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## *Where STEM binds, and ST(eee)EM flows* *A case for the where in STEM discourse and practice*

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### Abstract

*STEM may encounter issues of educational relevance as the concept (STEM) proliferates, generalizes, and becomes disconnected with its own climate and the climate of our times (educationally and societally). Most commonly, STEM is assessed (beholden/sustained) by two criteria: economy and quality. This results in linear movement between these two. This work suggests that complex movement exists within the concept STEM (as it does within all life and atmospheric weather) that can be understood from the perspective of STEM's climate. By reconceiving STEM as STeeeEM, through the infusion of three additional e's (environment, ecology, and ethics), movement infuses into the concept STEM, illustrating complex, non-linearity as integral to STEM, in what may be described as STEM weather. Over time, STEM weather may be observed (through patterns) as STEM climate. It is suggested that STEM weather may be explored as complexity, via considerations of three variables: 1) environment, 2) ecology, and 3) ethics, and how these three move in relation to where STEM education happens. These three illustrate complex movements of STEM, provoking question of need for a third criterion through which to assess STEM. Usefulness, outlined as a) health/wellbeing, b) environmental/sustainable ethics and practices, and c) learning stickiness, is posited as a third STEM criterion, in addition to economy and quality. By way of the development of a concept of the where of education, as a unique ontological category separate from (yet connected to) curriculum and pedagogy, distinct where usefulness is reflected upon, with particular discussion of outdoor where and STEM. Outdoor where and time spent outdoors (TSO) are proposed as particularly useful to STEM. STeeeEMing STEM, by blending in a third criterion (useful), along with movement noticed through interactions of the three "e's", responds to STEM conceptual reification. In situating STEM learning experiences in relation to where's climate, STEM presents revived educational relevance as a concept.*



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## Introduction

“The freedom of the storm and the bondage of the stem join hands in the dance of swaying branches.” (Tagore, 1994 p. 444)

[T]he hardening and congealing of a metaphor guarantees absolutely nothing concerning its necessity and exclusive justification.” (Nietzsche, 1873 p. 6)

Perhaps a project to (re)consider STEM (Science, Technology, Engineering, and Mathematics) education emerges out of realizations of STEM’s potential sedimentation, and disconnection as a concept. STEM, as a rigid concept, is not relevant for educators and/or learners (and other stakeholders), particularly in acknowledgement of movement and interconnection as ontological aspects of existence on Earth (Capra, 1996). In accepting movement and interconnection as ontologically valid (which does not seem a significant reach to propose accord on), attention may now turn to how we might situate and consider/engage with the perpetual stream of educational literature (from education scholars worldwide informing education) imagining urgent need for Science Education qua science education to consider its own aims with respect to 1) health/well-being, 2) environmental/sustainable ethics and practices, and 3) learning stickiness (Slattery, 1995; Gruenewald, 2004; Davis and Sumara, 2005; Button and Clark, 2010; Blenkinsop, 2012; Wiek et al., 2012)? STEM education is a concept that may bring relevance to science education that has potential to be useful in various ways. One manner in which STEM education<sup>1</sup> is imbued with conceptual power is through a fusion of a range of diverse fields (Science, Technology, Engineering, and Mathematics). In this coming together, this con-fusion, STEM elicits an ever important sense of movement, however STEM, as a congealed metaphor (a Google Scholar search for STEM education returns almost 27 million results instantaneously), presents challenges (*aporia*) that scholars, educators, community-based practitioners and policy analysts/makers may have overlooked in prior assessments (Kaufman, et al., 2003; Morrison, 2006; Breriner, et al., 2012). As STEM becomes increasingly conceptually regularized (understood) and ubiquitously referenced in a sea of literature and popular educational discourse, regardless of how diverse STEM actors experience and influence particular facets of STEM, STEM’s potential may fizzle to obsolescence in learning settings if perceived as static and severed from broader life and learning. Presently, STEM seems to serve but two masters, namely economy and quality, and apart from puzzlement around what STEM *is* (STEM’s definition, a STEM *aporia* in and of itself), it is clear from STEM literature and policy documents that STEM generally is assessed by these two rulers, such as 1) (economy) STEM is considered successful based on the number of actual jobs created for STEM students entering post-secondary or the labour market (i.e. potential employees with the skills and competencies required for STEM industry jobs), and 2) (quality) performance quality of these employees in their particularly jobs (awards won, breakthroughs, grants...) leads to many benefits, including financial, patriotic, and pride, resulting in increases in prestige; high quality leads to higher quality. With but two main criteria assessing success, STEM movement is limited, moving back and forth in STEM assessment reviews between these two. By introducing a third criterion, distinct movement results in how STEM may be assessed and how STEM may be useful. More and more we are reading and hearing stories of inadequate emphasis/value being placed on common educational goods such as health & wellbeing for individuals and communities, environmental & sustainable ethics and practices required for the 21<sup>st</sup> century, and how learning experiences may stick with us over time. These three are significant to life, now and in the future.

They inspire, infuse, inform and influence us in our vibrancy, bringing usefulness to our lives and definition to usefulness' ontology.

As Tagore (1994) reminds in his poem, it is in the “dance of swaying branches” that we notice flexibility and connection through movement, and STEM gains increased potential relevance when real movement exists in STEM, movement that can be mapped, conceptually and in practice, showing STEM climate, or more precisely STEM weather patterns. Bateson (2002) captured this sense of movement in relation to science with his notion of *pattern* when he wrote:

...the right way to begin to think about the pattern which connects is to think of it as primarily (whatever that means) a dance of interacting parts and only secondarily pegged down by various sorts of physical limits and by those limits which organisms characteristically impose. (p. 13)

Distinct STEM climates may be noticed once we turn our attention to patterns that occur in distinct STEM learning *wheres*, for example laboratories, classrooms, museums, parks, streams, textbooks, websites, virtual reality simulators, and so on. For each of these *wheres*, different climates exist, distinctly impacting STEM learning and relevance. For example, the outdoor *where* invites useful movement for STEM, by offering rich opportunities to explore personal and social health and wellbeing, experiences with nature including care/respect for self, others and the more-than-human, and through learning experiences that have great potential to stick with us (individually and collectively) over time. This particular connection between outdoor *where* and usefulness in connection with STEM is explored below. With this spirit, this work suggests that educational *usefulness* is a valid (as relevant) criterion in ways that supplement economy and quality. The triad (and three is significant as you shall read shortly) of 1) health and wellbeing, 2) environmental/sustainability ethics and practices, and 3) learning stickiness is hence referred to as *useful* throughout this work, and *usefulness* shall be the name assigned to the third STEM criterion proposed in addition to economy and quality. The above three *useful* relevancies for STEM are not suggested to mute or trump the existing two (economy and quality), but rather to support those other two STEM criteria towards a healthy economy and high quality life.

This work explores *where* STEM practices occur by reflecting on emergent patterns connecting health/wellbeing, environmental/sustainable ethics/practices, and learning stickiness that exist in distinct STEM *wheres*, noticed as STEM climate. The movement in any distinct learning context allows for a mapping, which may be described as weather-esque, the *weather* of the learning experience (this could be aligned with actually weather, if you are outdoors for example, or it could include other indicators of movement in learning experiences such as a class vibe), that over time produces noticeable patterns that remind us that our experiences in our lived daily existences are moving. Every learning experience involves distinct *wheres* (may be one or multiple), and each of these *wheres* has distinct weather, and thus distinct climate. Climate may be understood as patterns noticed as movement (non-linearity) through time (as layering of maps would show), and that at least three variables must be considered for complex movement to occur.

