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Wanted: The Intersection of Feminist Pedagogy and Science Education

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ABSTRACT
As a graduate student earning a doctorate in science education and a certificate in women's studies, I often found myself torn between two worthwhile fields that used two very distinct approaches to pedagogy and content. My experiences granted me an opportunity to explore the differences between these two fields and how the incorporation of feminist pedagogy could positively shape future science education courses. Exploring this topic through literature and my own experiences, I first focus on the differences between classic (science education) and feminist epistemology, and the importance of framing science education within feminist epistemology. I then discuss how we can model and enact feminist pedagogy in science education. I conclude with my thoughts on the potential intersection of feminist pedagogy with science education.

"…girls should not be taught physical science except at the most elementary level, because the expenditure of nervous energy involved in the mastery of analytic concepts would be injurious to their health" – W. Felter, 1906. (Kelly, 1981, p. 1)

KEYWORDS
Science; science education; postsecondary education; feminist pedagogy; women's studies

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INTRODUCTION

Female scientists and science educators begin their careers by first defying a very popular and long-held stereotype: women do not succeed in science. It is clear that this is a stereotype ingrained even in young minds. In studies with elementary school students using the Draw-a-Scientist test, the majority of students draw male scientists (Steinke et al., 2007), while the majority of high school students asked to write essays about scientists use male pronouns (Steinke et al., 2007). Moreover, science education research suggests that many students, and in particular female students, do not feel confident in their science skills and actually feel disconnected from science as early as in elementary school (Barton, 1997).

This stereotype has persisted. For instance, while we have made great strides in some STEM fields, such as the biological sciences, women are still a minority in engineering, the physical sciences, and mathematics (National Science Foundation, 2011). This inequality is represented not only by employment statistics, but also through salary. Women earn less than men in nearly every science and technology field and, when ethnicity is taken into account, the gap increases for both Hispanic and African–American women (National Science Foundation, 2011). Not surprisingly, this inequality is also evidenced by public recognition: only fifteen women in history have been awarded the Nobel Prize in science (physics, chemistry, or physiology/medicine) (Nobelprize.org, 2014). In addition, these inequities exist transnationally. For instance, the percentage of women who hold doctoral degrees in science and technology fields is much lower than the percentage of men in many European countries, including Denmark, Germany, Norway, and Turkey (Catalyst, 2013). A recent study by the Women in Global Science and Technology Foundation also found that women remain severely under-represented in the fields of engineering, physics, and computer science (less than 30% in most countries) (Elsevier Foundation, 2012). It has been suggested that presenting science as socially and culturally embedded is more appealing to girls and women, and presenting science as otherwise tends to push them away (Hodson, 1998). Others suggest that the alienation of girls and women from science is simply a matter of social expectations. It has been consistently demonstrated that girls match or outperform their male counterparts in science, yet many of them fail to pursue the subject at post-secondary institutions (Siraj-Blatchford, 2001). Additionally, we know that even at very young ages children have definite views of "women's work" and "men's work" (Siraj-Blatchford, 2001). Regardless of the reason, what ultimately occurs is what researchers have termed the "leaky pipeline" (Blickenstaff, 2005), which describes the phenomenon of women continually dropping out of science as they go through primary, secondary, and post-secondary schooling and into STEM professions.

The leaky pipeline is commonly represented in scholarship (eg. Brotman & Moore, 2008; Carlone & Johnson, 2007). Although some scholars have employed essentialist reasoning to explain this problem, such as focusing on the biological differences between men and women (Sax, 2005), others take a more critical stance. For instance, Blickenstaff (2005), after a review of the relevant literature, proposed a list of possible reasons, including:

> girls' lack of academic preparation for a science major/career, girls' poor attitude toward science and lack of positive experiences with science in childhood, the absence of female scientists/engineers as role models, science curricula are irrelevant to many girls, the pedagogy of science classes favors male students, a "chilly climate" exists for girls/women in science classes, cultural pressure on girls/women to conform to traditional gender roles, an inherent masculine worldview in scientific epistemology. (Blickenstaff, 2005, pp. 371–72)

