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Where am I in STEM?

Critiquing STEM Through Lived Experience as a Science Education Researcher

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Abstract

This critique of STEM comes from a feminist, embodied approach, which takes into account how my positionality in relation to the acronym intersects with my lived experience and perspective. My hope is that speaking from personal experience will help initiate fissures and dissonance about STEM discourse, in chorus with other positions and arguments, to critically question and hopefully dislodge the STEM acronym as a hegemonic, pervasive, and unexamined construct. I offer my experiences as a way of joining others in open critique of an often unquestioned yet neoliberal dominating force in science education. My lived experiences (and frustrations) with STEM are numerous. I condense these experiences into four episodes: the STEM academic job interview, the STEM education meeting, dissonance between STEM and my gendered identity, and exclusion of my humanist science research interests by the STEM acronym.

Introduction

The STEM acronym is a stealthy, evasive, and pervasive construct; a slow flood, seeping into the scene and drowning disciplinary fields in its wake. What may have begun as simply a shorthand (Sanders, 2009) or umbrella (Weinstein, 2017) term for a collection of related yet distinct fields has exploded into a worldwide "STEMmania" (Sanders, 2009). This seemingly benign assemblage of letters has become normalized as "common sense" (Bencze et al., 2018), even garnering "mantra-like invocations" (Zeidler, 2016, p.11). Within this paper, I name the phenomenon "STEM the acronym" to call attention to the acronym as an actor. By calling attention to the construct as an acronym, I work towards playful disruption of a term that is taken too seriously and given too much weight and power.

Increasingly, critical scholars in science education are critiquing the STEM acronym. A number of scholars have pointed out the acronym's tight connection to neoliberal framing and discourse, in that it aims to develop human capital for the sake of corporate profit (e.g. Bencze et al, 2018; Chesky and Goldstein, 2017; Hoeg and Bencze, 2017; Weinstein, 2017; Wolfmeyer, Lupinacci, and Chesky, 2017). Weinstein (2017) points out that, in accordance with its neoliberal orientation, the acronym has allowed engineering to subsume science, through for example, a heavy emphasis on design projects. Likewise, Wolfmeyer, Lupinacci, and Chesky (2017) note that STEM conflates science with technology for the purposes of economic growth. Several science education researchers (e.g. Weinstein, 2017; Zeidler, 2016) argue that the STEM construct has resulted in a marginalization of the history and sociology of science. The omission of sociocultural-political contexts has led critical scholars to deem STEM a deficit frame (Zeidler, 2016) and a shallow construction (Weinstein, 2017; Wolfmeyer, Lupinacci, and Chesky, 2017). Zeidler (2016) challenges the "prevailing assumptions that STEM initiatives are a panacea to prepare the next generation of an informed citizenry" (p.11). Bencze et al. (2018) call out the STEM acronym as a "Trojan horse" that uses a seemingly innocuous, even appealing, call for interdisciplinarity to mask more insidious intentions of corporate greed and capitalist profit at the expense of social and environmental systems.

The now-ubiquitous STEM acronym has been credited to the National Science Foundation (NSF), which originally coined the rather unappealing term SMET to describe a collective focus on related fields—specifically science, math, engineering, and technology. The reordered STEM acronym was suggested in 2001 by NSF director Judith Ramaley, who recognized that SMET sounded unpleasant and felt that it made more sense to place engineering and technology inside science and math, in keeping with NSF's mission to encourage the use of science and math to address engineering and technology challenges. It took several years for the STEM acronym to fully replace SMET in NSF programs, but once it did, Ramaley reflects that, "To my amazement—because wither goeth the NSF apparently goes the community—we ended up with STEM everywhere" (Patton, 2013). It is interesting that an acronym that has become globally pervasive (Invasive? Insidious?) can be traced to one governmental agency in the US. It also brings into question the power and privilege of institutions and should prompt critical questions about their motivations and intentions.

I was initially reluctant to write a critique of STEM the acronym because I felt that it was somewhat outside of my realm of expertise. I had, as Foss and Foss (1994) have pointed out, "come to distrust and suppress [my] own knowledge claims" (p. 42). To respond to the call issued by Wolfmeyer, Lupinacci and Chesky (2017) to put into writing our personal critiques of STEM, I

bring my experiences as an assistant professor of science education to the conversation. I am frequently identified by others as a "STEM faculty," I have advised on multiple STEM project boards, and I am asked to be part of STEM initiatives regularly. I was even offered multiple academic tenure-track positions with "STEM" in the title. Those circumstances might make me an unlikely suspect for being highly skeptical of the STEM acronym. In thinking about my positionality with respect to the acronym, I realized that I could use my own embodied, lived experience as a position through which to critique it.