In recognition of this need for three variables to instigate even the most basic of complex movements, this work opens STEM to STeeEM (pronunciation: steam), an act of inserting three additional “e”s , into STEM is an effort perhaps to oppose STEM galvanization, however more so towards relevance of *where* STEM learning occurs and STEM *usefulness*. By permeating

STEM and creating STEeeeEM, through the “e” variables of (e)thics, (e)nvironment and (e)cology, this paper invites STEM discourse and practice to move in ways that value STEM not only within indoor school classrooms, manufactured museum exhibits and websites, but that broaden STEM to include *usefulness*, along with economy and quality. This shall be exemplified through consideration of *where* STEM learning occurs in relation to the criterion of *usefulness*. Through a development of an ontologicality of *where*, outdoor *where* shall be explored in relation to STEM education in particular, and learning in general. However, first climate is explored in connection with learning experiences, particularly STEM learning experiences.

### **STEM Climate**

“In my life's garden my wealth has been of the shadows and lights that are never gathered and stored.” (Tagore, 1994 p. 473)

Prior to a discussion of *where* in relation to STEM, let us begin with a conceptual exercise to conceive of movement in STEM and STEM weather, which may be noticed in STEeeeEM. Question: What exists between shadow and light, precisely where these two meet? It is at junctures such as these that notions of boundaries emerge and take (give) shape to movement. Bateson called this ethos, and used an analogy of riverbanks and river’s water being engaged in an endless dance, continually changing the form of the river’s edge and water’s flow as they moved with one another (1979, p. 84). Boundaries simultaneously create perception of homogeneity via binding mechanisms (membranes, classrooms, concepts), as well as permit interaction (flow) between boundedness via porosity (thus *aporia*?) and radical movement. The emergent shapes of shadow-light dances also tell stories of (e)thics arising and fluctuating (Banack and Bai, 2007) in learning settings, akin to rising and falling water levels and water’s erosion of banks over time. These processes are examples of complex movement. What we decide to do, our actions as educators, are always immersed in a constant flow of movement’s change, which produces what might be referred to as weather, that over time, through noticing of pattern, may be understood as climate. These stories of movement in human action have been described as ontological. Juarrero (2000) noted in her exploration of action dynamics, “Far from representing messy, noisy complications that can be safely ignored, time and context are as central to the identity and behavior of these dynamic processes as they are to human beings” (p.27). Boundaries, those moments and places where difference(s) meet(s) and co-mingle(s), offer novel possibilities as emergent learning experiences, based on a variety of contextual variables and how they interact. Movement is produced as boundaries meet and infuse, instigating flexibility and flow. To map the boundary of shadow and light is to map (Strand’s Dark Maps) an unpredictable and unrepeatable dance (dynamic), such as wind twirling through sky, night becoming day, or learners learning through K-12 years. Consideration of movement in STEM learning experiences acknowledges that Tagore’s dance evocations of swaying branches and shadows and lights produce distinct shapes depending on where STEM learning happens, and these distinct patterns can be considered STEM climate. To illustrate STEM weather, I invoke three differentials relevant to STEM that when considered over time, generate complex movements. I have called these three: 1) environment, 2) ecology, and 3) ethics. These three additional “e’s” have been introduced to STEM to make STEeeeEM, exemplifying movement. Tagore’s poem reminds that boundaries do not make sense once reified (gathered and stored as concrete artifacts), but rather their sense exists where life and learning happen, where there is always movement.

Our terrestrial climate physically embeds us in connective tissue<sup>2</sup> bounded by and binding (e)nvironment, which sustains and (re)iterates an ever-changing (e)cology (a/biotics interacting in place over time), informing (e)thical practices (more-than-human acts of *phronesis*-knowing what to do based on context and circumstance). Weather, climate's movements at any instant, creates transitory and ephemeral boundaries (high and low pressure fronts) that constantly collide and influence (shift) boundaries. These mutable and shifting boundaries are noticed in patterns such as the thermals birds rise upon or the gathering of clouds from which storms are born, or breath on a cold day. Every physical *where* has a climate whose weather circumscribes and is circumscribed by (e)nvironment, (e)cology, and (e)thics. By considering STEM learning experiences in relation to *where* STEM happens, this paper draws attention to movement in STEM as noticed through the interactions produced when the three "e's" are infused to make STeeeEM, demonstrating non-linear movement as a ontological necessity of existence existing some *where*, a sense often experienced through weather (at this moment you may wish to consider the day's actual weather where you are as you read, and then consider the day's weather in relation to the climate of the location, and now get back to reading). The additional "e"'s introduced to STEM act as *cues* and *catalysts* that re(collect) that events on Earth are actually always in motion, thus producing currents that can be traced and that trace<sup>3</sup>. The perhaps awkward<sup>4</sup> (re)assemblage STeeeEM offers, in turn, may be *useful* to educators, students, and learning experiences, insofar as *useful* refers to STEeeeM's ability (capacity) to generate meaningful learning experiences (analogous to energy moving turbines to generate electricity) that include contemplation of present and future generations<sup>5</sup> in unpredictable ways that accept and morph ( $\Delta$  = change) through time and place (*where*), affecting our individual and collective health and wellbeing. Again, *usefulness*, as a criterion of assessment, is defined as: health & wellbeing, environmental & sustainable ethics and practices, and learning *stickiness* (how learning experiences *stick* with/to us)<sup>7 8</sup>. It is suggested that STeeeEm's impact on STEM might be evidenced through  $\Delta$  in these three variables over time. The triptych of "e"'s (ethics, ecology and environment) in STeeeEM have been chosen as representative of necessity for a minimum of three differentials for non-linear flow to occur. This sense of infusion of additional "e"'s shall be (re)turned to (re-iterated) throughout the paper. By this point, you, dear reader, may have also noticed that the writing *style* of this work (attempts) (intentionally) has weather unto itself as it rises and falls, twisting and twirling in/out on/of itself.

Unlike landscape and celestial-scape, which generally appear as somewhat static or predictable to human eyes and senses (of course some change is noted within our perceptual ranges), sky-scape (as weather) changes regularly as air pressures shift, temperatures change, and humidity varies (clouds flowing through the sky or Heraclitus' contemplation of stepping into the same river and not stepping into the same river). Complex movement and flow are distinct from solid and linear ontologies, and require at least three differentiated variables. STEM learning experiences (conceptually and in practice) always have at least three variables and thus STEM relevance has something valuable to glean from this realization.

In his influential work on weather systems, Lornez (1963) wrote:

To verify the existence of deterministic nonperiodic flow, we have obtained numerical solutions of a system of three ordinary differential equations designed to represent a convective process. These equations possess three steady-state solutions and a denumerably infinite set of periodic solutions. (p. 141)

In considering how three differentials interact, impacting change over time, Lorenz noted patterns illustrative of the ontological nature of dynamics (movement). Analogous patterns are observed through isotopic lines on weather maps or changes in wave intervals at the seaside, or swirling convection vapour forming steam as it rises from a lake warming in the morning heat on a sunny summer's day. These patterns also occur in learning experiences through/as the emergence of the experience, not as recorded story, but as realization that no matter how much we may plan and prepare for a journey (including an educational journey, as teacher, student, or other), we can only ever aspire to a degree of certainty in our preparedness. Learning experiences are stochastic processes. For example, consider all the work that goes into preparing for teaching with students. I have written the course outline, and know what the readings and assignments are to be, I have set a list of course objectives...and then a real life experience, a learning experience, actually happens. I arrive to the learning experience, with my lesson plan at hand and it begins. From then on, my preparations guide the experience, but always much shifts. Comparing lesson plan to actual lesson is like comparing weather forecast to actually weather at a specific time and place. For me, an outdoor educator, the weather of the class climate also aligns with external weather, and the patterns of the skies infusing movement into the learning, complexly immerse us in real life, giving meaning to *usefulness*.