Many of these problems can be traced to science education, including how we prepare pre-service science teachers for schools and how we frame science curricula in K-12 science classrooms. Shrewsbury (1987) wrote, "Feminist pedagogy begins with a vision of what education might be like but frequently is not." By framing science education within the context of feminist pedagogy, I believe that many of the issues Blickenstaff (2005) describes can be alleviated, and we can create post-secondary science education settings that value girls and women in science. In this brief perspective piece, I first focus on the differences between classic (science education) and feminist epistemology, and the importance of framing science education within feminist epistemology. I then discuss how we can model and enact feminist pedagogy in science education. I conclude with my thoughts on the potential intersection of feminist pedagogy with science education.

CLASSIC VERSUS FEMINIST EPISTEMOLOGY

An epistemology is a theory about knowledge: what it is, how it is acquired, and who can possess it. Classic epistemology assumes that "the 'perfect knower' is a universal ideal, that all knowing is cognitive, that scientific knowledge is paradigmatic, and that the production of knowledge is politically neutral" (Bailey & Cuomo, 2008, p. 669). There are several assumptions present in this statement. The first is that the "perfect knower" is ideal and exists only within the mind, separate from the body; the second is that knowledge exists without political context; and the third is that there is only objective knowledge, and no other. Feminist epistemology has emerged as counter to this viewpoint, and is used to critically examine the structure of knowledge and, more specifically, male knowledge (Dillard, 2000). Feminist epistemology criticizes the idea of the mind without body, challenging that sexism and other social biases mar the political neutrality of knowledge that the classic view perpetuates. Feminist epistemology also acknowledges the influence of socio-historical context on knowledge production and conceives of knowledge as situated.

Interestingly, feminist epistemology is more closely aligned to progressive science teaching movements than classic epistemology. For instance, current progressive education movements have pushed for science educators to have a more thorough understanding of content, culture, and discourse. This push is represented in many science standards, including the Next Generation Science Standards (Achieve Inc., 2013). This need is echoed in feminist literature. For instance, as Barton (1997) states, it is important "to make explicit the content, culture, and discursive practices in science class so that students and teachers have a basis from which to understand and critique the knowledge base of science" (p. 145). Additionally, many well-known professional organizations highlight the tentativeness of science and the importance of understanding the sociocultural contextual factors that influence science (NSTA, 2013). Similarly, feminist epistemology acknowledges socio-historical influences on knowledge construction. For instance, Brickhouse (2001), whose work focuses on the achievement of girls in science, wrote, "Scientific knowledge, like other forms of knowledge, is culturally situated and therefore reflects the gender and racial ideologies of societies" (p. 283). In view of this, while the inclusion of women in the STEM fields is an important goal, we should be striving to rework science as a whole, since the absence of women from science "has resulted in a masculine construction of science" which has also "been constructed around white, middle- and upper-class work and family values" (Barton, 1997, p. 145–46).

WALKING THE WALK: MODELING AND ENACTING FEMINIST PEDAGOGY

Female science educators enter an environment in which they are responsible for teaching a subject that has been written by men: "In order to teach our subjects we must adopt the language and ideas of our fathers – ideas that often exclude us as women or describe us in ways that at times have been oppressive" (Brickhouse, 2001, p. 283). In opposition to this pressure, feminist educators have sought to develop new pedagogies that alter conventional hierarchies in the classroom and the role of the teacher, placing the educator in a role where they assist the student in knowledge production, rather than act as a dispenser of knowledge. Pedagogy is often defined as instructional strategies, and there are many different kinds. What is important to note, though, is that pedagogy does not speak only to the way that knowledge is imparted, but to how knowledge should be used.

