

Teaching EcoJustice in STEM Methods Courses

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Abstract

This article provides concrete critical and ethical responses to dominant educational policies promoting the teaching of STEM fields. Recognizing how dominant discourses of modernity (Martusewicz, et al. 2015) work discursively to constitute STEM, this paper examines and exposes how STEM education is prioritized via funding in teacher education. As well, STEM is prioritized throughout state teacher licensure policies, to the effect that, e.g., all licensed elementary teachers are required to take STEM methods courses. This article provides an example whereby the space that mainstream STEM creates can then be appropriated for radical, EcoJustice Education (Martusewicz et al., 2015). Specifically, this paper shares conceptual research theorizing the inclusion of Ecojustice Education in elementary science methods and elementary math methods courses. Building on the work of social justice education, this article presents several practical considerations for including an EcoJustice perspective. Furthermore, the article suggests the complexities and tensions arising when methods courses include foundations topics. Ultimately, the author suggests and shares a curriculum for methods courses that provides teacher candidates the opportunity to consider mathematics and science content's usefulness through exposure to a critique of the global marketplace and

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opens students to a potential for releasing the imagination for social and ecological change.

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Introduction

In light of a recent and widespread neoliberal movement to eliminate foundations coursework in teacher preparation, more than ever, teacher educators need to think about the ways that sociology, history, and philosophy of education can be worked into methods courses (e.g. Kelly, 2017). This article presents the project of teaching a transformative philosophy of education within elementary science and math methods courses and the movement towards the elimination of foundations motivates my desire to integrate foundations into teacher preparation methods courses. Drawing on my own analysis of national mathematics education policy (Wolfmeyer 2014), I suggest that Science, Technology, Engineering, and Mathematics (STEM) teacher preparation overlooks a rich comprehension of the purpose and context of education in its training of future teachers. Thus teacher educators, realizing the harmful effects of such policy, can and must reinsert these elements in the spaces that state policies for teacher education allow, such as STEM methods courses. To support these efforts, this article sketches a theoretical practice emerging from my own experiences teaching elementary STEM methods courses. Specifically, these are explored in their relation to EcoJustice Education frameworks (Martusewicz, Edmundson, & Lupinacci, 2015) and provide a model for further work in appropriating methods spaces, whatever the orientation of critical foundations.

The actions pushing out foundations of education from teacher preparation came at the same time as calls for greater preparation in content knowledge and pedagogical content knowledge in so-called critical content areas, such as science and math (Wolfmeyer, 2014). This shift in teacher education prioritizes content knowledge at the expense of courses in educational foundations. It assumes that future teachers primarily need to know the subject matter they teach, and secondarily some pedagogy about how to teach the subject; within this shift, the histories of schools, the interaction of schools and society, philosophy of education, and certainly critical pedagogy and other radical knowledge related to education is understood as superfluous.

This shift in emphasis towards content knowledge is seen throughout a variety of institutions working within and around educator preparation. This increase is due to teacher education research that specifically

points to the content knowledge deficiencies among the teacher force, with particular attention to STEM teachers especially (e.g. Ball 2000). Although these claims have led to important changes in STEM teacher preparation, a secondary consequence is at risk. Namely, these motivations have decreased the opportunities that future teachers have in learning the contextual information surrounding STEM teaching. For example, in my own state (Pennsylvania), we are no longer required to provide a foundations course for future teachers. Fortunately, my program at Kutztown University still requires such a course. One key example illustrating this trend is nicely laid out by Kelly (2017), in which the alternative, university-housed teacher preparation program UTEACH has across the board all but eliminated the foundations from its educator preparation programs. This paper is motivated by such policy directions and aims to provide teacher educators with the means to offer foundational work in STEM methods courses because work in educational foundations is marginalized. It is my intention to provide pedagogic methods that can be used in programs where foundational and contextual work in STEM teacher preparation has been pushed to the side.

