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Ecological concept development of preservice teacher candidates: opaque empty shells

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Аннотация

In the Ontario publically-funded school system, there are no provincial curriculum guidelines or distinct courses for Ecological Literacy. Rather, the Ontario Ministry of Education policy is that “environmental education” should be taught in all grades and all existing subject matter. Because there are no specific Ecological Literacy courses in the provincial curriculum, few programs in Ontario Faculties of Education exist to train teachers in Ecological Literacy. Thus, in this study, we examined what incoming teachercandidates from various disciplinary backgrounds know about general concepts of Ecological Literacy, as the expectation is that all teachers should teach “environmental education” in whatever subject area they end up teaching. Specifically we wanted to determine how teacher-candidates would define and explain various concepts with the presumption that these are the same or similar definitions they would be using in their own classrooms when they become qualified teachers.

Ключевые слова: Environmental Education, preservice teacher-candidates, ecological literacy, concept development, ecological education

Introduction

As ecological degradation becomes more pervasive, severe, and potentially intractable, implementing appropriate and effective policies to face these issues is more and more crucial. The ecological literacy of Canadian and world citizens is central to both the creation and implementation of such policy, because the change that is necessary must be well-informed and have the political will behind it to find implementation. We use the term ‘ecological literacy' instead of ‘environmental literacy' because the former more specifically refers to interconnected relationships of which humans are a part. Disinger and Roth's (1992, p. 2) generally well-accepted definition of environmental literacy demonstrates the subtle yet pervasive sense of humans as somehow separate from natural systems, but having a special stewarding role: “Environmental literacy is essentially the capacity to perceive and interpret the relative health of environmental systems and take appropriate action to maintain, restore or improve the health of those systems.” However, we do agree with the active portion of this definition of literacy, echoed and emphasized by St. Clair's (2003, p. 77) statement that “environmental literacy ... means developing and participating in the social practices likely to change the way our societies think about and act upon ecological issues.” Ecological literacy, as we define it, is a capacity, based on a comprehensive understanding of the interconnections between natural systems and human systems, required to make informed decisions about the future of life (Puk, 2009, p. 119). In our view, the term Ecological Integrity is a required accompanying behavioural term, meaning "to preserve the resilience of ecological systems and their capacity to assimilate and rejuvenate as they continue to change" (Puk, 2009, p. 120).

Ecological literacy, as alluded to, is not simply the amassing of knowledge. Piaget (1952, 1973) and Vygotsky (1978) offered foundational constructivist theory on conceptual development, arguing that children need opportunities to engage with their surroundings if they are to gain and develop the ability to abstract learning to novel situations, and apply such learning to new challenges. As Shayer (2003) pointed out, however, movement beyond Piaget's (1952) concrete cognitive operations requires that learning contexts which offer active exploration of learning materials are present. Vygotsky's (1978) notion of the zone of proximal development included the ‘teacher' (though this can be a text, peer

or cultural artifact) as part of the context, within which students learn through interaction with teachers that can help them to construct more sophisticated and complex organizations of conceptual understanding. Zhou, Nocente, and Brouwer (2008) found that pre-service teachers' 'preconceptions' of physics concepts were largely based on personal experience, which supports the constructivist notion that students must have experiences in order to form long-lasting concepts, which influence understanding and behaviour in novel situations. Stephen, Dixon, and Isenhower (2009) offered evidence for an understanding of concept formation based on the self-organization properties of complex systems (in this case, the complex system of a brain), that is consistent with constructivist principles. Their research demonstrated that exposure to experiences, which were either novel or incongruent with students' preconceptions of science concepts, led to peak entropy in their cognitive systems, which was followed by negentropy and the self-organization (creation) of new conceptual understanding. Further, Stephen et al. (2009) were able to demonstrate that accelerating entropy accelerated discovery through a re-organization (self-organization) of concepts. At the very least, then, the formation and development of ecological literacy as we have defined it requires extensive exposure to experiences and information that challenge preconceptions.

