MATHEMATICS FOR THE FUTURE OF HUMANITY:

A RADICAL ONTO-EPISTEMOLOGICAL APPROACH

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Abstract:

In this paper, the authors utilize a Freirean utopian pedagogy to envision a mathematics education for the future of humanity. To begin, the authors investigate how mathematics and its education correlate to particular dominate social norms and institutions that play a significant role in perpetuating our present shared social reality. Utilizing the work of ecofeminist and ecojustice scholars, the authors explain how mathematics' and its education perpetuates a "logic of domination." Next, the authors explore how mathematics and its education could be envisioned and practiced in ways that directly counteract its previous uses and offer alternative pedagogy and curricula choices for fostering a utopian vision where the human race that live in balance with the ecosystem. Drawing from the work of Bateson and philosophers of mathematics, aesthetic aspects of mathematics are shown to be essential aspects of a new form of mathematics. Last, the authors turn to the work of Bookchin to help understand how mathematics can be envisioned to better serve a utopian world marked by anarchist concepts of usufruct, complementarity and "irreducible minimum." The authors conclude with suggestions to implement an onto-epistemological mathematics education curricula and pedagogy in the classroom.

Keywords: utopia, Freire, mathematics education, ecojustice, ecofeminism

We find ourselves living in a time that what could be understood as a paradoxically interwoven world–where technological advances seem to portray a teleological pathway towards an almost idyllic human future; yet, statistical facts and real-life stories of people living on the planet tell a much different story. The 21st century has been a time of increasing ecological destruction and its accompanying social injustices, and these have affected vast populations of humans living around the world (IPCC, 2007, 2013). These devastations are not limited to indigenous tribes or remote regions on the planet; rather, climate change, as many scientists have reported, has affected vast areas of the world's diverse human population (AMS, 2012; Andereeg, 2010; Doran & Zimmerman, 2009; IPCC, 2007, 20013; Oreskes, 2004). Simultaneously, as income disparities and social suffering in connection with poverty and climate change increase for even *developed* communities, the WWF (formally known as the World Wildlife Fund), reports that since 1970 the planet has experienced a 52% loss in species (WWF, 2014).

There is little dispute that humanity ought to move towards compassionate, equitable, and sustainable solutions if we are going to survive as a species on planet Earth. Envisioning and enacting such a utopian future involves countless humans working in diverse fields. One such field is education because it is fundamentally involved in changing and/or perpetuating what perspectives and knowledges are valued in future generations. In particular, mathematics education, as we will argue, has an essential role to play within the educational landscape. In this article, we aim to articulate a mathematics education within the context of rapid technological advance and propose a new framework for educators, and educational researchers, interested in the role—and potential role—for a mathematics education in support of a future in which humanity lives in balance with each other, with all living and non-living things on the planet, and with the ecosphere that continues to support our shared biological heritage. As former mathematics teachers, we are deeply committed to critical approaches to mathematics teaching and learning, and see our role as university professors to help envision how mathematics education can play a more central role in supporting diverse efforts toward the betterment of humankind and planetary health. Indeed, such a striving for a better world, can be referred to as an utopian

agenda; however, such an impulse is never a goal, but rather a never ending unfinished process. An educational act indeed!

Freire contended that utopia is not a given idealist unachievable realm, but "a historical commitment" (1972, 41). He defined 'utopia' as "the dialectical process of denouncing and announcing – denouncing the oppressing structure and announcing the humanizing structure" (Webb, 2013, 285). For Freire, it was not enough to critique social inequities, but to bring forth new ways of governing, alternative ways of knowing and thinking about the world, and new ways of acting as human beings that can bring forth a utopian vision. Such a utopia is not an end to be achieved, but a process to be enacted (Webb, 2013). Wegner (2002) suggests that to proclaim a Freirean utopian pedagogy, we must perform two simultaneous operations – deterritorialisation (the critical dismantling of existing social norms and institutions) and reterritorialisation (the construction of new forms and institutions through a pedagogy of desire and the education of longing). In this paper, we follow such a Frierian utopian pedagogy by first investigating how mathematics and its education correlate to particular dominate social norms and institutions that play a significant role in perpetuating our present shared social reality. Next, our work turns to reterritorialisation to explore how mathematics can be reconstruction in new forms and institutions that serve human flourishment models grounded in ecological frameworks and anarchist visions.