Reinserting Critical Foundations into STEM Methods Courses with an Ecocritical Emphasis

This section provides theoretical sketching of an ecocritical insertion of foundations into STEM methods work. Although primarily a non-empirical project, these sketches integrate my readings in ecocritical foundations with my experiences in instructing STEM methods courses at the higher education level. To begin, I will review the ecocritical tradition in foundations of education.

Ecofeminist Karen Warren (2000) articulates a “logic of domination” by which Western industrial culture operates:

To illustrate how differences are turned into justified domination by a logic of domination, let us suppose ... that what is unique about humans is our conscious capacity to radically reshape our social environments to meet self-determined ends, as Murray Bookchin suggests. Then one could claim that humans are better equipped to radically reshape their environments in consciously self-determined ways than are rocks or plants—a value-hierarchical way of speaking—without thereby sanctioning any domination or exploitation of the nonhuman environment. To justify such domination, one needs a logic of domination—a moral premise that specifies that the superiority of humans as Ups (here, their superior ability to radically alter their environment in consciously self-determined ways) justifies the domination of nonhuman natural others as Others, as Downs (here, rocks or plants that do not have this ability). (p. 49)

This logic of domination perpetuates the value-hierarchy of human supremacy over nature. Warren argues that similar logics of domination, acting almost as subconscious assumptions, exist in the case of white supremacy and male superiority, for example. This lumps together the “isms,” not in order to make their oppressive natures equal but to demonstrate the consistency in Western thought, the omnipresent habit of mind embracing superiority and consequential power. As some scholars of ecocritical education put it, such logics of domination need to be “recognized, resisted and reconstituted” in schools (Lupinacci & Happel-Parkins, 2015). Lupinacci and Happel-Parkins explain:

Social justice movements fighting against these injustices often have an arduous time creating and sustaining alliances among movements dedicated to eliminating human suffering and ecological devastation [and] we suggest there is an underlying common conceptual framework that perpetuates these cycles of violence. (p. 46)

In light of this framework, Lupinacci and Happel-Parkins discuss teacher preparation that addresses the logic of domination so that teachers in schools, in turn, resist and reconstitute the habits of mind that perpetuate violent actions justified through hierarchical thinking.

Bowers (1993) articulates the lack of attention to matters of the ecological crisis among all major paradigms for education. These include “conservative advocates of social reform” such as E.D. Hirsch and William J. Bennett (p. 35), the liberal “technocrats” emphasis on “competency-based teaching” (p. 74), and the emancipatory liberals who address the “social divisions and inequities” present in modern times (p. 89). Bowers argues that all of these major paradigms fail to address the root cultural problems that contribute to both the social ills that the emancipatory liberals aim to address as well as the ecological crisis that all paradigms explicitly fail to address. The cultural basis for both the social and environmental crises are one and the same, and generally relate to notions of hierarchy, domination, and subordination.

Writing on Bowers’ formulation of the cultural basis for the ecological crisis, Martusewicz, Edmundson and Lupinacci (2011) list several “discourses” that emerge from Western modernist cultures’ “set of hierarchized dualisms” (p. 66). These include individualism, mechanism, progress, rationalism/scientism, commodification, consumerism, anthropocentrism, androcentrism and ethnocentrism (p. 66-67). Arguably, all of these have strong relevance to STEM education, and I will elaborate on a few of these in what follows.

Individualism is the “assumption that humans are autonomous agents, who are at their best when independent from community and

culture, and who are naturally predisposed to the accumulation of goods and materials to satisfy their own needs and wants” (Martusewicz et al., 2011 p. 71). Mainstream STEM education, with its commitments to corporate profit as discussed in Wolfmeyer (2014) and Chesky and Wolfmeyer (2015), supports this discourse because the basis of competition is self-interest. Instead, preparing STEM educators with EcoJustice tenets would encourage decision-making that includes impacts on the social community and environment. Note that this type of thinking is based in cultural practices and would not counter scientific or mathematical principles. In other words, such a STEM education would not be un-scientific.