The education system has a central role in encouraging the growth of ecological literacy (Puk & Makin, 2006; Tuncer et al. 2009). In 1998, the Ontario Ministry of Education eliminated the Environment al Science secondary school curriculum guidelines (Ontario Ministry of Education, 1988a; 1988b), and instead directed that these concepts should be infused within other existing courses, such as biology, physics, chemistry and geography. A survey conducted subsequent to this policy found that very little environmental science was being taught in Ontario secondary schools (Puk & Behm, 2003). Puk and Makin (2006) subsequently found that 88% of a representative sample of elementary teachers in Ontario elementary schools (N=132) taught ecological education two (2) hours or less per week (34% responded zero (0) hours per week). As conceptual development theory and evidence suggest, such a lack of ecological education would lead to generally low levels of ecological literacy in Ontario students, some of whom will become the next generation of pre-service teachers. There has, though, been relatively little investigation assessment of ecological literacy in pre-service teachers. Peer, Goldman, and Yavetz (2007) found that

environmental literacy levels in Israeli pre-service teachers were generally low. Similarly, Tuncer et al. (2009) discovered that pre-service teachers in Turkey had low levels of environmental literacy, and correspondingly failed to perform high levels of ‘pro-environmental' behaviours. Only 49% of pre-service teachers achieved even a passing grade on Tuncer et al.'s (2009) main measure of environmental literacy.

There is ample evidence to suggest that such a lack of ecological literacy in pre-service teachers causes these students to avoid or reduce the amount of ecological education they offer
when they become teachers. Moseley and Reinke (2003) noted that even when pre-service teachers were confident about teaching environmental curriculum, their confidence plummeted after several weeks of actually teaching environmental science. The researchers surmised that their initial confidence was tempered by the experience of facing their actual level of environmental knowledge when in the field. Tuncer et al. (2009) demonstrated that low levels of environmental knowledge stunted the ability of teachers to promote environmental literacy in future students. Teachers self-reported to Puk and Makin (2006) that the number one reason for not including more ecological education in their classrooms was the absence of a distinct subjectmatter and curriculum guidelines in ecological education. Teachers stated that if ecological education was not a formal component in the provincial curriculum guidelines, they did not have time to include it in their daily lessons which were otherwise confined to existing subject-matter such as language, science, mathematics, etc. Other reasons included a lack of support and training to increase their knowledge.

In 2009, the Ontario Ministry of Education published a policy document stating that "environmental education'' should be embedded in all grades and in all subjects of the Ontario curriculum (Ontario Ministry of Education [OME], 2009, p. 12) rather than creating a distinct subject area in Ecological Literacy. However, since Environmental Science was removed as stand-alone courses (OME, 1998), Bachelor of Education teacher training programs in Ontario seldom offer specific ecological education courses, either for secondary specialists or the generalist. Since under the new policy all teachers are expected to ‘teach' environmental information in all subjects once in the classroom, the evidence suggests a vicious cycle. Because these teachers are exposed to low levels of ecological literacy or none at all, they may either not offer much by the way of ecological education to their students, or offer lessons that are based

in an inadequate understanding of ecological concepts and issues. This leads to insufficient exposure to ecological education for the students of today and tomorrow, and the cycle continues. Our concern is that pre-service teacher-candidates may complete their Bachelor of Education and enter into teaching roles with the level of ecological knowledge that they have acquired in elementary, secondary and undergraduate education, which is likely inadequate. This preliminary study, then, is aimed at assessing the ecological conceptual knowledge of such teachercandidates. We intend to assess the impact of participating in a pre-service ecological literacy course in a later study, comparing the students' pre- and post-course levels of ecological conceptual knowledge.

Participants

The study involved a cohort of fifteen teacher candidates entering into a nine month Bachelor of Education teacher education program in Ontario. There were nine (9) female, and six (6) male participants, with ages ranging from 22-33. Six candidates had undergraduate degrees in science (e.g. Honours Bachelor of Science, Bachelor of General Science), four had degrees in geography (e.g. Bachelor of Arts in Geography) and five had degrees in social sciences (e.g. Honours Bachelor in Social Work, Bachelor of Social Sciences in Religious Education). In total, 66.6% had degrees in either science or geography.

Methodology

The Concepts

During the first week of classes in September, the teacher candidates were asked to define nine concepts as they related to ecological education: The Environment, sustainability, green, fossil fuel, entropy, waste, ecological literacy, ecological integrity and ecological consciousness. The first six of these concepts were chosen for the study because they are found in various Ontario Ministry of Education curriculum guidelines within compulsory expectations and both teachers and students are required to understand and use these concepts. The latter three were included because they are featured in the teacher education program that these teacher-candidates were entering, as well as being embedded in the literature (Orr,

1992; Cutter-Mackenzie & Smith, 2003; Biriukova, 2005; Puk & Makin, 2006).