The work of deterritorialisation occurs in the first two sections where we argue that the discipline of mathematics, and its education, is located at the epi-center of our social reality. We also explore how mathematics is central to domination, a key characteristic of modernity; drawing from ecojustice literature and critical theory, we illuminate a "logic of domination" (Warren, 1990). Then in the last two sections, we turn to reterritorialisation pedagogy and explore ways in which mathematics and its education could be envisioned and practiced in ways that directly counteract its previous uses and offer alternative pedagogy and curricula choices for fostering a utopian vision where the human race that live in balance with the ecosystem. To conclude, we turn to the work of Bookchin to help us understand

how mathematics can be envisioned to better serve a utopian world marked by anarchist concepts of usufruct, complementarity and "irreducible minimum."

MATHEMATICS OF DESTRUCTION: CAPITALISM, STANDARDIZATION AND QUANTIFICATION

In deterritorializing mathematics, we point to its role in western civilization at large and how its education continues to perpetuate a rational reductionist worldview that maintains as well as justifies the status quo. As with all sections of this paper, we use philosophical methods to interrogate the onto-epistemology of mathematics and mathematics education.

In order to understand the role mathematics plays in shaping humanity, we observe how mathematics forms underlying human perceptions about the nature of our world and ourselves. Popewitz (2004) explains:

> mathematics becomes the hand maiden to get another industrial agenda, an agenda outlined by managerial corporate needs, functions and other operations will serve the operating desire of the technological complex as the future unfolds…mathematics becomes a means of transforming experience into bits of information, it concurrent mutates learners into consumers. (p. 265)

Since World War II, the discipline of mathematics has been supported primarily by the federal government. Mathematicians have relied on the political system for the unstable opportunity to continue their passionate work, with currently 81% of them employed by government run agencies. (D'Ambrosio, 2001). Indeed, the growth of the hegemonic forces of free-market capitalism worldwide has substantially influenced the United States and other world industrial countries' values on knowledge. The fear of not maintaining global dominance has led to the United States investing heavily in technologies that utilize highly complex mathematical operations. Compounding this trend, knowledge-based immaterial labor has changed the landscape of global relations, threatening the imperial

western powers to push for further innovation and expertise in sciences, which naturally has the bedrock of mathematics.

In the status quo, mathematics is used mostly for profit and its education is used as a means of control. Apple (1992) suggests that in western society mathematical knowledge is often utilized for its "technical/administrative" relevance that is "convertible ultimately into profits" (p. 420). An example of this is the recent use of mathematics by numerous Wall Street hedge funds for grandiose profits for a very small minority of its privileged stakeholders and executives, while lower ranking employees were laid off by the thousands (Patterson 2010). In this case, mathematical knowledge was highly regarded for its ability to analyze, dissect, and predict outcomes for capitalists seeking to turn their money into more money.

A narrow view of Mathematics, or more precisely, the dominance of discrete values and quantification has enabled corporations to infiltrate all segments of the public sphere, dismantling public spaces and institutions, and targeting individuals in underrepresented groups and their families. It is hard to argue that a loss of a job or a home was a result of larger institutional barriers and systems of oppression when such events are justified as necessary for "the bottom line" or an "objective" system of rationalizing statistical information. Currently in the U.S., companies have begun using credit ratings as a means of differentiating future employees. This unconstitutional practice decontextualizes mathematical knowledge from social, political, and cultural variables, thereby legitimizing hiring practices that marginalize economically disadvantaged groups from obtaining gainful and meaningful employment.