In vivo, the fields in which Science, Technology, Engineering, and Mathematics systems exist regularly display non-linear movement tied to time and place. As examples of complexity and non-linearity occurring in STEM time and place, consider the impacts of (re)introducing a species into a landscape (i.e. Kane toads in Australia or wolves in Yellowstone, or...), or modeling global pollution impacts (i.e. effects from Krakatoa's eruption on ocean temperatures or spread patterns after an oil spill at sea, or...), or structural design for seismic activity (i.e. Tacoma Narrows bridge failure or earthquakes and tsunamis everywhere..., or... ), or digital databases (i.e. server security and hacker/viral breaches or death of electronic equipment, or...). Individually, examples from each of STEM's four fields illustrate complex, non-linearity and movement. In STEM's conceptual fusing non-linear flow also occurs between the fields, further (re)corded as movement. These collisions produce complex dynamics that have epistemological implications. STEM examples of complexity acknowledge that knowing climate, in relation to situated *wheres*, is *useful* to learners and the learning experience in ways not connected to economy or quality. Disrupting STEM conceptual inelasticity via STeeeEM is not an attempt to create a new STEM brand (new and improved), but rather a (re)consideration of derivative usefulness from fusing science, technology, engineering, and mathematics into STEM.

### **Section: STEM**

A galvanization of STEM may be understood as a disconnection from what Bateson (2002) called *patterns that connect* (p.8). Connections between the four STEM fields are clear and logical in relation to one another (e.g. Science uses Mathematics for statistical analysis, Science uses Technology to conduct research, Science uses Engineering to design tools to collect and analyze data, etc.), as well as in relation to economy and quality, however STEM relevance may be limited if STEM is decontextualized from *real life*. This disconnect from life beyond learning may be noticed via STEM documents that restrictively link STEM assessment to economy and quality, insofar as STEM practice outcomes remain requested to respond to these two alone. And apart from any (re)quests that actual STEM education practitioners may make of STEM to include other objectives, or recommendations from STEM policy and research

documents, real pleas for including STEM aims for health and wellbeing, environmental and sustainability ethics and practices, and learning stickiness seem to remain limited for STEM, and this may be addressed by broadening STEM assessment criteria to include *usefulness*. Consider what the 2012 white paper entitled *What Is STEM? A Discussion About Conceptions of STEM in Education and Partnerships* found in their search for a unified definition for STEM. Their survey of over 200 post-secondary faculty members from across the U.S. was conducted to explore what STEM meant to the respondents, towards developing a singular definition. This is clearly an attempt to re-calibrate STEM objectives, it seems. Responses were categorized into three groups based on how connected respondents felt to STEM. The results were as follows: 1) null relationship (36%), 2) personal relationship (50%) and 3) societal reasons (21%). Responses from the societal reasons category were further sub- divided to “...fit into loosely framed, broad descriptions that included (1) the university community, (2) the state in which the university is located, (3) the U.S. government, and (4) the global issues” (p. 9). Only 21% of the respondents felt that STEM had societal relevance, and recommendations proposed by the document were summarized as: “(1) increasing the talent pool through improving K-12 science and mathematics education (*economy*); (2) sustaining and increasing long-term basic research related to the economy, security, and quality of life (*economy and quality*); (3) increasing the attractiveness of the United States to recruit and retain the best and brightest scientists and engineers in the world (*economy and quality*); and (4) increasing incentives for innovation (*economy and quality*)” (p.2- *italicized words* were not from original). Even though there are four recommendations, they all tie back to the two STEM criteria: economy and quality. Not one of the examples from practice cited in the paper related STEM to the three “e”s, or *where* STEM occurs, beyond mention of a particular institution or course, or usefulness.

Examples can readily be drawn to illustrate the dependence STEM has on economy and quality. A case from research is found in Stohlmann, Moore, & Roehrig (2012) who looked at integrating STEM education into a middle-school program. The paper’s discussion section identified various complex and non-linear aspects inherent in STEM (teacher effectiveness, teacher content knowledge, and teacher support), yet this observation remained un(der)validated as the paper concluded, “Effective STEM education is vital for the future success of students” (p. 33) in relation to jobs and global competition, again emphasizing economy and quality. The other week, I was invited to attend a visioning day for STEM held by my local science center. The organization spearheading the work (STEM Learning Ecosystem Initiative, 2017<sup>10</sup>) had held similar sessions around North America, and shared two of the vision statements that these other STEM communities had arrived at around their local STEM goals, both vision statements similarly highlighted economy and quality as unique assessment criteria. There seems little doubt that STEM assessment rests on these two criteria, yet curiously, various STEM advocates also emphasize how connecting STEM to real life is key for STEM success, often with specific calls to increase STEM outdoor learning.

Learning beyond the classroom has been written about in STEM policy documents. For example, California’s STEM Task Force (2014) policy document *INNOVATE: A Blueprint for Science, Technology, Engineering, and Mathematics in California Public Education* stated, “STEM education, however, is much more than a convenient integration of science, technology, engineering and mathematics; it is an interdisciplinary and applied approach that is coupled with real world, problem- based learning.” (p. 7), emphasizing a vital need to connect STEM learning with real world *where* happenings. Another STEM policy document, the National Research

Council's (2012), *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*, noted that students "also need experiences that help them recognize that the laboratory is not the sole domain for legitimate scientific inquiry and that, for many scientists (e.g., earth scientists, ethologists, ecologists), the "laboratory" is the natural world where experiments are conducted and data are collected in the field." (p. 60). Here particular attention is given to outdoor STEM learning. The second *dimension* described in the document was titled *Crosscutting Concepts* and included the following themes: a) patterns, b) cause and effect: mechanism and explanation, c) scale, d) proportion, and e) quantity, f) systems and system models, g) energy and matter: flows, cycles, and conservation, h) structure and function, and i) stability and change (p. 3), a list reminiscent of Bateson's (2002) assessment of formal schooling<sup>11</sup>; all these concepts seem to invite real life movement. The Crosscutting Concepts demonstrate not only the importance of non-linear processes to STEM, but also how STEM is connected to real life. Another instance from the National Research Council (2009) argued for outdoor learning by stating, "There is evidence that outdoor experiences foster social development and academic success (Hattie, Marsh, Neill, and Richards, 1997) and that being in nature is a stress reducer for children (Wells and Evans, 2003). Given this emphasis, it is surprising that few have directed attention toward science learning within different outdoor (nondesignated) environments." (p. 230). The second conclusion, found in the section Learners and Learning, indicated, "A great deal of science learning, often unacknowledged, takes place outside school in informal environments— including everyday activity, designed spaces, and programs—as individuals navigate across a range of social settings." (p. 293). STEM literature provides many examples that extend STEM, not only beyond the school environment to include outdoors, but also beyond economy and quality to consider real-life *usefulness*.