On the other hand, mechanism—defined by Martusewicz et al. (2011) as the assertion that “the world and everything in it functions like a machine” (p. 68)—is a metaphor that is a bit more entangled with the course of science since the Enlightenment. A major project in science has been the use of this metaphor for explaining causal effects and thick descriptions of the ways things seem to work. It is hard to argue that the use of this metaphor, leading to things like the discovery of antibiotics, is entirely problematic. Outright rejection of the mechanistic metaphor in an alternative STEM would collapse the educational project by eliminating many of the beneficial and productive assumptions and practices within science. However, the over-use of the metaphor of mechanism, especially by asserting that the world is knowable and describable in these terms, and that every machine functions on its own and separate from others, is the problem. As Martusewicz, Edmundson and Lupinacci (2011) point out, scientists have begun to move outside the metaphor in this way: “Some Western scientists, particularly quantum physicists and ecologists, have stepped outside the limitations of mechanism by emphasizing the interconnections and interdependence of physical and living systems” (p. 69). Preparing educators for STEM teaching within an EcoJustice framework will mean realizing the uses and limits of mechanism; whenever a scientific description uses the mechanistic metaphor as a means for explaining, the descriptions will be integrated with other, related descriptions. For example, in understanding the science behind agricultural processes, teacher candidates in STEM classrooms must not look simply at the input/output that profit-drive food production typically expects and instead focus on what economists term “externalities,” or those aspects of the agricultural process that come about due to food production and yet do not enter into the material economics of it. Water supply and run-off would be one such externality that expands our thinking beyond the machine-like sense we have for food production.

This section has reviewed aspects of EcoJustice education, and its

philosophical underpinnings, as it relates to the preparation of STEM educators. Given these frameworks, I now turn to the ways these discourses can be introduced in STEM methods courses so that STEM educators can in turn disrupt logics of domination as they work to teach STEM content. First, however, I attend in the next section to one aspect of EcoJustice education, scientism, and the role that mathematics is thought to play in STEM education.

Shifting the Philosophy of Mathematics in STEM Education

Here I address the issue of mathematics in STEM education. As a tentative framing, I suggest we consider STEM education as an assemblage of content areas, pitted typically against the humanities, for its rationalist qualities. Beyond the scope of this paper, I make this argument regarding STEM as a “discursive assemblage,” along with my coauthors in Wolfmeyer, Lupinacci, and Chesky (2017). For the forthcoming discussions about STEM educator preparation, I want to make clear the significance that mathematics, as a perceived rational and objective discipline, is assembled together with the other three in STEM. In reviewing philosophies of mathematics, such as those contained in Ernest (1991), mainstream philosophies of mathematics position mathematics as objective and rational, whereas advanced counter-theories like social-constructivist perspectives on mathematical knowledge are not readily considered by most. Thus, the discipline of mathematics is most closely associated with objectivity and rationality, which in turn bolsters the notion that all STEM content should enjoy such status. However, this does not follow when considering advanced philosophies of mathematics that trouble mathematics’ claims to universality and objectivity.

Mathematics is often thought of as the supreme instance of objectivity, of knowing the world objectively and through deduction. This supreme status has received significant pushback, especially by the work of philosophers of mathematics. In fact, argued are two natures of mathematics: mathematics as an objective, value-free knowledge, and mathematics as a social construction. The philosophy of mathematics literature rests primarily on a debate concerning the relationship between humanity and this particular knowledge. The longstanding and most popular epistemological viewpoint for mathematics conveys the Platonic image of objective knowledge. This means that mathematics abstracts the concrete real world objects into “ideal” shape and quantity. This overarching narrative to philosophy of mathematics relates to further branches developed in the 19th and 20th centuries, such as Frege and Russell’s logicism, Brouwer’s intuitionism and Hilbert’s formalism

(see, e.g. Wolfmeyer 2017, chapter 1 for a more detailed description of these). While all three philosophies of mathematics differ regarding what counts as legitimate processes for the creation of mathematical knowledge, they all understand mathematics as a knowledge that is objective and value-free.