In mathematics education, using mathematics as a disciplinary tool that separates populations into future have and have-nots is well understood and documented thoroughly, noted in recent years by this concern over Algebra as the new civil right (e.g. Moses & Cobb, 2002). As the argument goes, because success in school math, specifically Algebra, is correlated with financial success, this means that we must figure out how to have everyone succeed in Algebra. This dominant policy push stands in direct opposition to the critical argument that mathematics education is used as a quantitative sorting

mechanism for social reproduction (e.g. Gutierrez, 2008; Gutstein, 2008; Martin, 2003; Stinson & Bullock, 2012).

The current educational policy agenda, STEM (science, technology, engineering, and mathematics) initiatives and reform discourses (e.g. Education to Innovate, 2009; Change the Equation, 2010; Prepare and Inspire, 2010; Rising Above the Gathering of the Storm, 2007) further entrenches the meritocratic myth embedded in the dominant policy agenda, while venerating skills that are delegated as needed for national security and economic purposes in order to remain competitive in the global market-place (Brown et. al, 2011; Bybee, 2010). In addition, STEM policy's utilitarian conception of mathematics assumes specific ontological modernist views of mathematics, namely that mathematics is a universal rationalistic language that can provide absolutist claims on reality (Chesky & Wolfmeyer, 2015). The consequences for positing mathematics in this way are manifold, such as justifying standardized test practices, endorsing "best-practice" quantitative methodology for educational research, and constructing a mathematical pedagogy that disenfranchised learners, especially ones from under-privileged backgrounds (e.g. Apple, 2004; Atweh, 2007; Skovsmose, 2006). The underlying argument in this paper is that the discipline of mathematics and the way in which it is educated appears strangely the justification as well as the methodology of the western world's neoliberal destructive practices and policies. Thus, mathematics is not only a system of knowledge and a loci of power, but a cultural, perhaps even psychological phenomenon.

In Marx's (1976) critique of capitalism, algebra was explained as generating such abstract concepts as the rate of exploitation, expressed as the ratio of surplus labor to necessary labor. In this imagined world of capitalist markets, commodities are exchanged for money and vice versa. All exchanges of commodity for money are assumed to be fair to both parties entering the agreed exchange. However, Marx also points out that in the imagined schema, the capitalist turns money into more money, but through the process of fair exchanges. "In its pure form, the exchange of commodities is an exchange of equivalents, and thus it is not a method of increasing value" (261). At this point, he has

played by the rules of the imagined world and found that they do not follow logic. Continuing on, he reasons that there must be more to the definition of "fair trades." This leads to differentiating the cost of labor, as the needs of a worker to live, and the increase in assets that the employer gains via the labor. "The value of labour-power, and the value which that labour power valorizes in the labour-process, are two entirely different magnitudes" (p. 300).

Bookchin (2005) gives us another specific example of the way in which mathematics played a central role in created our modern society. In indigenous societies, or as Bookchin calls "ecological societies," abstract money systems did not exist, nor did bartering as we understand it today. The origins of monetary and bartering systems, according to Bookchin, can be traced to Mesopotamia where cuneiform writings depict meticulous records made by temple clerks to record products given and received. Later, this system of quantification and standardization seized by certain groups of people to acquire prestige and power, was justified by abstract formulas given to the products in which they now claim to own. Unlike ecological societies, these new societies no longer operated under the principle of reciprocity, gift giving, and complementarity, but rather on competition, scarcity thinking, and later property rights. Bookchin (2005) explains:

> until capitalism completed its hold on social life, merchants were the pariahs of society. Their insecurities were the most conspicuous neuroses of antiquity and the medieval world, hence their need for power was not merely a lust but a compelling necessity…. The new code that edged its way into those preceding it picked up the principles of an exact, quantifiable equivalence from advanced forms of reciprocity, but without absorbing their sense of service and solidarity. (p.222-223)

What these two examples have in common is the underlying concept of quantification. Both show that quantification was used to generate schemas that serve the powerful while supporting systems of oppression. The assumption that numbers can refer to discrete quantities is an ontological position and therefore in order to conceive of a world not marked by the destructive uses of quantification, we

ought to ask if there is another possible ontological position about numbers. We will consider what this might look like in mathematics education in section three and four of this article. Now, we turn to how the language, modeling, and practice of mathematics contributes to the destructive practice of domination and the false understanding of hierarchical systems.