Concept Analysis

A form of qualitative content analysis (Graneheim & Lundman, 2004) was utilized to interpret and code these definitions. This is more broadly a form of discourse analysis as the text of the participants was parsed and categorized in order to understand the mental representations that the participants had for these concepts. The assumption in this form of concept analysis is "that reality can be interpreted in various ways and the understanding is dependent on subjective interpretation" (p. 106). Whenever discourse/text is examined, there is always a degree of interpretation.

In this study, the following methodological sequence was followed: a/ the teachercandidates were asked "what is it ? (provide a definition)'' in regard to each concept. These written responses became the "units of analysis". Concepts that were not defined at all were coded as such at this stage, b/ Within these units of analysis, "content areas"/criterial attributes were identified, each of which contain a nugget of meaning, c/ These content areas were then collapsed into "categories" (Amandin & Mintzes, 1986) and coded primarily on the basis of 1/ the number of similar and different criterial attributes in each definition and 2/ the degree of vagueness in the attributes, d/ Finally, "dominant themes" were formulated to signify the "thread of underlying meaning" found in each category.

A sample of how this process was utilized for all the concepts can be found in the following sequence for the concept of The Environment: a/ Identify Units of Meaning', some of the units of meaning for this concept included i/ "the physical world around us"; ii/ "all aspects of the natural world around us- air, water, soil, sunlight"; iii/ "an interconnected system including air, soil, water, plants, animals, earth, humans and all living and non-living things"; iv/ "it is everything (landscape, flora, fauna, humans, all elements) and how they interact with one another"; v/ the surroundings of where you live; before the and after urban; vi/ before it and after surroundings. It can be the physical, emotional, tactile or mental surroundings; b/ Identify Criterial Attributes'. criterial attributes were identified e.g. in i the whole response is one criterial attribute whereas iv has three criterial attributes: "it is everything", " how they interact", "with one another"; cl Determine Categories', i and ii referred to the physical world only (no reference to humans) and were placed in the same category; iii and iv referred to everything

including humans and were placed in the same category; v and vi were placed in the same category as they referred only to the surroundings of human beings; d/ Provide Themes', i and ii were given the theme of "systems in the natural world", iii and iv were given the theme of "everything", and v and vi applied to "human surroundings".

Unless there are specific courses in ecological literacy provided for teacher candidates, it is highly probable that these definitions would be the same or similar ones that they would be using to teach their K-12 students once the teacher candidates become qualified teachers after the nine month program.

Data and Analysis

The Environment

There are three main themes that the definitions given for "The Environment'' fall under: a/ systems in the natural world; b/ one's surroundings; and c/ everything i.e. natural and human systems. Seven responses (46%) described The Environment as involving elements of the natural world only e.g. "all aspects of the natural world around us- air, water, soil, sunlight". This would imply that the human-made world is not part of The Environment. Four responses described The Environment as being the human-based surroundings that influence human beings e.g. "it is what surrounds you. It can be the physical, emotional, tactile or mental surroundings". Four described The Environment as "everything" including natural systems and human beings e.g. "an interconnected system including air, water, soil, plants, animals, earth, humans and all living and non-living things". Many of the responses were not really robust definitions due to their vagueness e.g. "flora and fauna and everything that creates a setting" and "the world/surrounding/ habitat".

We would suggest that many of the responses were so vague because the term itself is dysfunctional. The definite article "The" gives the impression that The Environment is a geographical location as in "the Rocky Mountains" or "The Southern Hemisphere". This impression allows people to maintain a disconnected relationship with the natural world and ecological systems. It is as if there is a door labeled "The Environment" that people pass through as they enter and exit The Environment. This allows people the luxury to believe that they are only part of or need to take some responsibility

for natural systems when they are in The Environment and forget about it when they are in the human-made world. Thus the majority of teacher-candidates indicated that it was a physical space containing natural systems as opposed to anything to do with humans. The notion that The Environment is one's social surroundings dates back to the early 20th century when the debate over "nurture vs. nature" was popular. At that time, one's environment was the socio-cultural surroundings that influenced the development of people (Worster, 1994). Thus 11 of 15 candidates (73%) did not include both humans and natural systems in their definitions for The Environment.