In the United States, the National Science Foundation (NSF) has been, and continues to be, a significant STEM actor in STEM policy and practice. Currently, the NSF motto is *where discoveries begin*. This NSF acknowledgement of STEM *where* is another example that extends beyond indoor classroom or laboratory settings. A recent posting for a NSF funded learning project illustrates how this motto translates to practice, "San Francisco's Exploratorium is taking its mission outside its walls and into the community. The 'Outdoor Exploratorium' is a National Science Foundation-supported project that includes a collection of interactive exhibits that encourage users to notice and experiment with outdoor phenomena. The move outdoors stemmed from a simple vision: to engage people of all ages in science and help them understand their own connections to the environment" (Snyder, 2009). Yet it seems to remain worthy to consider how moves to infuse real life into STEM may ultimately go unrecorded by STEM if STEM criteria are guided by economy and quality alone. By infusing three additional "e's" into STEM, dynamic movement that considers *where* STEM practices occur and how they are connected to real life may be noticed. The triad presents STEM an additional assessment criterion: *usefulness*. The next section conceptually analyzes *where*, towards establishing an ontology of *where*, and then moves to focus on how outdoor *where* offers particular benefits to STEM education and learning writ large.



## Section: Where

“Nothing will tell you  
where you are.  
Each moment is a place  
you’ve never been.”  
(Strand, 2009 p. 53)

This section has the following aims: 1) to present philosophical evidence establishing a domain of *where*, unique in and of itself, 2) to establish the *outdoors* as a sub-domain of the broader category *where*, and 3) to consider the relevance of *usefulness* and outdoor *where* to STEM learning experiences. Subsequently, the concluding remarks shall (re)-fuse (confuse, infuse, and fuse together) STEM and outdoor *where* in STeeEM.

### *Where*

We long for place; but place itself longs.” (Michaels, 1996 p. 53)

This sub-section presents diverse *traces* of conceptual *evidence* that invite patterns of *where* to exhibit, so that *where* may be inscribed as an essential (*ontological*) concept. This evidence shall serve to act as primary testimony to the claim that *where* is a unique and constitutive aspect of being (sufficient and necessary) and learning (epistemological). *Standing on this foundation*, the task of establishing outdoors as a realm of *where* will then be developed.

*Aside:* Dear Reader, I request notice that *where* is not being suggested as synonymous with *place*, but as a broader conceptual frame to which *place* belongs. Consider Russell’s (1908) type theory in which he explains logical typing relationships. A Russellian example would be: any tree is a member of the group tree, however, the group tree is not a tree and thus not a member of the group. This is akin to what is being proposed about place, place is a member of the category *where*. There are other members of the category *where*, as shall shortly be presented. Even place may be sub-divided into many dissections, including common binaries such as indoor/outdoor, yet really there are infinite permeations of place, as there are innumerable *wheres*. This venture into *where* is not meant to be exhaustive or complete (it is not taxonomic), but rather an attempt to re(mind), through iterative shades of *where*, *where*’s ontology and relevance as an epistemological concern. These various examples of *where* shall act to validate *where*.

In *Building Dwelling Thinking* Heidegger (1993) wrote, “From the simple oneness in which earth and sky, divinities and mortals belong together, building *receives the directive* for its erecting of locations” (p. 336). His unity of being and the fourfold (earth, sky, divinities, and mortals) acknowledge *where* (*Dasein*- being-*there*) as an ontological imperative. Casey (1993), a philosopher of place, noted, “The point is that place, by virtue of its unencompassability by anything other than itself, is at once the limit and condition of all that exists” (p.15). MacIntyre, in *After Virtue* (1984), pointed out, “a setting has a history, a history within which the histories of individual agents not only are, but have to be, situated, just because without the setting and its changes through time the history of the individual agent and his changes through time will be unintelligible”(p. 206-7). Environmental educator Orr (1996) stated, “We are reflections of our places. Locality is etched on our minds in more ways than we can know” (p. 234). All moments are *whered*, occurring some *where*; yet *where* is not a cohesive concept (not unlike STEM), and

*wheres* may be nested (with two or more *wheres* possibly occurring simultaneously). Whether *where* is physical (indoor/outdoor), or mental (memory/déjà vu), or cybernetic (chat room, three-dimensional movie, or website), or otherwise (thought, celestial, subjective, nowhere, utopia, etc.), *where* is connected to primary perceptions, those bedrock perceptions that guide our everyday existence (Varela, 1992; Audi, 2010). What follows are but cases to help distinguish diverse iterations of *where*.

Foucault has played a significant role in helping to articulate diverse notions of where. His 1967 paper, *Of Other Spaces: Utopias and Heterotopias* (1984), considered *celestial spaces* as examples of *where*. “For the real scandal of Galileo’s work lay not so much in his discovery, or rediscovery, that the earth revolved around the sun, but in his constitution of an infinite, and infinitely open space. In such a space the place of the Middle Ages turned out to be dissolved, as it were; a thing’s place was no longer anything but a point in its movement, just as the stability of a thing was only its movement indefinitely slowed down” (p. 1-2). Foucault was informative in his reflections on space (place), particularly his treatment of utopia and heterotopia. “The mirror is, after all, a utopia, since it is a placeless place. In the mirror, I see myself there where I am not, in an unreal, virtual space that opens up behind the surface; I am over there, there where I am not, a sort of shadow that gives my own visibility to myself, that enables me to see myself there where I am absent: such is the utopia of the mirror. But it is also a heterotopia in so far as the mirror does exist in reality, where it exerts a sort of counteraction on the position that I occupy” (p. 4). Through Foucault’s investigation, we are invited to sense *where* as a set of relations, and to question what (or *where*) *real* might mean (or be).

Foucault also invited us to contemplate the *subject* as *where*. In *The Subject and Power* (1982), Foucault wrote, “It soon appeared to me that, while the human subject is placed in relations of production and of signification, he is equally placed in power relations which are very complex” (p. 778). Through this *placing*, subject, now established, goes on to create an understanding of subject as *where* within a constellation of power dynamics. In *Discipline and Punish* (1995), Foucault described the history of subjects and places in relation to power. “The execution was often carried out at the very place where the crime had been committed” (p. 44). His tracing of historical documents ultimately (re)mind that there was no separation between subject and *where* (both in terms of a geographic location and a place on the subject’s body) in the development of the policed subject. “It also made the body of the condemned man the place where the vengeance of the sovereign was applied, the anchoring point for a manifestation of power, an opportunity of affirming the dissymmetry of forces” (p. 55). This allowed for total surveillance of subjects at all moments, in all places, a complete con-fusion of the two. Foucault went on to conclude that: “The true objective of the reform movement, even in its most general formulations, was not so much to establish a new right to punish based on more equitable principles, as to set up a new ‘economy’ of the power to punish, to assure its better distribution, so that it should be neither too concentrated at certain privileged points, nor too divided between opposing authorities; so that it should be distributed in homogeneous circuits capable of operating *everywhere*, in a continuous way, down to the finest grain of the social body” (1995, p. 80. Italics added). Constant surveillance of every *where* as subject and geography, connecting subject and place, as land, as subject, and as body, ceaselessly dancing. “Children should be allowed to come to the places where the penalty is being carried out; there they will attend their classes in civics. And grown men will periodically relearn the laws. Let us conceive of places of punishment as a Garden of the Laws that families would visit on Sundays” (p. 111). Taking experiential learning to task! Bradiotti (2014) extended Foucault’s *whered* subject to conceptions

of colonialism and anti-oppression via her theory of the *nomadic subject*, a resistance to Foucaultian totalitarian surveillance. Braidiotti stated:

Not all nomads are world travellers; some of the greatest trips can take place without physically moving from one's habitat. It is the subversion of set conventions and the consciousness-raising that defines the nomadic state, not the literal act of travelling. Attention to embodiment and the politics of locations produces a visionary epistemology. (p. 182)

She turns the subject inside to thought and memory, and how we understand ourselves as subjects bound to experiences of *where*, as simultaneously repressive and liberating.