MATHEMATICS OF DOMINATION: HIERARCHY, PATRIARCHY, AND DICHOTOMY

Next, we deterritorialize mathematics and mathematics education from a different perspective. Whereas in the previous section we focused on its usefulness in western industrial culture's methods of destruction, now we consider the ways that mathematics as a discourse feeds into western industrial culture's habits of mind. We begin by proposing mathematics and mathematics education as a Batesonian "myth of power" and review philosophical work calling attention to the logic of hierarchies and binaries, as well as the destructive implications that ensue. Bateson (1972) wrote

> The myth of power is a very powerful myth. Probably most people in this world more or less believe in it. It is a myth, which is everybody believes in it, becomes to that extent self-validating. But, it is still epistemologically lunacy and leads inevitably to various sorts of disaster. They say that power corrupts. But this I suspect, is nonsense, what is true is that the idea of power corrupts. (p. 494)

The idea of something is more important than the idea itself. Applied to mathematics, the language and practice of mathematics provides more strength to neoliberal patriarchy system than the idea of western mathematics itself. In other words, regardless of our ontological assumptions about mathematics, if we extol mathematics, its uses, and its education to power, we implicitly create a system of oppression in which the few remain in power while the many suffer. Only later, the epistemological commitments mathematics offers the modern world solidify into beliefs, practices, and habits of mind that form powerful domains of knowledge that become extremely difficult to question or critically examine.

Ecofeminists, including Warren (1990, 2000), Plumwood (1993, 2002), and Gaard (2011), illustrate how all forms of domination and hierarchy are mutually supportive and equally destructive. Warren (1990) names the underlying understanding of and justification for oppression via hierarchized binaries the "logic of domination" (p.128). Warren (1990) explains:

> A logic of domination is not just a logical structure. It also involves a substantive value system, since an ethical premise is needed to permit or sanction the "just" subordination of that which is subordinate. This justification typically is given on grounds of some alleged characteristic (e.g., rationality), which the dominant (e.g., men) have and the subordinate (e.g., women) lack. (p. 128)

According to Warren, within a Western logic of domination, value-hierarchized thinking in conjunction with value-dualism as hierarchical binaries inform how we conceptualize relationships, and how we therefore justify how we act in the world. Building from this understanding of a conceptual framework Warren asserts these frameworks are socially constructed and provide the oppressive lens through which we see the world. Mathematics is one such language we use to understand the world in which we live, and thus can be understood as a "language of domination" in its western usages. Indeed, mathematics has fundamentally shaped our concept of hierarchy, which for many anarchist and feminist scholars is the epi-center of capitalist, racism, patriarchy and other oppressive systems of power.

The social evolution of hierarchy is woven in western history, through Ancient Greece, Descartes's Cartesian linear system and to the standardization movement today. For example, hierarchical thinking became further entrenched into the western psyche in ancient Greece with the god Justitia, depicted with a scale and a blindfold illustrates the need to measure with exactness, reducing all "qualitative difference to quantitative ones" (Bookchin, 2005, 223-224).