The term "The Environment" is used constantly in the media on a global basis. Even though the Ontario Ministry of Education has many policy and curriculum documents that refer to The Environment, none of these documents defines what it is or where it is found. How can teachers of all courses teach concepts for which there are no definitions provided? In this particular case, we would suggest that the term The Environment should be phased out as it gives the impression that it is something separate from homo-sapiens.

Sustainability

This concept generated the 3rd most varied and dissimilar definitions. One teacher-candidate did not provide any response at all and another simply used the root "sustain" as a criterial attribute ("a concept to sustain the elements on earth") which doesn't provide a definition. Otherwise there were six themes for this concept: a/ leaving things the same (6 people (40%) in this category); b/ having the smallest impact (3 people); c/ protecting needs of future generations (1); d/ self- sustaining (1); e/ to continue without loss (1); and f7 create minimal waste (1). If one only had the responses to go on and did not know they were attempts to define the same concept of sustainability, it might be hard going to identify the root concept. However the vagueness of the responses was even more evident: "something that continues without any loss"; "to save or to sustain our human use on certain elements/products"; "self-sustaining systems which need not influence or alter of any kind to regenerate life cycles".

The large variances in responses and their degree of vagueness is once again an indication of the vagueness of this concept as it is used in the media, by governments, business and industry and by the

general public. The largest number of responses referred to behaviors and systems that keep things the same. However, one of the basic laws of ecology is that "everything is always changing'', thus trying to keep things the same is futile. The Ontario Ministry of Education does provide definitions for this term, however they are only found in the Science (K-12) curriculum guidelines. In the Grade 1-8 elementary science guidelines (Ontario Ministry of Education, 2007), sustainability is defined as "a process that can be maintained without interruption, weakening, or loss of valued qualities. Sustainability ensures that a population remains within the carrying capacity of its environment" (p.165). The grade 9-10 Science guidelines (Ontario Ministry of Education, 2008a), add the following to the definition found in the grade 1-8 guidelines: "The term is often used in reference to the ability to meet the needs of the present generation without compromising the ability of future generations to meet their needs" (p.102). The grade 11-12 Science guidelines (Ontario Ministry of Education, 2008b) define it as "the capacity to maintain a certain process or state indefinitely" (p.258). The term is not defined any other curriculum guidelines.

We would suggest this term is also problematic. Sustainability in terms of capitalism, for example, implies maintaining or keeping things the same, i.e. record profits for large corporations at the expense of ecological degradation. This would be consistent with the definitions provided in the Ontario Ministry of Education guidelines. None of these definitions explicitly refer to our entire dependence on the health of ecological systems. They are also quite anthropocentric when they suggest that something is sustainable when it protects the future needs of "people" with no reference to the needs of other life-forms. We would suggest that the term "ecological integrity" would be a much more focused goal for the global society, i.e. "preserving the resilience of ecological systems and their capacity to assimilate and rejuvenate as they continue to change" (Puk, 2009, p. 120).

Green (as applied to human use of resources)

This concept tied for the most varied and dissimilar definitions with seven (46%). First of all, four of the responses were classified as non or limited responses as one had no definition for this concept, one wrote "same as sustainable?", one wrote "sustainable" and one wrote "environmentally sustainable". The rest of the definitions resulted in seven different categories: a/ three referred to "ecologically friendly products" or "ecologically conscious decisions"; b/ two referred to "environmentally friendly" products or

decisions; c/ two referred to "limiting carbon impact" or "conserving energy"; d/ two referred to the use of natural resources that resulted in "limited" or "decreased waste"; e/ one of the definitions in (b) also referred to "cycling back into the environment"; f7 one referred to "thought given to the health of the environment"; and g/ one referred to "healthy products". Two of the definitions also added that the term "green" was used to "sell things" and to protect "the health of the environment- or so the ads would lead us to believe".

Once again, one would be hard pressed to know what concept was being defined with all these quite varied and dissimilar responses. Some refer to the health of "the environment" while others refer to healthy products. Some refer to limiting carbon impact while others refer to decreased waste. Some suggest that the term "green" is the same as sustainability, which as described above, is also dissimilar in its understanding. Not only were many of the definitions vague e.g. "altemative/healthy products and practices/behaviors", "environmentally sustainable/in support of a healthy enviro"; but this concept drew definitions that invoked even more complex concepts to define "green" e.g. "environmentally friendly", "ecologically friendly'', "ecologically conscious" which makes the definition of green just as opaque as vague definitions. Once again, while the Ontario Ministry of Education provides many documents and programs that use the term "green", there are no definitions provided in any of these policy documents, nor in any curriculum documents.