"Where do thoughts reside?" is an interesting question. Thinking is not material in the way much other existence is and thus physical where takes on other senses. Arendt, in *The Life of the Mind* (1978), coupled place and thought in the development of her notion of thinking as being *nowhere*. She wrote, "the 'essential' is what is applicable everywhere, and this every-where that bestows on thought its specific weight is spatially speaking a 'nowhere'. The thinking ego, moving among universals, among Invisible essences, is, strictly speaking, nowhere; it is homeless in an emphatic sense-which may explain the early rise of a cosmopolitan spirit among the philosophers." (p. 199). We are unable to physically locate emergent thought in a spatial manner, and once an author has passed away, the author's thoughts remain decentralized, residing in other humans or in written words scattered around the globe on bookshelves and in libraries or in cyber space. Thus, Arendt offers *nowhere* as yet another conception of *where*, a sense of *where* without physical place; shadows of forms reminiscent of Moore's Utopia and the ancient Greek concept *eutopia*.

In the digital (cybernetic) realm of *where*, we are able to transport ourselves, through modification of our basic perceptions, to *virtual* realities. The progression to virtual reality totality has been slow and filled with challenges, particularly when quality of the virtual experience is compared with real world counterparts. In "*He's Behind You*": *The Experience of Presence in Shared Virtual Environments*, Büscher et al. (2001) discussed challenges for virtual *where* to replicate physical *where* as it considers digital environment designers' attempts at capturing the complexity of weather. The following commentary reflects on a virtual immersion experience. "The weather is another resource for orientation. A woman states 'there's going to be a storm', as a cyclist is proceeding towards a vista of dark clouds on the horizon. However, the fact that 'the weather' does not worsen even though they should be getting closer to the center of the storm exposes it as governed by different physical laws than weather in our familiar physical environment" (p. 93). Nowadays, digital *where* holds substantial emphasis in many STEM education documents, along with a permeating presence in STEM educational practice which may be illustrated by school investment in acquiring digital technology or support for teacher digital professional development. The document *Learning: Engage and Empower* (2016), produced by the Office of Educational Technology (OET) of the US Department of Education, stated, "The challenge for our education system is to leverage technology to create relevant learning experiences that mirror students' daily lives and the reality of their futures" (webpage). Similar sentiment may be found broadly echoed in education literature throughout nations worldwide. The application of digital *where* has been strongly promoted in U.S. STEM government documents from both Bush and Obama administrations, and US Department of Education grants are available for educators to develop digital learning environments. However, there also exists hesitancy around digital *where* as panacea. The vision statement of the OET

warns, “Technology and media should not take the place of interactions in the real world, including playtime with adults and peers, physical and outdoor activities, and the social interactions and experiences that are essential for a child’s development. For these reasons, frequency and duration of technology use are important considerations for families and early educators” (webpage). There is an increasing concern that digital *where* may engulf other educational (and ontological) *where*’s, including textbooks, schools, and teachers (subject *where*)! Notwithstanding, digital represents another iteration of *where*.

Memory is yet another distinct sense of *where*. Memory records lived moments, creating facsimiles in our brains that may trigger powerful responses, create art, or guide life choices. Memories live inside us, yet often times they are incomplete or inaccurate, as we humans are limited in our capacity to record memory in various ways (physical location, memory formation capacity, memory recall, etc.). Returning to Heidegger in *Building Dwelling Thinking* (1993), he referenced memory as *where* in the contemplation: “If all of us now think, from where we are right here, of the old bridge in Heidelberg, this thinking towards that location is not mere experience inside the persons present here; rather, it belongs to the essence of our thinking *of* that bridge that in *itself* thinking gets through, persists through, the distance to that location” (p.334). Heidegger suggested that memories actually transport through time, in a physical way, linking distinct *wheres*, and that this memory is as definitive of the place as the place itself. The geographer Tuan commented in *Space and Place* (1977), “Place can acquire deep meaning for the adult through the steady accretion of sentiment over the years” (p. 33). The amount of time we spend in places impacts our meaning making of these places through memories, which leads to how we might come to understand a *where*’s weather and climate. We might suggest that time spent in digital environments produces familiarity and memories of digital climates, or time spent in memory produces familiarity and memories of ties to the past, and so on. Much research supports the claim that time spent outdoors produces familiarity and memories of/with/for/about outdoor *where* that are rather *useful*. (Chawla & Cushing 2007; Lugg, 2007; Arnold, Cohen & Warner, 2009, Lima, 2011). In an age of dwindling outdoor *where* opportunities<sup>12</sup>, outdoor familiarity and memories seem to be decreasing, along with outdoor knowledge, and this has significant repercussions for relationships between humans, relations with the more-than-human world, and learning.

In the above section, it has been suggested that *where* be accepted as a unique ontological domain, of equal stature and footing as *what* (curriculum) and *who/how* (pedagogy) in ontology’s pantheon. From the above discussion, it appears that *where* is a broad enough category to capture diverse senses of its *ontos*, including illustrating *where*’s complexity as nested or simultaneous *wheres*, for example in your bed room and in cyberspace at the same time, or at school yet thinking of skipping stones on a lake when you were a child. *Where* is inherently complex and changing from moment-to-moment. Each *where* has its own conditions, which produce weather-like phenomena that, over time, exhibit as climate, and different *where* climates afford distinctly. Particularly, outdoor *where* offers benefits that may be considered *useful* in relation to health and wellbeing, environmental/sustainability ethics and practices and learning stickiness.

*Outdoor where*

“When I walk  
 I part the air  
 and always  
 the air moves in  
 to fill the spaces  
 where my body’s been.”  
 (Strand, 1990 p. 393)

One domain of *where* is very physical. This is the tangible world we all dwell in. In this *where*, when something heavy falls on your foot it hurts, and you can show others *where* it hurts. We inhale and exhale this *where*. There is an ever-present and insistent *physical* (e)nvironment, (e)cology, and (e)thics in this *where*. Different philosophers have contemplated physical *where*’s relation and value in/to/of/for/... our lives. This section explores physical *where* by focusing on outdoor *where* and how outdoor *where* offers *useful* STEM understandings that value non-linearity and STEM climate, as illustrated through the three “e”s.