In 1981, at Mankato State University, Carolyn Shrewsbury created the first feminist pedagogy course, designed to prepare students to act as teaching assistants in women's studies courses (Bright, 1987). She describes her vision of the feminist classroom as

> … a liberatory environment in which we, teacher-student and student-teacher, act as subjects, not objects. Feminist pedagogy is engaged teaching/learning – engaged with self in a continuing reflective process; engaged actively with the material being studied; engaged with others in a struggle to get beyond our sexism and racism and classism and homophobia and other destructive hatreds and to work together to enhance our knowledge; engaged with the community, with traditional organizations, and with movements for social change. (Shrewsbury, 1987, p. 6)

Shrewsbury (1987) wrote that feminist pedagogy relies on three main principles: community, empowerment, and leadership. Community is essential in a feminist classroom, as the ultimate goal is to create a "community of learners where there is both autonomy of self and mutuality with others that is congruent with the developmental needs of both women and men" (Shrewsbury, 1987, p. 10). This is especially important in respect of activism, as communities have more political power and a greater ability to promote discourse than individuals do. By focusing on empowerment, feminist classrooms actively work to remove the power differentials that surround professor–student relationships. Additionally, students are taught to recognize power and resist forms of domination. Leadership, the last principle, is very closely tied to both empowerment and community:

> … students who take part in developing goals and objectives for a course learn planning and negotiating skills. They also learn how to develop an understanding of, and an ability to articulate, their needs. They learn how to find connections between their needs and the needs of others. They learn about groups and about the different leadership tasks in groups and take different leadership roles throughout the course period. (p. 12)

Feminist pedagogy creates leaders by empowering students to be active participants in their education. The feminist teacher is not merely a fount of knowledge out of which information pours from teacher to students. She is a role model, and a guide to feminist pedagogy and, above all, action. Feminist teachers are not only instructors: they are activists.

Kathleen Dunn (1987) took an alternative approach to analyzing feminist pedagogy by focusing on students. Using a psychological approach, she theorized that there are three barriers to learning that are often confronted in women's studies classrooms. The intuitive/affective barrier occurs when a student is afraid that her answer to a question or response on an assignment is incorrect. As her anxiety increases, her understanding of the subject matter lessens. Ethical barriers are raised as students withdraw from learning environments that challenge their current value systems. Women's studies material often provokes this reaction simply because of the nature of feminist thought. For anyone taking their first women's studies class, the reaction is jarring, as the coursework often challenges traditional value systems in which many women and men have been raised. Finally, critical/logical barriers are raised when new information fails to fit into existing thought structures. This is slightly different from an ethical barrier, as the thought structure does not rely on a value system, but rather on existing paradigms. For instance, going from a positivist to a feminist perspective is not a change in values. Rather, it is a shift in conceptual paradigms. When a critical/logical barrier is raised, the student can experience cognitive dissonance and either stop paying attention to the course material while trying to fit the information into her pre-existing thought structure, or give up on learning the material completely. Ideally, the cognitive dissonance is eventually resolved, and results in an individual paradigm shift. However, whether or not this happens depends on the classroom, the teacher, and the student.

Many feminist pedagogy techniques can be incorporated into science education, though perhaps the most important implication relates to how we view education. During my time as a science education student, I was often asked for my opinion on a subject, but rarely was I pushed to examine *why* I think the way that I do. I believe that this is an integral difference, and connects to Kathleen Dunn's (1987) theory of intellectual barriers, because although identifying the above-mentioned barriers is important, I find that what is even more important is promoting a learning environment that *confronts* these barriers. Thomas Kuhn (1970), in his seminal work *The Structure of Scientific Revolutions*, wrote about paradigm shifts, which occur when one system of knowledge is replaced by another. Kuhn was referring to scientific revolutions, but such paradigm shifts can occur within an individual. Confronting intuitive, ethical, and cognitive barriers can result in these shifts. Often times, the most productive learning occurs during these shifts. By utilizing Shrewsbury's (1987) feminist pedagogy in science education courses, students and instructors can approach and break down these barriers in more productive ways.

FEMINIST SCIENCE EDUCATION

Science and science education represent a way of knowing and learning that can all too often seem one-sided and black-and-white. What does a field with very few women and very few ethnic minorities in it say to a student who is a part of these groups? It says that this is not your subject, this is not your strength, and this is not your place. How knowledge is learned, used, and understood is essential to science and science education. Additionally, knowledge production can be very variable and individual. Being female represents a very different experience of schooling than being male, as does being black instead of white, and poor instead of rich. These are all qualifiers of identity that do more than categorize: they shape and affect identity and experience. Knowledge production is a part of these identity markers, and feminist epistemology gives science educators a way of accounting for identity and context in schools without brushing the issue aside and feigning ignorance.