Fossil Fuel

There were three non-responses for this concept. There were also nine vague responses (60%) i.e. the responses given did not define the concept in a valid manner. These responses included "nonrenewable source of energy", "deposits of natural raw material found within the earth", "energy in the organic form of fossil energy", and "limited resource". One response referred to "billion year old swamp organisms mostly plant". One stated that a fossil fuel was "created emissions from vehicles". Only one response stated that these were carbon based energy sources i.e. "carbon based energy sources that were created over long periods of geological time by natural processes".

It may be somewhat surprising that this concept was so ill-defined, given that these are all university graduates and especially given the number of university geography graduates in the sample. This may be an indication of a much larger issue that our educational systems

use (presumably) well known terms and elaborate on various things about those terms but don't ever get around to spending time on understanding what those concepts are, i.e. without really defining them. The Grades 1-8 Science guidelines (Ontario Ministry of Education, 2007) does provide a definition ("carbon fuels that were formed hundreds of millions of years ago from the remains of plants and animals", p. 157) but no definition is provided in the Grades 9-10 and Grades 11-12 Science guidelines (Ontario Ministry of Education, 2008a; 2008b). None of the geography provincial curriculum guidelines provide a definition for this concept (Ontario Ministry of Education, 2004; 2005a; 2005b).

Entropy

Perhaps not surprisingly, this concept produced the highest number of non-responses, i.e. 10 plus one vague response, "what is given off or lost in a cycle". Thus 73% of responses were not definitions. One response simply referred mistakenly to the 1st law of thermodynamics e.g. "energy can neither be created or destroyed" and another simply stated "2nd law of thermodynamics". Only two responses stated that it was something to do with a transfer of heat or light e.g. "energy released as heat", "a release of energy through chemical reactions, metabolism, etc. Usually released as heat or light". None of the definitions referred to the various attributes of entropy as a universal force that degrades energy, reduces disorder and increases equilibrium in a closed system.

Entropy is a key concept in understanding ecological systems and human technologies. Although the concept itself is not used in any of the Ontario of Ministry of Education curriculum guidelines and there are no definitions for entropy provided in any of these documents, the concept of "energy transformations" and "energy efficiency" (Ontario Ministry of Education, 2008b, p.218), and "heat transference" (Ontario Ministry of Education, 2007, p. 135) are featured in the curriculum expectations. This is a very complex topic and requires specific, ongoing instruction to understand what it is and how it works.

Waste

There were seven different themes in the definitions for this concept, tied with "green" for the most. Three teacher-candidates used the word "useless" or "unusable" elements or products to

describe the concept of "waste'' e.g. "useless product that is not being used for anything and will not be used", "things that humans do not see a use for", "unusable elements/products". Three responses focused on the concept of "cycling" and described waste as anything that cannot "cycle naturally back into the environment", or cannot be "recycled or reused" or can't "biodegrade". Two responses simply said that waste was "human byproducts". One response stated that waste was "energy or matter that is not utilized in an effective manner". One response stated that waste was "excess use of materials, etc., by humans resulting in the excess being passed on to the enviro with no use". One response stated that waste was "non-renewable resources in an urban perspective". Only four teacher-candidates indicated that the concept of "waste" is a "human made concept" that "does not exist".

The term "waste" is used repeatedly throughout the Ontario Ministry of Education science and geography curriculum guidelines Grades 1-12, yet there is not one definition provided for teachers and students (Ontario Ministry of Education, 2004; 2005a; 2005b; 2007; 2008a; 2008b). Indeed everything on earth is made up of the elements and over time the natural world employs processes that will convert complex entities into their simpler components. We would suggest that the concept of "waste" is problematic in that it provides a rationalization as to why we can create byproducts that are simply dumped in landfills or storage areas without any further thought rather than creating systems that constantly cycle the elements back into use.