Drawing from feminist methodologies, I use the personal experience of a white, cis-gendered woman—in this case, my own embodied experience as a science education academic. Foss and Foss (1994) have defined personal experience as "the consciousness that emerges from personal participation in events" (p. 39). According to Foss and Foss (1994), feminist scholarship takes seriously the narratives of those who identify as women, and considers their feelings and interpretations of events. My critique of STEM the acronym comes from a feminist, embodied approach, taking into account how my positionality in relation to the acronym intersects with my lived experience and perspective. In writing this self-reflective piece, my hope is that speaking from personal experience will help initiate fissures and dissonance about STEM discourse in chorus with other positions and arguments, to critically question and hopefully dislodge STEM the acronym as a hegemonic, pervasive, and unexamined construct. Responding to Weinstein's (2017) call to subvert STEM discourse by "highlighting STEM's problems (not letting STEM become commonsense)" (n.p.), I offer my experiences as a way of joining others in open critique of an unquestioned yet increasingly dominating force in science education. My lived experiences (and frustrations) with STEM are numerous. I condense these experiences into four episodes: the STEM academic job interview, the STEM education meeting, dissonance between STEM and my gendered identity, and the exclusion of my humanist science research interests by the STEM acronym.

Episode 1: The STEM Academic Job Interview

Scene: On-campus tenure-track job interview. I sit at a large, imposing conference table surrounded by faculty members from various departments around the college. Given that the advertised position was for a "STEM Teacher Education Assistant Professor," I was expecting the question. *How will you enact STEM through this position?* At dinner the night before, the search chair (who had no experience or training in STEM-related fields) told me that creating a STEM position was his solution to the problem of needing someone in his education department who could wear multiple disciplinary hats. As I listened to the faculty introduce themselves, it became evident that only one interviewer—a math professor—had expertise in a STEM-related field. I was faced with a decision: to speak my truth and risk not being offered the position, or to tell them what I assumed they wanted to hear and risk getting the position under false pretenses.

When the question arrived, I decided to tell my truth. I explained my doubts about the possibility of one person possessing expertise in each of the fields included in the STEM acronym. I expressed that "science education" alone encompasses biological, physical, chemical, earth and environmental sciences—all separate disciplines requiring distinct teaching credentials and undergraduate majors. I then articulated that technology was a vast (and nebulous) descriptor, and that engineering required different and specialized training and coursework not offered in any school I had attended, K-16. I concluded by explaining that math education was a separate scholarly field from science education and science, with different literatures, journals, conferences,

and scholarly communities. For those reasons, I could not imagine how one academic could truly embody expertise in those multiple and varied fields, and prepare teachers across such large domain areas. I *could*, however, envision being one of several people involved in collaborative STEM projects, assuming others brought expertise from other STEM fields. I knew I was taking a risk in articulating this position, but I felt it was important to be honest and not claim expertise I did not possess.

As I explained my position, the math professor nodded vigorously in agreement while others sat quietly, considering. As I finished my admission, one interviewer spoke up, "Thank you for explaining that to us." We moved on to other questions. A little while later, another faculty member joined us belatedly and promptly asked a similar question about STEM. She was immediately answered by another interviewer who said, "She already explained very well to us why our thinking wasn't quite right on that topic. We'll catch you up later, but basically, we need to rethink our conception of that."

I was offered the position as their first-choice candidate (though I did not end up accepting it).

While STEM the acronym was originally coined to encourage multi-disciplinary approaches within projects seeking external funding, it has increasingly been applied to individuals. Bencze et al. (2018) have also observed that teachers of any of the fields included in the acronym are often simply called "STEM teachers." As is evident from this episode, STEM the acronym has created the expectation that one person possesses expertise in all fields indicated by the acronym. If experts are specialists, perhaps a "STEM expert" is an oxymoron since no one human could possibly specialize in all these disparate and multifaceted areas. Wolfmeyer et al. (2017) argue that this labelling of individuals as "STEM" professionals (or, by contrast, non-STEM) can be unnecessarily divisive and exclusionary. They also suggest that when ascribed to faculty members, the STEM descriptor may be used to label faculty as particularly eligible for external funding (Wolfmeyer et al., 2017). I suggest that we avoid using STEM the acronym to describe individuals (unless perhaps referring to someone whose specializes in interdisciplinarity between/among the included fields). Put simply, as a science education professor, I am not automatically a "STEM" expert.

