and robots (negative). While most non-science students described the positive contributions of technology, several mentioned their concerns about their consequences. For example, one student believed the development of robots was negative because "people are losing jobs." This student believed that regulations were needed to minimize unemployment. Another student commented on the atomic bomb, stating that people downwind of the testing areas "got cancer" from the fallout. Examples such as these demonstrate students' awareness of the direct relationship between science and its potential harmful impacts on society. Yet, most comments about products for both STEM and non-STEM students were positive.

Disparities in Social Perceptions

STEM and non-STEM students revealed critical similarities and differences in their responses about science, with STEM students less likely to mention the social aspects of their work than non-STEM students. All student responses about science resembled traditional textbook conceptions of it, with definitions largely entailing method and discovery (Abd-El-Khalick, 2006). However, STEM students were more likely to focus on discoveries in the natural world, something "out there," while non-STEM students believed discovery was to improve the quality of life, to benefit society. Student responses to "What is the role of science?" focused on understanding (to gain knowledge) and improving life (used to primarily benefit human life), with well over half the students emphasizing them. There was a difference, though, in how STEM and non-STEM students responded. STEM majors seemed much more inclined to emphasize the pursuit of knowledge for the sake of understanding the natural world. Non-STEM students focused on scientific advancement for the benefit of human lives. Holders of one view— STEM students—tended to appreciate science for the sake of knowledge itself which ultimately benefits society, while holders of the other view— non-STEM—thought of it primarily as a means to improve lives and society. Students clearly perceived the role of science as positive and goal directed but emphasized different purposes.

Asked about their views of science, a large proportion of STEM students viewed science through the lens of their own experiences. Engaging in science was a prominent perspective throughout responses as STEM students told of early personal memories, experiences in the lab, and of their sense of connection to doing science. They tended to focus on increasing scientific knowledge through their involvement. Most non-STEM students did not have first-hand accounts of doing science but held a deep respect for scientists for their ability to develop products to improve life, focusing on what science provides the world. Analysis of the two groups' notions of science shows STEM students generally emphasizing science as a means of knowledge production and non-STEM students emphasizing science as a social commodity. STEM students saw themselves as the drivers of knowledge and innovation and non-STEM students saw themselves as the consumers of such public "goods." Few students noted the potentially negative social impacts of science.

Although both groups prioritized science and society differently, their views of benefit to society were generally limited to normalized scientific thinking, primarily issues of quality of life as defined by engineering and medicine. Students often referred to products and inventions that make life easier, more enjoyable, and lengthier. What was lacking was an awareness that science could be different in its thinking about the social.

The results of our inquiry allowed us to see that surprisingly, STEM students did not differentiate much from non-STEM students when defining science, but clearly did when thinking about its social situatedness. Many STEM students tended to think of science for "science's sake" as seen in the responses that indicate its role is a quest for knowledge. Second, many understandably tended to be siloed in their views of science, focused on their unique field's contributions to knowledge. Entrenched in their unique positions, however, STEM students placed society second to that of knowledge in their responses. The students' relationship was with science first and with society second, establishing a hierarchy of importance, rather than viewing them with parity, as STEM granting organizations increasingly require, and which in today's era are increasingly important given the social emphasis on issues (see Tomblin & Mogul, 2020). Grant-writing may be one way to introduce students to the social in STEM by focusing on its broader impacts statements which explicitly direct attention to consequences.

Why Grant Writing?

In a time when social awareness seems imperative for the practice of science, STEM students may be at a disadvantage because of normative attitudes that persist in the field, including their own. Students in our study demonstrated traditional textbook attitudes with the majority of STEM students differentiating between science and its social value. "Historically," reports Grasso et al., "engineering [and STEM] ha[ve] been taught outside of the context of societal need and impact, rendering the typical engineering [and STEM] education deficient" (p. 413). WAC/WID courses can help obviate such deficiencies through direct instruction. Genre theory as it is already woven into WAC/WID can motivate students to begin thinking about how research impacts society. In particular, grant-writing, a critical genre for STEM, is one place in the curriculum where STEM students can learn to fuse the laboratory with the world outside. Broader impacts statements afford them the ability to view their innovations with parity to their consequences. Current approaches to broader impacts in grant-writing are well-intentioned but limited. Of note is a recent study of NSF grant applications at an R1 university that showed that in their broader impacts statements, faculty tended to limit activities to those that were academically oriented, much of which they already do: "[t]eaching courses, enhancing curriculum, presenting at conferences and publishing in peer-reviewed journals, and researching and training students in the lab or dominant research space" (Wiley, 2014, p. 32). While this is important, it is not particularly transformative for science as routinized understandings of the social are enacted. Extending beyond such activities to think about larger publics and their needs has the potential to engage science beyond creating easier and longer lives for a limited public. Grant-writing provides a potent lens for raising awareness of broader impacts: it anticipates applicants understand the relationship between STEM and its impact on society and can move beyond traditional perceptions of the social that Wiley unfortunately uncovered in her analysis of faculty grants. The list of broader impacts listed by granting institutions also includes other measures of value, including well-being of the impacted.