Ecological Literacy

Four teacher candidates provided no definition for this concept. Five candidates described ecological literacy as "knowledge of' or "understanding of' "natural systems" or "the environment e.g. "Being able to understand and regurgitate information about the environment". Three candidates broadened the emphasis of not only understanding but being able to do something with that understanding e.g. "understanding and being able to interpret the natural world and its complexities". Two candidates referred to being educated in natural processes e.g. "being educated in ecological processes and systems". One response simply wrote "same as ecological integrity and consciousness?"

The Ministry of Education does not use the term "ecological literacy" in any of their curricular documents. "Environmental literacy" is used in one of its policy documents i.e. "An

environmentally literate student will have the knowledge and perspectives required to understand public issues and place them in a meaningful environmental context" (Government of Ontario, 2007, p.6). Puk (2009) has suggested that ecological literacy is more so "a capacity to make informed decisions about the future of life based on a comprehensive understanding of the interconnections between natural systems and human systems" (p. 119), rather than simply knowing facts about ecological systems.

Ecological Integrity

If all teachers are expected to be teaching ecological education, then they are going to require a solid foundation in concepts beyond those just of physical processes. Educators will need to understand the overarching aims of ecological education in order to ensure that the programs, courses, units, lessons and topics that develop emanate from a well defined core. In regard to defining "ecological integrity", there were two teacher candidates that provided no definition. Five candidates provided vague responses which are not really definitions, e.g. "knowing and seeing everyday processes or environmental issues that surround us", "the intensity in which ecology plays an important part of your life", "being informed about the functions of our ecological environment", "being considerate of the environment". One candidate simply said
"this is being green'' (this same candidate defined green as being "sustainable" and sustainability as "a concept to sustain the elements of life on earth". We will comment later in this paper about the serious limitations of this tautological or reductionist pattern of defining some of these concepts). Two candidates used the world "sustainable" to define ecological integrity as in "the quality of the area as natural and sustainable". Four candidates described ecological integrity in the sense of maintaining natural systems as they are found, e.g. "maintaining an ecological system so it will continue to produce at its natural rate". Only one candidate referred to this concept in terms of the resilience of natural systems i.e. "the strength, diversity, and resilience of an ecological system".

We would suggest that ecological integrity is the paramount meta-challenge we face in the 21st Century as a global community, i.e. "to preserve the resilience of ecological systems and their capacity to assimilate and rejuvenate as they continue to change" (Puk, 2009, p. 120). The Ontario Ministry of Education does not use this meta-concept in any of its policy or curricular documents. Without this

overarching goal, teachers lack the purpose of ecological education and a clear focus for developing their curriculum.

Ecological Consciousness

Two candidates did not provide a definition for this concept. Seven candidates (46%) referred to knowing what impact living our lives has on natural systems or "the environment" e.g. "the understanding of ones own/groups impacts on natural systems". Interestingly two candidates said that ecological consciousness had something to do with right and wrong without any indication of what that might be e.g. "knowing and following through with what one knows is right or wrong. And doing what is right"; "knowing what is right for sustained living". One candidate stated that ecological consciousness was about "...understanding our place in the overall ecological system", while another defined it as "...how aware one is of the environments issues". Three felt that it was about awareness or understanding of ecology, e.g. "...awareness of ecological concepts, relationships, issues, effects". One participant simply said "same as above", referring back to their definition for ecological integrity.

Once again the responses were quite varied. Some focused on having an awareness of ecological knowledge, others on issues, others on place, some on a notion of right and wrong and others on the human impact on the natural world. The Ontario Ministry of Education does not use this term in any of their curricular or policy documents. We see Ecological Consciousness as a meta-term, signifying "the human condition in which all daily behaviours are viewed through a lens of ecological literacy and responsibility such that these behaviours form an ecologically beneficial lifestyle" (Puk, 2009, p.115). Developing ecological literacy is a vital part of the process of developing ecological consciousness.

Meta-Analysis

1. Broad range of different meanings.

What we found in the teacher candidate definitions was a very broad range of meanings for each concept, many of which were completely opposite to each other (Table 1). The concepts of "green", "waste" and "sustainability" had the widest range of variability. By variability or different, we don't just mean that the words in the definitions were different but rather that the meaning was different

for these concepts. None of the definitions had a dominant theme that 50% or more of the teacher-candidates described. Even though the range for the concept of "The environment" was relatively small (three themes) the theme that most candidates (46%) described did not include human beings in the definition but rather saw "The environment" as a place or space in nature. This variation in meaning is not helpful at a time when we need to be taking action to resolve serious global ecological degradation. We also found a high degree of vagueness in most of the responses. Many of the definitions were so poorly stated as to not really result in a definition and therefore not allowing for meaning to be derived from the definition. This vagueness suggests a lack of robustness in the preconceptions and/or misconceptions that many people possess (Chi, Slotta, & de Leeuw, 1994). While the study is of a small sample size, we believe the results are representative of the general teacher-candidate population.