A second lesson emerging from this experience is that we *can* articulate reservations about STEM the acronym. I did, and as a result, I was offered the position and possibly even altered the way the department viewed the acronym. Our (real) fear of not obtaining academic positions and/or being labeled as non-conforming in an academy which continually creates "STEM" faculty positions may prevent us from challenging the acronym because of its real or imagined power.

Episode 2: The STEM Education Meeting

I attended several meetings for a regional STEM education group and found the experience highly frustrating. Though the group was still in a nascent stage, it had already acquired substantial grant money. Yet, in the meetings it was apparent that nearly everyone around the table had a different conception of the acronym. As a result, I was struck by the implicit and unstated assumptions lurking within every exchange. To some, the acronym seemed to be about fostering tight connections between education programming and business (a neoliberal positioning). Others seemed to support learning initiatives focusing on applied health careers. Still others seemed to support environmental education initiatives. Some seemed convinced that getting students into the

"STEM career pipeline" was the ultimate aim. Given these different conceptions, the overall aims of the group were unclear, and what qualified as a "STEM project" within the region was unproductively ambiguous. I was particularly concerned by the uncritical way many around the table were advocating local business connections, as if their primary agenda was to serve businesses in recruiting workers. Indeed, some participants directly represented business interests, and their very presence at the table troubled me.

These observations prompted me to ask explicitly if the group had previously or, if not, could take a moment to define what STEM meant to the group, within our regional context. My question was met with blank stares, and my concern was dismissed. While I struggled to understand our collective definition of STEM, the others around the table (most of whom had little to no education or experience in any STEM-related field) seemed unconcerned.

That everyone seems to possess a different understanding of STEM has been reflected in the literature (e.g. Breiner, Harkness, Johnson, and Koehler, 2012). Breiner et al. (2012) found that even within an academic institution where faculty participated extensively in STEM projects, there was "no common operational definition or conceptualization of STEM" (p. 9). The acronym has been used as a synonym for the separate fields of math, science, engineering, and technology (Breiner et al., 2012). It has also been used to refer to projects that embed one or more of the included disciplines. In different contexts, some letters within the acronym take precedence over others. For instance, engineering and technology may be the contexts through which to learn math and science, or conversely, math and science may be simply tools to apply within engineering contexts. Weinstein (2017) cautions that the letters in STEM are not meant to be equals—that the primary letters taken up are S and E with only hints of T and M.

Bakhtin's concept of *heteroglossia* is a useful construct through which to analyze multiple conceptions of STEM the acronym (Holquist, 1981). Heteroglossia describes the circumstance in which words can have multiple, varied meanings that are taken up, transformed through use, and used differently by mainstream and/or subcultural groups, for different ends. Bakhtin cautions that heteroglossia is unavoidable for words taken up by popular discourse. My concern is that there is far too little open examination of the heteroglossic nature of the STEM construct. Assumptions about the meaning of the acronym abound; therefore, we must continually and openly examine the STEM construct within each context. I agree with Breiner et al. (2012) that we should not strive to operationalize a set definition of the acronym for universal use on any project. In fact, if we perceive the acronym as heteroglossic, and therefore open to interpretation, mutable, and adaptable to context, it may lose some of its power as a hegemonic, neoliberal device, instead yielding to the needs of users and their contexts.

Returning to my experience, the group's reluctance to openly question STEM in our context was a missed opportunity to best meet the needs of our community. Had the group engaged in critical examination, we may have (re)defined STEM in a way that honored our region's strengths around sustainability, garden education, and food production, rather than allowing assumptions about external funders' priorities to drive local initiatives.

Episode 3: My Gendered Identity and STEM

I majored in chemistry in college, worked as a middle/high school science teacher, earned a PhD in Curriculum, Instruction and Teacher Education with a focus on science education, and am now a science teacher educator and researcher. Nonetheless, I feel that my interests and identity are excluded by STEM the acronym. If I feel this way, *who else* feels excluded by the acronym, as it sorts and chooses?