Exposure to thinking about—and thinking through—issues in terms of broader impacts might direct attention to the critical role science plays in what Jerome Ravitz (2020) terms 'post-normal science,' where the "social, ethical, and ideological" influence and direct STEM practices. This may take more than STEM majors learning about content and reflecting more on its socially embedded aspects, including its relationship to broader publics and what constitutes well-being. As long as student scientists see science first and society second, rather than as mutually supportive, their understanding of STEM may remain deficient.

Instruction undergirding grant-writing courses have the potential to enact change. The goal of emphasizing broader impacts, however, is to have students extend their scientific lens to also focus on the various publics that STEM hopes to serve. There are several ways to shift the normative interpretative framework through which they may operate. First, students might be sensitized to how publics are concerned about the impact of scientific innovation. One good example is a course designed by Stephanie Phillips (2019) whose students created websites to explain why genetically modified mosquitos were released into neighborhoods in the Florida Keys. Prior to designing their site, students were able to view public hearings where residents voiced their concerns about the release. The goal was to create an awareness in students that the public does not necessarily operate out of a knowledge deficit, but of deep concern—two separate issues. This exercise sensitizes students to consider the lives of those impacted by research, and we think, case studies such as Phillips's have the potential to help STEM students consider the public in decision-making as some scientists have done.

A second way to sensitize students is to present examples of scientists who have engaged publics. One such role model is Kevin Esvelt, a professor at MIT, who works with the public prior to introducing his science into communities. His website states, "By emphasizing universal safeguards and early transparency, [Esvelt] has worked to ensure that community discussions always precede and guide the development of technologies that will impact the shared environment." Esvelt does not assume the community will approve of advancements deemed safe by science but respects the voices of those who will be directly impacted.

A third way to sensitize students is to have them analyze the social quality of the research itself. In her recent book, Heather Falconer (2022) provides a lengthy list of populations who have been overlooked or ignored in clinical trials, leading to results that may not consider those most affected by conditions. She writes "Biomedical research studies on environmentally related diseases (e.g., asthma, cancer, diabetes) are less likely to include people of color in their participant cohorts than White counterparts, despite the reality that BIPOC communities are disproportionately affected by such health issues"(p. 41). A prime example of flawed clinical trials relates to the pulse oximeter. The pulse oximeter, a small apparatus used to measure blood oxygen saturation, was especially critical during the height of the COVID pandemic, but research shows that the oxygen readings for darker skin is often inaccurate and therefore potentially dangerous for a patient (Sjoding et al., 2020). The article, used in one of the author's courses, has provided insight into flawed research and clinical trial design, leading students to consider improved technologies that benefit many publics.

Case studies such as Phillips's, role models such as Esvelt, and analyses of shortcomings in practice that researchers like Michael Sjoding et al. expose humanize STEM practices, "putting humans—in all of our complexity—at the center of our practices" (Longo, 2000, p. 168). Grant-writing is a ubiquitous genre in STEM, and with its explicit requirement for broader impact statements, is a strategic place in the curriculum to expose students to existing examples of the social aspects of STEM.