Buber, in *I-Thou* (1996), described three spheres of life (nature, man, spiritual), and the first sphere, nature, he positioned physically as *where*, a *where* undergirding all other. Lingis (1994) reminded us that human life is actually comprised of earth. “One whose flesh is made of earth- dust that shall return to dust- who stands facing another with the support of the earth rising up in him or her” (p. 117). He goes on to state that reality will never become solely virtual or academic. “[T]he space where the things are encountered is not suspended in the network of geometric dimensions or in the void. It extends in the light, in the warmth, in the atmosphere, and in a clearing stabilized on the supporting element of earth” (p. 123). Ingold (2007), in contemplating relationships of place with weather and life, wrote, “To inhabit the open is not to be stranded on a closed surface but to be immersed in the fluxes of the medium, in incessant movements of wind and weather. Life is borne on these fluxes which, felt rather than touched, permeate the inhabitant’s entire being. In this weather-world there is no distinct surface separating earth and sky. Life is rather lived in a zone which substance and medium are brought together in the constitution of beings which, in their activity, bind the weather-world into the textures of the land” (p. 34). For these philosophers, and many others, outdoor *where* was/is an undeniable, unique and legitimate ontological domain, and present day research, from various fields, discusses myriad of benefits associated with time spent outdoors (TSO).

*Benefits of TSO*

There is a growing body of literature from health, wellbeing, planning, environmental and physical education researchers connecting time spent outdoors (TSO) with overall health and wellbeing, environmental and sustainability ethics and practices and learning stickiness that is *usefulness*. The work of Chawla over the past decades has provided various examples illustrating connections between environmental and sustainability ethics and practices in adults and formative childhood experiences outdoors (Chawla, 2007). Chawla’s 2015 paper *Benefits of Nature Contact for Children* discussed Sen’s and Nausbaum’s “capability approach” to wellbeing as a way of thinking about why nature contact and time spent outdoors are so important for health and wellbeing. Chawla reminded us how ancient Greeks were guided by a *telos* of *eudemonia* or flourishing, which contrasts with today’s prevalent medical notion of

health as *absence of illness* (Illich, 2003). This ancient sense of health as connection to the land was (re)told in Adelson's work on Cree understanding of wellbeing (Adelson, 1998). Ancients and Elders cannot conceive of learning as disconnected from place. Chawla's (2015) review of nature contact benefits considered both qualitative and quantitative studies that investigated a wide range of TSO benefits including: physical health, cognitive functioning and self-control, psychological wellbeing, affiliation and imaginative play, ethnographic studies of children's special places and indigenous connections to place. Her summary concluded, "A compelling body of evidence exists that trees and natural areas are essential elements of healthy communities for children", and by extension learning experiences. Again, as noted above, a significant volume of research also shows that outdoor experiences are at the heart of what many environmentalists cite as why they chose their adult careers (Chawla & Cushing 2007; Lugg, 2007; Arnold, Cohen & Warner, 2009). The following paragraph provides an (intense and quick) overview of some findings around TSO. It is meant to overwhelm, and raise questions as to why TSO findings have not been more broadly adopted by educators.

Waite, et al. (2011) found that outdoor play-based education supported sharing, team building, and collaboration amongst children. Gill (2014) conducted a systematic review of 71 studies and concluded, "findings support the view that spending time in nature is part of a 'balanced diet' of childhood experiences that promote children's healthy development, wellbeing and positive environmental attitudes and values" (p. 10). Taylor and Kuo (2009) resolved that, "not only does exposure to nature enhance attention in children with ADHD, but also that this effect holds for a wide variety of children, settings, and activities" (p. 407). Barton and Pretty (2010) stated, "acute short-term exposures to facilitated green exercise improves both self-esteem and mood irrespective of duration, intensity, location, gender, age, and health status" (p. 3950). Thompson Coon et al. (2010) found that, "exercising in natural environments was associated with greater feelings of revitalization and positive engagement, decreases in tension, confusion, anger, and depression, and increased energy" (p. A). Sherwin et al. (2012) demonstrated, "a 2% reduced odds of myopia per additional hour of time spent outdoors per week" (p. NP). Tremblay, et al. (2011) conducted a *Systematic review of sedentary behaviour and health indicators in school-aged children and youth*, finding, "Physical inactivity and sedentary behaviour are pervasive and persistent public health challenges to overcome" (no pg.), and they particularly noted the importance of outdoor activity as part of a remedy. Tremblay, et al. (2015) also found that, "those who play outdoors during the afterschool period take 2,100 more daily steps on average than those who do not" (p. 21). From Tremblay's two systematic reviews, a Canadian national *Position Statement on Active Outdoor Play* (ParticipACTION) was released in 2015. The statement plainly asserted, "[w]hen children are outside they move more, sit less and play longer" (p. 4). A particular recommendation from the Position Statement for schools and municipalities was to, "[e]xamine existing policies and by-laws and reconsider those that pose a barrier to active outdoor play" (p. 5). In 2018, the Council of Chief Medical Officers of Health of Canada adopted this position statement (webpage). Spending time outdoors is a direct response to unhealthy behaviours, a means for children to develop relationships with nature, and supportive of rich and sticky STEM learning experiences. Russell, et al. (2013) summarized overall beneficial impacts of TSO by claiming, "[t]he positive effects of nature on physiological health and mental health have been unequivocally documented" (p. 494).

Much of the above research on TSO in relation to health and wellbeing, environmental and sustainability ethics and practices and learning stickiness came in response to patterns of steady declines of TSO over the past three generations (Chawla, 2015). Even with abundant

empirical evidence, outdoor *where* remains limited in school learning experiences. However, outdoor learning experiences present real potential to be *useful*, particularly to STEM. Zencey (1996) wrote, “Transforming the world immediately outside the classroom into a laboratory will tend to erase the artificial boundary between the roles of student and citizen, thereby encouraging in the latter the habits of the former. A citizenry that is curious, skeptical, and reasonable, one that takes little on faith and is accustomed to carrying careful inquiry into the world, is a citizenry that more nearly fits the mold that democracy requires” (p. 19). In an era of constant change, outdoor learning offers real world potential to connect in *useful* ways that permit complex understandings through STEM approaches.

### *STEM Climate and Outdoor Learning*

“All the complicated details  
of the attiring and  
the disattiring are completed!  
A liquid moon  
moves gently among  
the long branches.  
Thus having prepared their buds  
against a sure winter  
the wise trees  
stand sleeping in the cold.”  
(Williams, 1986 p. 153)

“...all training in science should begin as well as end in research, and in getting hold of the subject-matter as it occurs in nature.” (Whitehead, 1967 p. 23)

The above conceptual development for an ontologicality of *where* suggests *where* is a legitimate epistemological concern. Within learning *wheres*, distinct and complex climates exist. In this work, senses of STEM climates have been developed and explored through an infusion of the three “e’s” shifting STEM to STEeeeEM to illustrate movement as intrinsic and significant to the concept STEM. STEM movement, understood as STEM weather, may occur within and between environment, ecology and ethics, and is distinct for any (every) STEM *where*, as each *where* has a distinct ontology at play that impacts (possible) weather outcomes, at any moment. It has been argued that currently STEM climate is guided by but two criteria, economy and quality, and it is suggested that by infusing another criterion, STEM climate may be observed. *Usefulness* (health and wellbeing, environmental and sustainability ethics and practices, and learning stickiness) is posited as a third criterion for assessing STEM, along with economy and quality, and outdoor *where* is investigated for its rich and important contributions to usefulness. Lorenz, who coined the phrase the *butterfly effect*<sup>13</sup> to describe interconnections and impacts as weather shifts, remarked that a characteristic of non-linear flow is the *unpredictable* nature in movement (and thus limits to manipulation or forecasting), due to how slight changes in initial conditions amplify and impact weather outcomes over time in place. He wrote, “When our results concerning the instability of nonperiodic flow are applied to the atmosphere, which is ostensibly nonperiodic, they indicate that prediction of the sufficiently distant future is impossible by any method, unless the present conditions are known exactly. In view of the inevitable inaccuracy and incompleteness of weather observations, precise very-long-range