We witness this system of hierarchical thinking and quantification both within the teaching and learning of mathematics and in what is

deemed "best practices" in educational research and policy making. Mathematics education is first delineated in hierarchical steps, each acting as a precursor to the one before it – first there is arithmetic, basic geometry, algebra, intermediate geometry, trigonometry, and then calculus only deemed worthy for those able to pass through the years of state mandated standardized testing practices and rigid high stakes curricula guidelines. Even horizontally within grade levels, mathematics is broken up into discrete domains – number sense, geometry, algebraic thinking, and measurement and data analysis (Common Core State Standards, 2010). Such compartmentalizing of concepts has made teaching and learning mathematics more complex than it needs to be, creates anxiety and animosity among learners, and disvalues educator agency from creating dynamic transdisciplinary lessons that empower their students rather than disenfranchise them.

How can we counteract the way in which mathematics is used to quantify, coldly judge, and prescribe measurable outcomes is an educational objective indeed! We may look towards the ways in which mathematics was used in ecological societies for clues. After all, "in nature, balance and harmony are achieved by ever changing differentiation, by ever-expanding diversity. Ecological stability, in effect, is a function not of simplicity and homogeneity, but of complexity and variety" and we would like to add beauty (Bookchin, 2005, p. 88). Bateson explained that we ought to be aware of the way in which we interpret "differences that make a difference" (Bateson, 1972, 315; Bowers, 2011). How can we witness beauty among difference, celebrate our uniqueness without competitive external benchmarks, and honor the multitude of talents without separation? A beginning, is to imagine an aesthetic ontological distinction rather than a quantitative one and an imaginary creative epistemology rather than a strictly rational rigid one.

To imagine mathematics outside our quantification paradigm would mean radically rethinking our ontological understanding of numbers as well as epistemological claims on knowledge that mathematical processes seemed to justify. In the next section, we do

the work of reterritorialisation by describing a mathematics education that focuses on imagination, aesthetics, and pleasure.

MATHEMATICS FOR FREEDOM: IMAGINATION, ABSTRACTION, AND AESTHETICS

Famous mathematicians from Poincare to Gödel have asserted that their practice of mathematics is latent with aesthetical experiences (Devlin, 2000). Scholars (e.g. Pfenninger, 2001; Sinclair, 2001; Tymoczko, 1993; Wang, 2001) have proclaimed the aesthetic dimension of mathematics as the key characteristic of the mathematical learning experience. We imagine a recontextualizing of mathematics and mathematics education towards its radical potential and to begin, we first turn to mathematician Lockhart (2009) as he presents an alternative nature of math. Lockhart describes the work of mathematicians as "making patterns of ideas" (p. 23). "I'm just playing," Lockhart (2009, pp. 25-26) explains. "That's what math is – wondering, playing, amusing yourself with your imagination…"

When viewing mathematical processes in this way, we can think of it first as a person inventing an imaginary space with objects and rules. Lockhart says, "there is nothing as dreamy and poetic, nothing as radical, subversive, and psychedelic, as mathematics" (p. 23). However, he does not explain what he means by radical and subversive, or exactly how math is such. Left undefined, there is a vague implication that the freedom and artistry of math opens us to do something beyond what is expected.

It also may help that Lockhart calls mathematics "our most fascinating and imaginative **art** form." Lockhart's suggestion that mathematics is art brings to mind the work of Herbert Marcuse. He claims that art "breaks open a dimension inaccessible to other experience, a dimension in which human beings, nature, and things no longer stand under the law of the established reality principle" (Greene, 1995, pp.138-139).

The ability to use one's imagination is perhaps the most important characteristic for gaining a strong, meaningful understanding of mathematics. Mazur (2003) argues that mathematical thinking is akin to other artistic activities, such as writing poetry, and that the type of

thinking mathematicians employs to attempt to prove the properties of imaginary numbers is analogous to the way great poets attempt to represent a particular emotion or other sensory experience to their readers.