In addition to sensitizing students to the publics STEM impacts, grant-writing can be directly taught emphasizing its contingent elements, especially the broader impacts section. A genre is often considered in terms of its totality, its social action, its aim in the social world in which it is operating. The action of the grant genre is to secure funding. However, conceiving of the grant genre as a location to leverage change—specifically the broader impacts section— requires being attuned to its subparts and their unique actions within the text. The shift from viewing the genre's overall action to its sub-actions is valuable because we believe ome genres hold the ability to enact social change through the sub-sections of the genre itself. In a grant proposal, for example, the various segments, we argue, act as types of writing prompts. This concept offers a view that because a writing prompt elicits a "stable structure" with "shared discourse characteristics," it anticipates a particular genre (Swales & Horowitz, 1988).

In the case of the grant proposal, we view the broader impacts section of the text as a type of prompt that invites a typified response. The grant proposal invites writers to demonstrate their grounding in the literature (literature review), in methods (methods section), in describing what and how the research adds to the field (contribution), and significantly, and in articulating the value of the project to communities large and small (broader impacts). Each segment influences the perceived credibility of the researcher as they respond to the particular prompts that indicate a level of knowledge and understanding. While the prompts organize the document as being identified as a grant proposal, they also establish the significance of the project itself, the ability of the researcher to carry it out—for what social benefit and for whom. Multiple rhetorical actions are embedded within the larger action of the genre. Reconceiving the broader impacts statement as a writing prompt provides the impetus for students to move beyond science for science's sake to reflect on the social implications of science. As Langdon Winner wrote,

> ...technologies are seen as neutral tools that can be used well or poorly, for good or evil, or something in between. But we usually do not stop to inquire whether a given device might have been designed and built in such a way that it produces a set of consequences logically and temporally *prior* to any of its professed uses. (1980, p. 125, emphasis in the original)

Winner's quote highlights the need for students to understand that the outcomes of STEM are not neutral. Research enacts change in cultures, societies, communities, and individuals across regions and demographics. While all STEM outcomes are intentional by design, some may have undesirable unintentional consequences. Examining and reflecting on the outcomes of STEM through focusing on the social impact statement is a step toward enhancing students' awareness of STEM beyond the laboratory.

Conclusion

Our inquiry revealed limitations in STEM students' views of the social. Because historically science has often been considered a means to observe, gather data, and analyze it, all while employing the scientific method, many in science think of science as a discipline free of human influence and impact. In the classroom, STEM students overwhelmingly learn about scientific discoveries and methods associated with practice, but not necessarily how the integral aspects of history, interpretation, or social factors influence their work. Starting STEM students to earlier reflect on science as a socially embedded construct before they embark on their careers may cultivate a better understanding of their research impact on society. Reported in Warren Burggren (2009), Arden Bement, the former NSF Director, was reported to have said in 2007 that the NSF "won't be doing science for science's sake" (p. 222). In other words, broader impacts matter and are taken seriously by funding institutions. Engaging STEM students in the post-normal realities of science may support learning about grants that moves beyond simply content as they write about their research and those it affects as they address the social implication of their research.

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Notes

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[2] Our method of analysis consisted of themeing, a qualitative process that is appropriate for examining participants' meanings about a phenomenon, in our case the construct of science (Saldaña, 2013). Similar to other forms of qualitative analysis, such as grounded theory (Corbin and Strauss, 1990; Charmaz, 2006), themeing is inductive with themes emerging from the data through a constant comparative method (Corbin and Strauss, 1990; Miles and Huberman, 1994). It is particularly well-suited for participant generated documents and interview analysis, where questions are open and well structured. Unlike grounded theory, it does not seek to develop a theory, but provides a description of perspectives (Saldaña, 2013).

Responses to questions one and two were typed to de-identify participants. Interviews were transcribed and made anonymous. To analyze the data, the researchers first looked through 10% of student responses and looked for particular themes within ideas, terms, topics, expressions, and theoretical issues. Once themes were identified, they were compared with other responses for similarities and differences with some themes being collapsed into others for thematic categories. After each cycle of themeing, the two researchers met to discuss and refine the themes, until both researchers were satisfied with them. Once themes were refined and judged to be internally coherent to the exclusion to others, each researcher read through the 90% remaining responses and individually coded them. The same process was conducted for the interview question, which had been transcribed.

The researchers had 85% agreement after negotiating coding for the "What is science" question and 86% agreement for the "What is the role of science" question. The researchers had 93% agreement for the interview question, "What is your view of science?" The raw number of students who invoked a particular theme was then tallied for STEM and non-STEM students and percentages for each group were calculated. The study was IRB approved (00090705).

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