forecasting would seem to be non-existent” (p. 141). The use of the notion classroom climate (a common term in education- implied by a Google search for *classroom climate* returning almost 4 million hits instantly) illustrates that movement is always at play<sup>14</sup> in learning experiences and that the *what, who, why, when, how, and where* of learning all must be considered (Banack, 2004) in designing and assessing learning experiences. As such, classroom climate may be understood as complex and analogous to Lorenz’s insights into the nonperiodic flow of atmospheric climate. It is not novel to educators that learning experiences have climates (vibes, feels, moods, energies) that result from and feed into the daily weather of learning experiences. In acknowledgment of every learning experience having a distinct climate, and how learning climates are impacted by *where, where* is/becomes an essential variable for considering learning experiences.

During pre-service teacher preparation, most teacher candidates take a course called classroom management (or classroom environments, or classroom process, or...), concerning how to “operate” (manipulate) classroom where, to order a learning ecology and impose (reproduce) accepted and acceptable learning practices. By in large, from my surveys, these courses focus on indoor and digital school *wheres*, in ways Bourdieu (1972) described as “dispositions of the habitus” (p.17), that unconsciously reproduce as *that what practitioners do*. In classroom management class, there is limited treatment of *where* as the learning context of the course is disconnected from where the pre-service teacher will eventually practice, at a school. Thus the courses reproduce (Bingham & Biesta, 2010) a culture of indoor classrooms and digital *wheres* as the rings, rinks, taken-for-granted forums for learning experiences<sup>15</sup>. The *in vitro* atmospheres of classroom and digital *wheres* are distinct from *in situ*<sup>16</sup> experiences outdoors. Indoor classrooms and digital *wheres* often have fewer variables “at play”, and thus significantly reduce complexity (i.e. climate control temperature, roofed school, textbook learning, website click options), whereas learning outdoors cannot be controlled (managed) as carefully, and resultantly complexity (non-linear flow) must be accepted and addressed (via recalibrations) in ways that indoor and digital contexts may avoid or ignore. With the vast abundance of complexity in learning experiences, avoidance of outdoor *where*, as a means to reduce complexity, may have resulted.

It would not be a stretch to suggest that not all *wheres* receive equal treatment in learning experiences. Higgins (2010) referred to the under-examined orthodoxy of indoor *where* (i.e. the classroom and school) as an educational omission that may marginalize of some *wheres*, de-emphasizing those *wheres*, perhaps bullying those *wheres* through where learning time is spent [TS(x)=the calculation of where actual learning occurs where (x) may be to equal to: indoors, online, outdoors, daydreaming...], particularly noted in a dearth of total outdoor learning experiences in comparison with overall learning experience time spent at school. A shift to (re)emphasize *where* in learning experiences, especially outdoor *where*, offers STEM a more robust consideration of actual *real world* learning variables (and associations) as they happen through time, as movement. The *usefulness* of additional variables (ecology, environment, and ethics) that emerge through outdoor learning experiences present STEM with *useful* educational relevance, yet educators need to be aware of how to interpret ever changing *usefulness* data, much as a ship’s crew needs up-to-the-moment, pertinent weather information to navigate successfully. Practitioners, researchers, and policy makers will have to recalibrate not only their perceptions of STEM, but also how to interpret patterns that emerge from STEM *where* learning experiences and what these might say about STEM success, in terms of *usefulness* and in relation



to economy and quality, and how this shift involves increasing time spent outdoors (TSO) for learning.

Complexity is ontologically inherent in learning experiences and school contexts, noticed through changes in the classroom climate over time (the same grade level, with same teacher, in same classroom has completely different experiences from year to year). Prior considerations of learning as complex have advocated for educators to integrate learning beyond the schoolhouse into heterogeneous and perpetually shifting environments and ecologies as a necessity for learning. Davis and Sumara (1997) called this learning outside<sup>17</sup> the classroom. Towards this shift they wrote:

Rejecting the cultural arrogance underlying the belief that the formal educational setting is the principal location for the study of cultural knowledge, we are suggesting that other sites be seen as places of teaching and learning: shopping malls, restaurants, food banks, retirement homes, churches, festivals, hockey games, etc. In our desire to separate the schooled experience from life outside the classroom, such locations have not been regarded as an integral part of who we are. Instead, inside the classroom they are named ‘the real world’, and nodding reference is made to this distanced realm through contrived word problems and fragmented discussions of social issues. Thus, at the same time that school and not-school are dichotomized, educators often delegitimize their own project by naming it as not part of the ‘real world’ (p. 122/3).

Separation between classroom learning *where* and learning outside the classroom *wheres* suggests an apparent irreconcilable challenge for educators in relation to how learning experiences are *useful* for *real world* life. The schism between classroom and *real world* learning can be observed via climatic differences between actual learning environments, ecologies, and ethics. In considering how each of the three “e’s”s complexify within learning experiences, class climate, as a map to approach learning, makes sense, and in turn, through this sense of motion mapped, we may be compelled to consider, with increased attention/intention, *where* learning occurs. Distinct parameters exist for the indoor classroom with respect to the 3 “e’s” as they describe indoor classroom climate and movement, and some of these are inherently impossible for an indoor classroom to escape (i.e. playing a very active running game in the indoor classroom is impossible, if not rather dangerous, but works in a gym, or on a school pitch outdoors). I/we have discussed the importance (and impact) of such constraints or contingencies on *wheres* as ethical predispositions in learning contexts (Banack & Bai, 2007) by considering *dis-position* as an example of ignorance of context (*where*). Juarrero (2000) reminded us that, while independent, all *wheres* remain constrained and contingent to some aspect of that *where’s* ontology. She wrote, “the establishment of context-sensitive constraints is the phase change that self-organizes the global level. Or, to put it differently, the self-organization of the global level is the appearance of context-sensitive constraints on the system’s components” (p. 26). Distinct learning climates have distinct context-sensitive constraints. There is just not the same movement in the indoor laboratory or classroom as there is in a forest or at the seaside. When indoor classroom or digital climate become severed from real world *usefulness* (observed in outdoor learning), *inert ideas* may result (Whitehead, 1967, p. 1). This paper particularly considers STEM *usefulness* as it applies to all learning *wheres*. Many context-sensitive constraints (cf. how indoor lighting or digital screens impact eye-sight, or how indoor air quality may reduce over time as mould grows, or how water quality may be impacted by materials used

for the indoor plumbing) contingent to the indoor classroom and digital climates limit “real world” nexuses, and thus may not be *useful*.