In formal and informal settings, artistic mathematics and mathematics education should, by definition, exist in the imaginary world. It involves thought processes such as Lockhart describes. In formal and informal settings, students can be prompted to consider such free explorations. In artistic mathematics, the imaginary impulse and reason therein is a beautiful, simple place. Sinclair et. al. (2006) distinguishes the different aesthetic notions of mathematical experiences and properties and separates a personal/subjective response to doing mathematics as Dewey (1939) recommended from a more formal aesthetic of mathematical elegance. Aesthetic, as Sinclair specified, must be enacted in the classroom through student centered activities. STEAM (art infused STEM education) advocates call for the importance of art in STEM subject areas but do so at their own peril. Unfortunately, by not questioning the objectives behind STEM and the ontologies it supports, infusing art simply further subsumes all creative capacities left in humanity to envision a new world under the oppressive one, leaving little room for revolutionary thought to erupt.

This brings us to ask how can mathematics education not focus on quantification, an ontological distinction, as a grounding principle? We also ask what type of pedagogy and ontology of mathematical entities and processes would underlie such efforts? A particular example of a philosophy of mathematics based on aesthetics that supports a non-quantification concept of number is Resnik's (1981) notion of mathematics as a *study of patterns* and Shapiro's (1997) *mathematics as a study of structures*. Within these views, mathematicians and philosophers of mathematics are not concerned with the ontological properties or truth-values of numbers themselves, but only the structures and relationships that bind them together. Thus, the absolutism claim that numbers exist outside of human understanding as well as the fallibilistic assertion that numbers are completely part of a human cultural understanding of a particular worldview, make way for an alternative. This alternative is not a compromise or a synthesis

of the two more popular dichotomous views, but an altogether new ontological conception of mathematics. Shapiro (1997) explains that on all versions of structuralism, the nature of objects in the places of structure does not matter – only the relations among the objects are significant.

While we do not claim that Marx first worked extensively in purely mathematical philosophical traditions, we do suggest that the parallels in process point to the ways that artistic math resonates with forward thinking analysis and imagination of social organization and systems. However, what Marx failed to understand is that beauty and pleasure is just as much a human necessity as labor and community. Herein lies an important difference between aesthetic notions of mathematics discussed above in relation to the communist and anarchist traditions. Communists are interested in labor mainly and the power of a centralized state to enact and maintain equitable resources and standards of living among its citizens. In contrast, anarchists are interested in human pleasure and the abolishment of any centralized governing body so that free individuals have the ongoing ability to imagine and enact the world in mutual agreement and collaboration. We believe anarchist traditions outweigh communist ideals for enacting a utopian world. More specifically, within the anarchist traditions, western notions of mathematics are most challenged and offered alternative conceptions, as well as uphold the aesthetic ideals of beauty and pleasure.

Anarchist concepts of pleasure and individuality have the ability to summon the utopian impulse. Aristotle explained in Nichomachean Ethics "all art (techne) is concerned with coming into being, that is, with contriving and considering how something may come into being which is capable of either being or not being and whose origin is I the maker and not in the thing made." (Bookchin, 2005, p. 305). Eastern philosophies such as Taoism mention the concept of the "way" as an alternative a homogametic omnipotent and non-earth god. The "way" defined as a "united ethos, ritual, sensibility, duty, and lifestyle and cosmogony and with the substances that made up the world" was known to members in the ecological society when they spoke of plants or nonliving things as having a spirit and was known by ancient and

modern sculptures and artists when describing the nature of carving a piece of marble or metal, by exclaiming the material itself tells the artist what it wants to be (Bookchin, p. 318). This differs substantially from a utilitarian view of labor such as Marx, which posits no such commune with the nature world or its objects, further separating humans from the very ecosystem that intrinsically we are forever tied to.

Looking to the educational arena, we find inspiration from the "maker movement" (e.g. Halverson & Sheridan, 2014). The maker has the potential to be not simply a maker, but a creator and perhaps even more so a midwife, allowing the object and her/himself to co-create to bring forth into creation something new, that is both an abstraction of the human mind in communing with natural impulses and processes. The potentiality of this movement to break the stronghold of late capitalism is tremendous. By evaporating the distinction between consumer and producer, the maker movement can revolutionize not only how we view labor and production, but our entire monetary system as well as our place within it.