Hersh (1994) asserts that Wittgenstein was the first to break from this view by acknowledging that “mathematics is something that people do” (14). This kind of thinking transferred work from the philosophy of science, such as Lakatos, Popper and Kuhn, onto the philosophy of mathematics, ultimately leading to a trajectory towards what Ernest (1991) termed the Fallibilist paradigm. Ernest writes:

Fallibilism views mathematics as the outcome of social processes. Mathematical knowledge is understood to be fallible and eternally open to revision, both in terms of its proofs and its concepts. Consequently this view embraces as legitimate philosophical concerns the practices of mathematicians, its history and applications, the place of mathematics in human culture, including issues of values and education—in short—it fully admits the human face and basis of mathematics. The fallibilist view does not reject the role of structure or proof in mathematics. Rather it rejects the notion that there is a unique, fixed and permanently enduring hierarchical structure. (1991, p. 3)

In this sense, the fundamental debate regarding the nature of mathematics centers on whether mathematics is objective, pre-existing to humans and known because of our discovering it, or primarily a human social activity, constructed by communities of practice. Embracing the alternative side to the debate will naturally lead to freeing mathematics from the burdens of superiority and objectivity.

In turn, STEM cannot enjoy such claims to objectivity and STEM educators prepared with an ecocritical foundations will reject that math or science is objective and the only way of knowing. Viewing the contest within the philosophy of mathematics brings to light the concerns over objectivity, which is at the very hearty of rationalism. This does not mean that science and mathematical processes are entirely invalid. As Martucewicz, Edmunson and Lupinacci (2011) suggest, “To question the universal nature of science as a way of knowing is not to be ‘anti-science.’ Rather, we must see science as one way of knowing rather than the only valid one” (p. 70). Therefore, STEM educators prepared with this knowledge will accept science and mathematics as a type of knowledge suspect to bias just as other knowledge, albeit these suspicions can take on different forms than do the suspicions of other knowledges.

A careful look at the discourses of individualism, mechanism, and scientism/rationalism has begun to sketch an alternative perspective in

preparing STEM educators. In summary, it is again interesting to note that the last two of these relate directly to the work of science and mathematics, and the first does not. While individualism, arguably, inevitably affects how humans construct the disciplines of science and mathematics, individualism is a cultural activity that exists outside the natures of scientific and mathematical processes, while scientism/rationalism and mechanism are very much a part of those processes. The scientific and mathematical program, as it currently proceeds, operates under all of these metaphors. This is especially the case with mainstream STEM education, as the corporate interests, individual competition and dominance over nature are clearly established. STEM educators prepared with this knowledge have greater potential to reject competition and human dominance over nature. They will challenge the tendencies of science to explain everything with the utmost authority.

To conclude the specifics of this section on EcoJustice education, I return to describing the primary issues at the heart of EcoJustice education with a look at writings from Murray Bookchin. My readings in EcoJustice education all point to a major theme, best put by Bookchin, the “dissolution of hierarchy” (Bookchin, 2005). As discussed above, “hierarchized dualisms,” such as white supremacy, male authority, etc, each refer to a pattern of domination through a variety of forms. In his own way, Bookchin discusses another understanding of the same concept:

My use of the word *hierarchy* in the subtitle of this work is meant to be provocative.... By hierarchy, I mean the cultural, traditional and psychological systems of obedience and command, not merely the economic and political systems to which the terms class and State most appropriately refer. Accordingly, hierarchy and domination could easily continue to exist in a ‘classless’ or ‘Stateless’ society. I refer to the domination of the young by the old, of women by men, of one ethnic group by another, of ‘masses’ by bureaucrats who profess to speak in their ‘higher social interests,’ of countryside by town, and in a more subtle psychological sense, of body by mind, of spirit by a shallow instrumental rationality, and of nature by society and technology. Indeed, classless but hierarchical societies exist today (and they existed more covertly in the past); yet people who live in them neither enjoy freedom, nor do they exercise control over their lives. (p. 67-68)

Just as ecocritical writings point to deeply embedded hierarchies, Bookchin indicates them as well. As the cultural patterns of domination and command are argued to lead to the ecological and social crises that Bowers and other EcoJustice writings suggest, Bookchin describes how these patterns, whenever present, inhibit freedom.