Table 1. Summary of definitional analysis

Total number of concepts in the survey	9
Total number of concepts without definitions	23 out of a total of 135 possible definitions
	17%
Concept without a definition the most	entropy, 10/15
	ecological literacy, 4/15
Most common concepts used to define other concepts	The environment, 25
	sustainable, 10
Concepts with largest number of different themes	green and waste, 7
	sustainability, 6
Concepts with largest number of the same theme	ecological consciousness and The environment, 7 definitions of the same theme each
Concept with the largest number of vague definitions	fossil fuels, 9
Number of definitions for these concepts found in Ministry of Education documents	2; two different definitions for sustainability are found in Grade 1-12 Science guidelines; a definition for "fossil fuel" is found only in the Grade 1-8 Science guidelines

2. No distinct courses in ecological literacy in the Ontario provincial curriculum

There are no distinct courses in the Ontario curriculum in regard to Ecological Literacy. We define Ecological Literacy as "the capacity, based on a comprehensive, gestalt-like understanding of the interconnectedness between natural systems (air, water, soil, energy, biodiversity and population) and human systems, required to make informed decisions about the future of life. " (Puk, 2009, p. 119). After an absence of a decade, there are two new courses in Environmental Science, both at the grade 11 level (really one curriculum adapted for university bound students and another for workplace bound students), in the Science guidelines (Ontario Ministry of Education, 2008b). Geography curriculum guidelines contain some of the concepts taught in this survey but few definitions or explanations are provided. However, we suggest that Ecological
Literacy is a meta-discipline and cannot and should not be confined to any one existing discipline but rather "Ecological Education should be developed as a meta-perspective, composed of an enriched subject-matter including sciences (geography, biology, physics, chemistry), history, arts, mathematics, language, economics, health, philosophy, aesthetics, and ethics'' (Puk, 2009, p.98).

3. Lack of concept definitions in Ontario provincial curriculum guidelines

Because of the lack of teacher training in Ontario in regard to ecological literacy, few teachercandidates graduate with a deep and comprehensive understanding of ecological concepts. All teachers are now expected to integrate these concepts into existing curriculum. While curriculum guidelines require teachers and learners to understand and use these concepts, the guidelines seldom provide explanations of these concepts. As demonstrated by the data, topics that do appear in the provincial curriculum guidelines (e.g. sustainability, 'green[1]) and those that do not (e.g. ecological literacy, ecological integrity), were both defined with great variability and lack of clarity. Without clear definitions it is difficult to imagine how teacher candidates will present these topics to their future students in any useful manner.

4. Lack of teacher training in ecological literacy

Because there are no distinct courses in the Ontario curriculum on Ecological Literacy, there are, and have been, few courses offered in Ontario Faculties of Education for preservice students. Some students may receive some training in some concepts in various courses such as science and geography but most will develop only a cursory understanding of a few disconnected concepts. Because there are no distinct courses on Ecological Literacy in the provincial curriculum K-12, Faculties of Education place little emphasis on providing distinct courses in Ecological Literacy. Thus, most teacher candidates will pass through teacher training and for the most part take these vague, limited and incorrect understandings into the classroom when they become teachers (as the Ontario Ministry of Education policy says that "environmental education" should be taught in all subject-matter) and pass on these same misunderstandings to their students as this cycle will continue to repeat itself. As Gregoire (2003) stated "teacher education programs are failing to do their job if perspective teachers enter into teaching with their initial beliefs intact" (p. 149).