I was initially brought into science through my love of horses. From my upper-elementary through college years, I voraciously consumed equine-related knowledge. (Even now, seeing the NGSS cross-cutting concept "structure and function" conjures to mind my "form to function" studies about horse conformation.) I even qualified for and competed at the national 4-H competition in Hippology, the study of horses. Consistent with research showing that young children can become domain-specific experts given intense interest and repeated experiences (e.g. Crowley and Jacobs, 2002), over the course of my childhood I became an expert on horses, and aspired to become a large-animal veterinarian. By the time I reached high school, I was interning with veterinarians and equine surgeons. In college, I switched to human medicine and majored in the natural sciences. While research has indicated that girls often lose interest in science in the middle-high school years (e.g. Sadler et al., 2012), my interest in science increased dramatically as I aimed toward a career in animal medicine. This is consistent with research showing that specific career interests foster continued interest in STEM fields throughout the high school years (Sadler et al., 2012).

Why does this matter beyond my single story? Numerous studies have found increasing and substantial gender differences among high school students, with those identifying as male typically showing preference to physics and engineering, while those identifying as female were more typically drawn to biology and careers in health and medicine (e.g. Baram-Tsabari and Yarden, 2011; Miller et al., 2006; Sadler et al., 2012). In other words, my interests and path are archetypal for those who identify as young women. In fact, Miller et al. (2006) found explicitly that high school students who identified as women typically chose potential majors based on a "desire to help other people or animals." While certainly there is much needed work to ensure that physics, engineering, and technology fields are welcoming to all, I argue that for many young women, including myself, it may not be a question of feeling less competent in those areas, but of being more interested and inspired by the "softer" more empathy-laden, "people-oriented" (Miller et al., 2006) areas of science.

STEM the acronym entered the scene just as I completed my science undergraduate degree, so as a student I largely escaped its influence. The label troubles me because it excludes or overrides aspects of science that enticed me as a young learner. I suspect that if science had been presented as "STEM-ified" (Weinstein, 2017), I would have felt alienated by it. (Indeed, I still feel alienated by STEM-y science!) Given that my journey into science followed a well-trodden passion-driven path, how many others like me—passionate about animals, medicine, and helping people—feel excluded by STEM the acronym? Might STEM the acronym threaten this particular gateway to enter science-related careers and professions?

Episode 4: The STEM House of Exclusion

I typically do not consider my research projects as included within STEM the acronym. This is primarily because they fall into the nexus of science, environmental studies, and cultural studies. As a researcher, I am interested in connections between science, social issues, and environmental issues and how we can support justice through these domains. I align my own science education priorities with humanist science constructs (Aikenhead, 2006, 2007). Humanist science "views science as a human endeavor embedded within a social milieu of society and carried out by various communities of scientists" (Aikenhead, 2007, p.881). It also includes the history, sociology, and philosophy of science. A humanist approach to science advocates that students should study science for its relevance to their everyday lives so that they can critically assess science and technology. This differs from the typically lauded aim for STEM education to get students into the "pipeline" of the future science workforce (Aikenhead, 2007).

That I do not view my work as fitting within the STEM acronym may seem inconsequential. However, as Zouda (2018) has pointed out, STEM is a "construct of power and control" (p.1112) to which funding is heavily tied. Seeing my work as excluded from the STEM acronym has made me reluctant to apply for external funding from groups using the acronym within their calls. Unfortunately, that excludes most funding agencies working within my subject areas.

STEAM. E-STEM. I-STEM. STEM-Ag. STEM+C. The litany of letters added to the base acronym speaks to the ways in which the acronym discursively excludes, effortlessly drawing boundaries. I am clearly not alone in feeling like my work does not fit into the acronym. Weinstein (2017) notes that the STEM acronym acts as a boundary creator, effectively determining that engineering is unquestionably connected to science, while other fields such as ethics and sociology are cut off. STEM the acronym effectively excludes more disciplines with important connections to science as it includes. This exclusion has resulted in the marginalization of these fields (Zeidler, 2016), disdain for the acronym by some in humanities fields (Breiner et al., 2012), and an omission of ways in which social justice connects to science fields. Zeidler (2016) argues that STEM's lack of attention to sociocultural contexts results in a "deficit" framing:

> It is intellectually and developmentally restrictive to view scientific understanding within the bounds of STEM…it is fundamentally important for any student to be able to frame any STEM topic in a personal, thoughtful and meaningful context…The ability to do so… requires a global perspective of scientific literacy that entails…ability to envision the role of sociocultural-political contexts…[and] the situational nature of those contexts (p.12).