Sociologists of Association (Latour, 2005) consider all actors (living and non-living) as having agency in all situations, commenting on how *where* we are located embeds us in distinct climates. Knorr-Cetina (2007) wrote about cultures much in the manner in which climate is being suggested in this paper. “We can assume that agency is constituted differently in different cultures, as is personhood, subjectivity, collectivity and other cognates of the term. This implies that questions of agency, objects and their symmetry and conception cannot be decided theoretically by the analyst prior to fieldwork, but must be traced in the field. In real life, this matter gets complicated for several reasons. In the field, the categorisations of entities are open to semantic drift and reinterpretation depending on context.” (p.365). It is this complex movement of the real world, this drift and reinterpretation, that this paper (re)collects via weather and climate. Indoor classroom and digital learning experiences (classrooms, laboratories, science centres, museums, websites, etc.) decrease contact with an outdoor real world, and this, in effect, has deemphasized the relevance of real world outdoor climates and cultures in learning experiences, generating a negative feedback loop. Moving STEM learning experiences outdoors invites STEEEEM climates, robust with real world *usefulness*.

Of the breadth of iterations of the concept of *nature* that exist, the school indoor classroom or digital learning interfaces are not high on the list, if on the list at all (though some classrooms include plants and animals and many websites show images or videos of nature and nowadays, often, classrooms have devices that can be taken outdoors on sunny days, for a while, with care). Nature, while categorically different from outdoors, exists outdoors. There are particular indoor examples of nature (cf. mould again), but nature, by and large, is accepted as having an outdoor ontology. Outdoors is *where* much life lives and outdoors sustains (food primarily comes from outdoors, sunlight, air and weather, drinking water, etc.). Through the patterns this paper (re)calls, we are (re)minded that time spent outdoors (TSO) builds relationships with nature, fostering environmental and sustainability ethics and practices, along with making curriculum and pedagogy *meaningful* through locally relevant learning experiences. This paper aims to urge us to consideration the *where* of education as important, by emphasizing how outdoor *where* offers much *usefulness*, particularly for STEM learning.

Presently, much STEM discourse about STEM success is tethered to either economic and/or quality criteria. Thus generally, considerations around *where* STEM learning happens are evaluated in relation to these two. (Re)sultantly, *where* (re)peatedly goes un(der)noticed and under-(re)corded (e.g. hard data on where teachers are during learning experiences has not been gathered), when left to the caprices of individual teachers to implement, and under-supported by broader educational agendas items, with (re)spect to STEM. In light of all the TSO *usefulness* explored above, and in (re)cognition and (re)sponse to decries urging STEM learning to move beyond classroom and laboratory *wheres*, this paper invites re(consideration) of STEM to expand its criteria of assessment so that usefulness in STEM learning experiences may also be considered (re)levant, along with economic and quality measures. In this way, STEM complexity, observed via movement found in STEEEM as well as in the constellation of *useful*, may be more overtly acknowledged and appreciated.

While mounting energy is gathering for outdoor learning, place-based learning, and indigenous learning, without the establishment of a recognizable and unique domain for the *where* in learning and education discourse and practice, independent from the *what* (curriculum)

and *who/how* (pedagogy) of learning, outdoor learning findings may become *just another educational fad*. In reconceiving the *where* of education as a distinct ontological domain, novel opening occurs that acknowledges and legitimizes *where* as not only ontological but also epistemologically valid for learning experiences. STEM has much to offer and benefit in/with/from fostering reciprocal relationships that accept the educational *where*, particularly the outdoor *where*, as useful. STEM as a rigid concept is not *wise* (as both Tagore and Williams observed in their poems). STEM, disconnected from a learner's life, a real world, and assessed primarily via economy and quality, ignores seasonal indicators of *where*; those useful reminders to trees that, "stand sleeping in the cold". In aim and with movement towards this mark, seeing forest through trees, this case for *where* in STEM discourse and practice has been explored "in the dance of swaying branches."

## Notes

<sup>1</sup> This work has developed through various iterations. A version was presented at the 2016 CSSE conference in Calgary, Alberta. This is the re-worked introduction that accompanied that presentation- *All knowledge known by a knower becomes known somewhere*. It is here today, where you read this article, that this known *takes place*. What occurs here or not is *what happened*, and is truth. I would like to acknowledge the TssuTina Nation, whose ancestors have lived human lives with this land *where* we now gather, for millennia, and whose enduring presence brings much knowledge about this place.

<sup>2</sup> See Ingold, T. (2008). Bindings against boundaries: Entanglements of life in an open world. *Environment and Planning A*, 40(8), 1796-1810. doi:10.1068/a40156

<sup>3</sup> See Deleuze and Guattari - discussion of tracing in *A Thousand Plateaus* on p. 14. Deleuze, G. and Guattari, F. (1987) *A Thousand Plateaus*. Trans. B. Massumi. University of Minnesota Press: Minneapolis.

<sup>4</sup> Awkward, of the root *ward-* turning towards, offers an alternative turn.

<sup>5</sup> See Brundtland, et al. (1987). Our common future – aka Brundtland report

<sup>6</sup> See Gladwell, M. (2000). *The tipping point: How little things can make a big difference*. New York: Little, Brown and Company. Gladwell writes of the sticky factor in change processes.

<sup>7</sup> Again, notice the triad (3) imperative illustrated through the supporting examples chosen. The three factors used are examples, others could have been selected. Also note the thread running between the three e's and the three criteria for a discussion of *where*.

<sup>8</sup> Criteria- Assessment may continually be nested. For example, health & wellbeing, environmental & sustainability ethics practices, and learning *stickiness* all need to be measured, if deemed criteria for assessment. So, how these might be measured is a question (and demand) that leads us down the nested assessment path. In the spirit of this paper, conjure fractals or patterns in nature...

<sup>9</sup> Usefulness is used particularly (rather than utility, or other cognates) to invite a conceptual sense of what the word offers. *Use*: deemed of value, *full*: having the amount required and balancing between changes in amount demand, and *ness*: that sense of inclusion, as contingent, but far from precise or predictive. For this work, I have chosen three examples of *usefulness*, however this category is not limited to those three. *Usefulness* shifts as does weather. *Usefulness* is understood through pattern and as movement in relation to real world contexts and contingencies.

<sup>10</sup> The STEM Learning Ecosystem Initiative website landing page presents three large words: cultivate, learn, innovate; three criteria that together permit possibility for complexity.

<sup>11</sup> Bateson wrote: “Even grown-up persons with children of their own cannot give a reasonable account of concepts such as entropy, sacrament, syntax, number, quantity, pattern, linear relation, name, class, relevance, energy, redundancy, force, probability, parts, whole, information, tautology, homology, mass (either Newtonian or Christian), explanation, description, rule of dimensions, logical type, metaphor, topology, and so on. What are butterflies? What are starfish? What are beauty and ugliness?” (Mind and Nature, 2002, p.1-2).

<sup>12</sup> In Frédéric Gros’ text, A Philosophy of Walking, he discusses time spent outdoors as being reduced to an instrumental step (movement) in reaching the significant destination (often indoors).

<sup>13</sup> Lorenz (1972) described how a butterfly flitting its wings in one part of the world could be connected with a hurricane in another part.

<sup>14</sup> Consider Gadamer’s (2004) notion of play when he wrote in Truth and Method, “The fact that the mode of being of play is so close to the mobile form of nature permits us to draw an important methodological conclusion. It is obviously not correct to say that animals too play, nor is it correct to say that, metaphorically speaking, water and light play as well. Rather, on the contrary, we can say that man too plays. His playing too is a natural process.” (p. 104)

<sup>15</sup> See Bourdieu’s treatment of Discourse on Practice in an Outline to Practice.

<sup>16</sup> Note connections between the concepts *where* and *in situ*.

<sup>17</sup> Outside being another *where*, but not synonymous with outdoor *where*.

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