We study gender in science education and feminist epistemology to counter this line of thinking, to empower women and other minorities to learn and grow in science, and to create a future in science that is better balanced and more equal than in any previous generation. Although women's inequality in the sciences has persisted, as discussed earlier, the treatment and representation of women in science has positively improved over time. Women now earn more than half of U.S. bachelor's degrees and 44% of master's and doctoral degrees across all science and engineering fields, and women's participation in STEM employment continues to grow (National Science Foundation, 2011). These gains are important, but are only part of the solution, as science is still characterized as a male subject. Women can do everything in their power to break into science, but it is up to feminist epistemologists and feminist science educators to alter the system and change our *approach* to science by changing the view that knowledge is male or resides solely in the mind; by acknowledging the political and contextual milieu that exists in every facet of science knowledge production; and by making sure that students appreciate that understanding is one-dimensional without situating it in a context.

In accomplishing these goals, feminist science educators and scholars can create a new era of science that is culturally and historically significant and responsible.

What does all of this imply for a vision of a feminist science education? Of course, there are simple changes and there are more complex ones. Structuring the classroom in a way that promotes discourse rather than lecture can open up the lines of communication between instructor and student (Roy & Schen, 1987). Why does the teacher stand at the front of the classroom, while all of the students sit in neat rows that trail to the back of the class? What does this format tell us about the power structures operating in that classroom? When the teacher clearly represents the "power" in the room, a power differential is automatically created without a word about power being spoken. Roy and Schen (1987) write that "the student–teacher relationship is complicated by issues of adolescent development, stages in a teacher's own life and career cycle, and the expectations of supervisors, peers, and parents. Within each of these frames are hierarchical assumptions as well as real problems with which we must deal" (p. 111). This is not limited to the primary and secondary levels of schooling, however, but translates to post-secondary classrooms. All of the relationships present in educational settings are replete with hierarchal structures that students may not understand or even be aware of, yet are forced to operate under. Something as simple as resituating the classroom tables and chairs can have a broad impact on issues that are operating, yet invisible.

In addition to classroom structure, we must also consider curriculum and assessment, two important aspects of any educational context. Incorporating feminist topics into science and science education represents a first step. Mary Maynard (2013) suggests several curricular topics, including

> What constitutes science, how feminists have investigated it, the ways in which science is able to construct women, the possibilities of generating new feminist discourses of science and the extent to which current developments might be to the advantage or disadvantage of women. (Maynard, 2013, p. 2)

Although traditional assessment methods may still be used in a feminist science education, we can, with the integration of the above topics, expand our definition and views of assessment. As feminist pedagogy necessarily incorporates a critical perspective, assessment of literature, concepts, and context can take the form of critique, rather than evaluation. For instance, one premise of feminist science is that "the researcher cannot be separated from the research. Research is never objective in the sense of being devoid of power relations" (Crawley, Lewis, & Mayberry, 2008, p. 3). Incorporating this perspective provides both teacher and student with opportunities to assess not only others' roles in the process of science, but their own roles as well. This method of self-critique and critical evaluation of topics, as well as the incorporation of feminist curricula, can help to reframe science education.

But what of the more complex changes? How do science educators empower their students, create leaders, build communities, and confront and break down barriers to their learning in the form of knowledge production or ethical dilemmas?

> As we empower voices, acknowledge diversity, and develop inclusive curricula and teaching strategies, we must apply the same revolutionary values to our own professional networks and relationships. The work of high school (and elementary school) teachers and scholars offers fertile models for change, models from which new scholarship and practice can develop. We insist that feminist educators need to gaze across, levelly at one another, to abandon the "up" and "down" assumptions that have stratified the world of education and limited communication among us. (Roy & Schen, 1987, p. 114)

My hope is that by utilizing feminist pedagogy and always being cognizant of the power structures operating within the classroom, science educators can abandon the ways in which we were silently instructed to carry out social reproduction and create a new learning environment that is accepting, open-minded, and activist.

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