To keep this notion of freedom consistent with EcoJustice, Bowers

(1993) has identified two versions of freedom, one the “guiding metaphor of a culture of progress and environmental exploitation,” and the other, a “new (and ancient) guiding metaphor for a sustainable culture” (167). For the former, freedom is a “choice of ideas and values by the autonomous individual,” and for the latter sustainable culture: “freedom is a restriction of self for sake of others. Self as a cultural being whose individualized needs and forms of expression are part of a larger mental ecology. Interdependence” (p. 167). The second understanding of freedom is consistent with Bookchin’s discussions of the dissolution of hierarchy.

In preparing STEM educators with an ecocritical foundation, then, we must address the cultural patterns of hierarchy as they relate to nature and social organization, with freedom and lack of command towards or domination of anything as the ideal. Particularly, these goals address some practices of science, but generally they do not conflict with what is understood to be the mathematical and scientific processes. In what follows, I suggest teaching practices that can insert ecocritical foundations into STEM methods courses. In so doing, I cannot intend for future STEM educators to appreciate fully these complexities, but suggest that such educators disrupt the patterns that are reproduced by mainstream STEM education.

Teaching EcoJustice STEM

Here I will suggest two opportunities for preparing STEM educators within a general framework for a primary school teacher preparation program that integrates EcoJustice perspectives as above. Given the political push for mainstream STEM education, as suggested in opening this paper, it is no surprise that future elementary teachers are required to take coursework devoted exclusively to the methods of science teaching and math teaching at the elementary level. As I have suggested earlier, these methods courses can be used as an opportunity for teaching ecocritical foundations to STEM educators.

The literature on teaching for social justice provides some cautionary guidelines for anyone considering this approach. For example, when teaching courses with overt commitments to social justice, Bell and Griffin (year) make clear the consideration of what students will perceive as safe, especially “in order to be willing to express and examine deeply held feelings, confusions and assumptions” (p. 55). To that end, they suggest careful sequencing of activities to ease into the big ideas and, perhaps, controversial topics. While their considerations pertain to designated social justice courses, the point of careful sequencing is applicable to teaching ecocritical foundations in math and science methods courses

because teacher candidates may not expect to learn alternatives to the mainstream in these courses. In other words, to successfully integrate ecocritical foundations in STEM, I suggest that instructors begin the course by giving the teacher candidates what they expect, especially the nuts and bolts of teaching scientific concepts; the, instructors can begin to slowly sequence in the ideas of ecocritical considerations while continuing with their methods instruction.

There is a natural entry point in science methods courses to begin an ecocritical STEM sequence. Science education generally includes environment and ecology standards, as is the case in my home state of Pennsylvania. In reviewing the curricular standards for science instruction, dedicated time can be taken to explore these standards, clarifying the terms sustainability, etc. However, as Martucewicz, Edmundson and Lupinacci (2011) write, such traditional standards which might be considered to fall within the realm of environmental education does not do the necessary work of EcoJustice; for example, as Martucewicz et al. illustrate, within traditional science standards, ecology is defined as “the scientific study and management of natural systems assumed to be outside of human communities” (p. 10). The discursive messaging contained in the statement suggests human supremacy through the “management” of ecosystems for the benefit of people and contradicts EcoJustice work. Keeping in mind the careful sequencing brought to light by considerate social justice education, such critiques of the assumptions present within environmental education can be dialogically explored with teacher candidates, especially by offering readings on conservation by Wendell Berry (1993).

In my experience, the ecological crisis is well understood by younger teacher candidates and such readings are not entirely frustrating or alienating for them to read. Out of these readings comes the consideration of other hierarchized dualisms, such as Plumwood’s (2012) likening of the domination of nature to the oppression of women. This occurs while teacher candidates grapple with the nature of science. The intention is an emerging tension between the two, with a push for a questioning of, and ultimately a subordination of, the scientist/rationalist paradigm. In other words, I am suggesting that the entry point to ecocritical foundations in a science methods course is attention to environmental education standards. We begin by complicating these and moving towards an understanding of human supremacy. With exposure to this frame of mind, learners in science methods can next appreciate the consistent logics of domination throughout Western industrial culture. The instructor can choose to focus on, say, male superiority or white supremacy, depending on current events and the context of the learners. In one setting,

the instructor might find it appropriate to link human supremacy to discussions of gender; in another, it might be appropriate to discuss white supremacy. In both cases, the teacher educator can tie back these discussions to the teaching of science pedagogies to all learners in the elementary classroom.