Similarly, Wolfmeyer et al. (2017) ask:

> Can an integrated framing of STEM education curriculum be appropriated and used with framings other than human capital? Can we define 21st Century skills differently, such as the knowledge, skills, and character traits that aim to address the ecological and social crises of our time? What conflicts might come about in using the depoliticized STEM curriculum for such different motivations? (p. 72)

Like Wolfmeyer et al. (2017), I am motivated centrally by helping students and teachers address ecological and social crises of our times. No issue holds larger concern in these domains than climate change. Yet climate change, with its massive, almost unimaginable social and political consequences, falls into an interdisciplinary area that does not wholly fit into STEM the acronym. This is a problem whose proportions we have not fully realized, particularly in science

education. Comprehensive, sociopolitical approaches to climate change largely lie outside of STEM in part because the two disciplinary domains most implicated are social studies and science. Some examples include exploring the role of courts in pushing governments to commence science-backed climate-mitigation actions for climate recovery, understanding social impacts on various climate-impacted populations, connecting science models about places in most danger to political activism and preparation, understanding the ways the most marginalized populations around the world are most impacted by climate change events, and using climate models to predict and prepare regions most likely to produce or receive climate refugees.

In addition to excluding sociocultural connections, the STEM acronym effectively omits important issues of social justice and consideration of the ways in which science and environmental issues are inextricably tied up with social inequities, such as seen through environmental and climate justice.

Is the answer to add on yet more letters to the STEM house, viewing the additions as needed remodeling? For example, Zeidler's (2016) critique leads him to suggest STEAM—inclusion of the arts—positing that arts should include humanities and social sciences that can "inform and contextualize science by grounding them in sociocultural contexts" (p.17). However, the STEAM acronym struggles with the same heteroglossic issues as its STEM sibling. My own version would require a more extensive remodel resulting in something like S^4EJ, for science, social sciences, and social and environmental justice. Ultimately, creating more acronyms will be in vain as long as the STEM acronym wields widespread power, influence, and connection to funding.

Learning from my Experience

But why does any of this matter? Is it all just semantics? I argue it matters because our frames shape—and limit—our thinking and our ability to define and address problems (or even see them). A few themes emerge across my experiences that tell us more about the workings of STEM the acronym within the life of a science education researcher.

First, STEM is a heteroglossic term, widely varying in its definitions and implementation. As a result, when left unexamined or challenged, assumptions about the acronym's meaning(s) abound.

Second, STEM is a boundary creator. The acronym readily labels and sorts people as well as disciplines. Not everyone who is labelled as STEM faculty identifies as such, and not everyone labelled as STEM faculty feels their work fits into the STEM box. We need to collectively push back and challenge the STEM acronym when it limits or marginalizes.

Third, many leading the charge for STEM initiatives are not themselves experts in any STEM-related fields. Perhaps as a consequence, they may be worried about being exposed as imposters on the outside of STEM, and therefore allow the acronym to remain unchallenged. Or, as outsiders, they may feel less emboldened to challenge the acronym.

Fourth, STEM the acronym has itself become an actor, using its widespread recognition and connections to funding as a shield from criticism and examination. It is, of course, worth pointing out that we cannot blame an acronym for all the ills of the movement. Perhaps this simple, succinct acronym has been victim of its own assumed simplicity, and in doing so, has become the inadvertent carrier of a larger, insidious neoliberal agenda.

What ought we do with this non-benign acronym? Do we seek to dismantle it, complexify it, or merely add letters? Do we attempt to create an alternative paradigm? Given the power and capital behind the STEM movement, it seems that hoping the acronym will go away is futile. Yet, when STEM the acronym remains unchallenged, it acts as a neoliberal dominating force dictating local priorities and projects. How then do we mount a critical resistance to the dominance of STEM in science education?

To be silent is to be complicit in the neoliberal STEMification of science (Weinstein, 2017). For starters, those in science education should begin to push back in our professional lives, for instance, when people call/label us "STEM faculty." To continue to allow others to name and describe me as a STEM faculty member is to signal that I am *part* of STEM's machine. Defining projects as "beyond-STEM," might help to point out the boundary restrictions of the acronym, and encourage disassembling the STEM box more directly than simply adding letters. Speaking up to clarify the aims and designs of STEM initiatives in which we are involved is another important action.

We should also occupy our so-called "STEM" spaces to create conditions for critical sociocultural perspectives to thrive. Perhaps an occupying of STEM is the best way to infiltrate and change the paradigm from the inside. As I see other scholars openly criticize STEM I feel emboldened to speak out about my own concerns. Hopefully, as more scholars call the acronym into question, we will stand on one another's shoulders and be able to, together, bring down—or at least tame—the beast.

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