5. Lack of instruction in the ability to define concepts

Not only did teacher candidates not appear to have strong understandings of various concepts as they relate to ecological literacy, they also appeared not to know how to formulate clear definitions, e.g. by using a/ propositions- criterial attributes that describe something that resulted from the concept, i.e. something about the concept, rather than what the concept is; b/ complex criterion that would require their own definitions (e.g. sustainable to describe "green"); c/ redundant criterial attributes that repeat the same meaning; and d/ vague criterial attributes that are so loosely constructed to not express decipherable meaning (Robinson, Ross, & White, 1985; Puk, 1997). This may indicate an absence of exposure in their previous schooling to the ability to define concepts, an absence of the skill of concept development in provincial curriculum guidelines and an absence of teaching how to teach the skill of concept development in teacher training programs. Declarative definitions contribute to the foundation for procedural knowledge and have "the advantage of being compact, yet precise and general" (Reif & Allen, 1992, p. 13). Without precise definitional knowledge of ecological concepts, application of that knowledge may lead to faulty

solutions and misdirected behaviors. It is disturbing to realize that what Reif and Allen found in 1992, i.e. that the central problem of misinterpreting scientific concepts was
"due to the fact that prevailing instruction does not adequately teach the underlying kinds of knowledge... required for the effective interpretation of scientific concepts'' (p.37), still appears prevalent today.

6. Ecological linguistic reductionsrrT

We also found evidence of a much broader tendency that we feel is also present in the general population, i.e. a kind of linguistic reductionism. Terms such as "The environment", "sustainability or sustainable" and "green" are simple (i.e. non-academic, non-scientific) words that attempt to describe very complex natural systems or human processes. Because there does not seem to be a strong emphasis in schooling to define concepts, i.e. to describe what something is, rather than using a word or a phrase to describe complex behaviors, we tend to throw around words carelessly. Within this phenomenon of "ecological linguistic reductionism", all the specific details that are part of the whole are omitted in place of single words or phrases. Terms such as "The environment", sustainability" and "green" become "opaque shells" that a/ the listener cannot see into (because of the fuzziness caused by trying to reduce complexity into simplicity), and thus cannot know what meaning is inside the shells, and b/ the speaker can utilize without having to really think about what meaning they have for the concept-the fuzziness serves their purpose of not having to think too deeply. Thus, in this study, the terms "The environment" was used 25 times and "sustainability" or "sustainable" 10 times to define other concepts in the list. However we also found that the opaque shells were actually empty in many cases as many definitions had no responses, vague responses or responses that demonstrated limited understanding. As stated previously, one candidate described "sustainability" as "a concept to sustain the elements of life on earth", then said the definition for "green" was the same as "sustainability", and "ecological integrity" the same as "green". Thus without really knowing what these concepts may signify, a teacher-candidate can appear to converse intelligently about various topics by simply invoking these concepts interchangeably. The real danger is that these "opaque empty shells" then get tossed around indiscriminately until a kind of "Tower of Babel" communication

results - everyone nods their heads without knowing the meaning behind the words. Concepts provide the bridging between the mind and the external world in order to create a "mind-world whole" (Gabora, Bosch, & Aerts, 2008, p.95; Bosch, 1999). If this bridging is faulty, how then can the individual participate in the global conversation in regard to ecological degradation in a meaningful manner? Without pre-service courses specifically focused on Ecological Literacy where these limitations can be addressed, it is quite probable that teacher candidates will become classroom teachers who will teach elementary and secondary school students about ecological concepts for which the teacher does not have precise declarative knowledge and does not realize their own limitations.

Conclusions

The lack of clear understandings of concepts central to understanding how natural systems work, how human processes impact these natural systems, and central to teacher education and ecological literacy, is disconcerting at such a critical juncture of global ecological degradation. Teacher candidates are the future teachers of students who are the future citizens who will impact ecological degradation the most in the future. Teacher education is the nexus for ecological integrity. How can we discuss solutions for ecological degradation if we are primarily passing around "opaque empty shells"?

Recommendations

1. Research is needed to assess the impact of taking pre-service courses in Ecological Literacy. We will be comparing pre- and post-course definitions in a cohort of students presently taking an Ecological Literacy pre-service course.
2. Comprehensive and in-depth courses in Ecological Literacy should be required for all teacher candidates in teacher education programs.
3. A focus on ecological concept development should be a central component of K-12 schooling and teacher education programs.
4. Due to the lack of robust definitions provided by our pre-service teachers, who are the products of the 'diffusion' model of teaching ecological concepts, Ecological Literacy as a

distinct metadiscipline should be created K-12, with associated provincial/state curriculum guidelines and compulsory, daily ecological literacy.

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