As another entry point to ecocritical foundations, the instructor of a science methods course can choose to focus on the rationality embedded in mainstream philosophies of science. With respect to developing in STEM educators a social constructivist philosophy of science, science education textbooks are similar to what is found in typical science textbooks. For example, Abruscato and DeRosa (2011) tell future elementary teachers that part of the scientific world view is that “The world is understandable” (p. 12). Such a statement as quoted here should be troubled by teacher candidates in the class, especially in light of them having read Berry (1993) and Plumwood (2012). This and other deficiencies should be seen as an opportunity for instructors to expose their future science teachers to philosophy of science and the myth of rationality. For example, this statement resonates with the mechanism metaphor discussed above in the EcoJustice section.

Moving to mathematics methods courses, similar entry points for the discussion of ecocritical foundations occur. In this case, I suggest developing a more detailed project out of the typical “Why teach math?” section found in a typical math methods textbook (Van de Wall, Karp, and Bay-Williams 2013). In it, the only answers to these questions are for “A changing world economy,” especially because “math lovers” have been argued by economists as always having career opportunities and options (9). Surprisingly, little in this commonly used textbook is even stated about the role math can have in a democratic society, something typically given lip service in math education but not well detailed in most mainstream writings. However, most teacher candidates in mathematics methods courses will be willing to explore the “why” question. After all, it is practically a cliché these days that a math student will ask “Why do I have to learn this?” and future teachers of math will likely want to engage with finding answers to the student question. Teacher candidates will enjoy having these discussions in their methods classes because many students ask why they have to learn mathematics.

Therefore, to complement the posing of this question, I include several readings on math education that, while not specifically providing answers, do suggest what reasons exist for teaching mathematics. These include Bob Moses’ (2001) *Radical Equations: Civil Rights from Mississippi to the Algebra Project* and John Allen Paulos’ (2001) *Innumeracy: Mathematical Illiteracy and Its Consequences*. The former attends to the

ways math education reproduces inequality and seeks to level the playing field with equal opportunity for algebra. In the latter, the authors argue that the consequences of not knowing math include manipulation by others and lack of participation in a democracy.

By exposing future STEM educators to other perspectives on learning mathematics, the instructor and learners can pose the question: What kind of freedom can be fostered by mathematics? The instructor can choose to review important concepts from the philosophy of education more generally, such as art's role in "releasing the imagination" (Greene, year, p. x). This will require that learners discuss various notions of oppression throughout Western industrial culture, and think through how mathematics as an art form might release us from these perspectives and move towards dismantling them. Thus a mathematics methods course has moved from the "Why teach math?" question to offer several alternatives including teaching math for civil rights, as in the case of Moses and Paulos, to teaching math to release us from oppression, as with discussions of Lockhart and Greene.

These suggestions for mathematics and science methods courses both push in the direction of philosophical underpinnings. Addressing the philosophies of teaching math and science, and the very philosophies of science and math, in STEM methods courses is one means of providing future EcoJustice educators with a STEM counterpoint, yet within mainstream STEM structures. Consistent with social justice teacher education literature, introducing ecocritical foundations into methods courses does not appear out of place to all involved. There are more opportunities for inserting ecocritical foundations into STEM methods courses, such as the implications of what I have reviewed in the EcoJustice section of this paper and how instructors might integrate these into their teaching of STEM methods. I have suggested the imperative of doing this work given the lack of inclusion of foundations work for STEM educators, and I suggest that future work is needed to develop and disseminate teaching practices that include ecocritical foundations in STEM methods courses.

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