MATHEMATICS FOR ECOLOGY: FREEDOM, COMPLEMENTARITY, COMPLEXITY

In this section, we draw from anarchist and ecological understandings to provide an ontological perspective on the future of mathematics and mathematics education. Still working with our reterritorialisation pedagogy, mathematics education is envisioned as a means to mutual aid and to promote complex understandings.

Bookchin and many others before him have made clear that in almost every period since the Renaissance, a very close link has existed between "radical advances in the natural sciences and upheavals in social thoughts" (p. 84). Mathematics, the bedrock of science is the epi-center for us to begin the work. The nature of our reality, the way the world is governed and the way in which humans interact in such a world is learned through social, cultural, political, and spiritual processes. How we perceive and relate to time, space, pattern, relationships, forms, concepts are mathematical fundamentally, and thus an ontological question as well. Thus, notions

that we imagine ourselves as discrete competitive entities rather than interdependent unique organisms is implicitly a mathematical error. Relating this statement to the celebrated book written by Bateson (1972) *Steps to an Ecology of the Mind,* we witness how our mathematical awareness, and the practice set forth by it, affects our perceptions of the world.

Bateson (1972) writes: "The major problems in the world are the result of the difference between how nature works and the way people think" (p. 470). What if our understanding of how nature works has a mathematical component that we have misunderstood or categorized incorrectly? Several accounts in the history of mathematics have given us such examples. For instance, Benoit Mandelbrot (1982) brought to the attention of the mathematical community the connection between what he termed fractals, what was then known as pathologic shapes, and the natural world. His famous example of the coastline of England illustrates that the earth itself, the way continents form and change indeed have mathematical dimension, such that humans can now study and replicate. While in certain mathematical circles throughout history (e.g. Pythagoreans for example), this knowledge was not new in any sense, it is far from our cultural psyche nor it is taught in schools at any level. As a further example, the irrational number known as "The Golden Ratio" and its connection to the Fibonacci Sequence is known in botany and mathematics to be indicative to natural growth patterns, yet most mathematics students never get exposed to such knowledge.

There has been a long tradition of anarchism and education (e.g. Suissa, 2010; Haworth, 2012), which directs us towards thinking of mathematics in this way. might better benefit from thinking about anarchist epistemologies and concerns of rationality as above. Anarchist work in education aims to rework our epistemic orientations. Wolfmeyer (2012) has forged the connections between mathematics and anarchism by drawing attention to the anarchist tenets that it can promote, such as collectivism:

> Collectivism denotes the curtailment of property rights, especially as they relate to ownership of capital. Fraternity describes an inclination for individuals to recognize the needs and desires of all other people, and accordingly to act in the

> spirit of mutual aid. Freedom indicates a lack of coercive actions by any person, group, or social institution on any one person, as well as individual autonomy within the boundaries of imposing on another's freedom. (p. 40)

What we believe has been missing thus in theorizing an anarchist education in this vision is the connection between anarchism and ecological thinking. During this pivotal destructive time in human history, however, this omission must be filled. In our effort to reterritorialize a mathematics education for the future of humanity, we insist that mathematics education must be reconceptualized in all its manifold areas – politically, pedagogically, and ontologically. Politically, we may teach mathematics in a way that asks students to critically examine how mathematics has been utilized to oppress people and destroy our planetary resources. Pedagogically, we may teach mathematics as a nonhierarchical, inquiry based aesthetic discipline that is related to how humanity's continuing mission to express the beauty of the natural world. Ontologically, we may teach mathematics as a language of sorts that helps us come a little closer to understanding how the universe functions, the types of properties

matter and/or energy have in such a world, and the ways in which humans and living and nonliving things co-create such a universe.

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