

Regression from meaning? Ecological concepts as opaque empty shells–Redux

Tom Puk ^{1*} 

¹ Faculty of Education, Lakehead University, Thunder Bay, ON, CANADA

*Corresponding Author: tpuk@lakeheadu.ca

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ABSTRACT

In 2000 the Ontario Ministry of Education decided to integrate environmental education into all subject areas rather than create a distinct, compulsory subject area K-12 for ecological literacy. The current study is a follow up to a 2010 study to determine whether the ability of teacher-candidates to define key ecological concepts has improved over the previous fifteen years while they were students during the Ontario Ministry of Education's policy of integration. The results of the current study are very similar to that of the 2010 study. For the concepts of the environment, sustainability, green, fossil fuels, and entropy, there were no consistent shared definitions for any of these concepts. Teacher-candidates appear to have quite varied understanding of these concepts. The suggestion is made that the results of both studies may indicate a "regression from meaning" and that for many teacher-candidates the words they use often represent "opaque empty shells."

Keywords: meaning, communication, teachers, education, concepts, ecology, literacy

INTRODUCTION

"When I [emphasis added] use a word, Humpty Dumpty said in rather a scornful tone, it just means what I choose it to mean—neither more nor less" (Lewis Carroll, 1871, *Through the Looking Glass*, p. 188).

Words, concepts, definitions, meaning. What is at the heart of understanding a topic? What is a definition and what role does it play in meaning-making? How should it be presented during instruction? What (if any) is the value of a definition? These are some of the questions that will be addressed in this paper as they apply in particular to K-12 and university education.

BACKGROUND

In 2010, we conducted a study of preservice student understandings of specific ecological concepts (Puk & Stibbards, 2010). This was a response to the Ontario Ministry of Education eliminating *environmental science* from the secondary curriculum in 1999 and 2000. This curriculum guideline was the main instrument that attempted to prepare teacher-candidates to teach their own eventual students about the human-nature relationship and the harm that human

behavior was having on that relationship, presently and in the future. As a consequence of that action by the Ontario Ministry of Education, I and others attempted to advise the Ontario Ministry of Education that rather than eliminating this key subject area at a time of an increasing global concern about our human relationship and use of natural processes, that a comprehensive and compulsory new subject area of ecological literacy be created K-12. The Ontario Ministry of Education chose instead to "integrate" environmental education expectations (i.e., objectives) into other existing curriculum subject areas rather than creating a specific, discrete subject area. The goal of the 2010 study was to examine how successful the government's "integration" policy was in creating ecologically literate graduates of the Ontario public school system.

The 2010 study asked preservice students entering into an ecological and experiential education specialization to define specific concepts including the environment, sustainability and 'green' (as in, for example, green economy). These three words in particular were by then used regularly in media, textbooks and everyday language. Students' prior knowledge has long been known to be a critical influence in acquiring an understanding of, in particular, scientific concepts. However, too often "there is an assumption that the terms are so widely used, everyone has a shared understanding of the terms" (Stichler, 2018, p. 6). Thus it is important to know what misconceptions (Suprpto, 2020) or alternative conceptions (Wandersee et al., 1994) students might have prior to

instruction in order to bring about conceptual change through teaching/learning strategies that target these alternative conceptions (Henson, 1983). What the study uncovered was that there was no consistent, shared understanding of these often used words by teacher-candidates who were themselves graduates of the Ontario public school system and the integration policy. And that, in fact, these words were used by these students as if they were “opaque empty shells” (Puk & Stibbards, 2010, p. 461). Specifically, the words the teacher-candidates were effortlessly using in their everyday conversations were more like shells that prevented the receiver from looking through to determine what was meant by these words. When examined closely, they were empty of any specific, consistent, shared meaning (more on the specific findings of that study when I compare the present study with the 2010 one further in this paper).

Thus, the current study is a fifteen year follow-up to the 2010 study in order to determine whether or not graduates of the Ontario public school system, i.e., the now teacher-candidates, could define these concepts any more consistently than teacher-candidates fifteen years prior.

What is different about the two studies is that the current one also involves Master of Education graduate students, all but one of whom are international students from India, China, Sri Lanka and Bangladesh. These students also defined the same concepts as the BEd teacher-candidates.

However, we must first define what a concept and a definition are in order to understand what they do or should do. Podsakoff et al. (2016) described a concept as “cognitive symbols (or abstract terms) that specify the features, attributes, or characteristics of the phenomenon in the real or phenomenological world that they are meant to represent” (p. 161). As mental models, concepts are “personal and intrinsic representations of external reality the people build to make sense of the world” (Donmez & Gulen, 2023, p. 57). I would add that a concept represents all of the features of the phenomenon in order to contrast it with the definition of a concept which is a concise statement describing the essence of the concept. “Concepts distill the entire set of observables into narrow, socially constructed groupings and categories” (Kamalova, 2023, p. 73).

We can go back as far as Aristotle who described a definition as “a formula in words that tells us what the object of definition is” (Deslauriers, 2007, p. 1) and that it is fundamentally “a statement of essence” (Cassidy, 1967, p. 109). Today we might describe the essence of a concept as criterial attributes, the characteristics of an entity that makes it different from other entities. Robinson et al. (1985) described a definition as a mental structure that contains representations of the criterial attributes (i.e., the defining characteristics) of a class of things and of the rule that relates these elements to each other.

Abbott (2002) argued that all departments of thought that are referred to as a discipline must be governed in turn by “a discipline of language” (p. i). Everyday language is most often not disciplined but uses words in a loose and indiscriminate manner, “talking ‘around’ key terms rather than being precise” (Marr et al., 2021, p. 1092). This often leads to confusion with no definite outcomes (Abbott, 2002, p. ii). However the more

complex the concept, for example biodiversity, the greater the need to have an adequate understanding of what it signifies as opposed to perhaps everyday language. Thus the purpose of a robust definition should be to provide some degree of discipline to discourse in order that a shared understanding of concepts may potentially lead to successful decision-making. Without this, we are often dependent on a perceptual interpretation of what we see or hear. It is also important to note that criterial attributes can be described using different words that have similar meanings.

It is also important to distinguish between the concept, which exists as a mental model, from the concept name, for example government and the concept definition which might be described as an organized extraction of that mental model into external discourse.

MATERIALS AND METHODS

The study of BEd teacher-candidates’ understanding of concepts involved three sections of the same course, Environmental Education in their final year of a two-year degree program taken after they had acquired their first university degree. Thus, they were in their sixth year of university. These three sections had a total enrollment of 98 students. The graduate student definitions were administered to students in two different Master of Education courses, ‘ecological consciousness’ and ‘ecological integrity’, with a total enrollment of 47. Thus, the complete study involved a maximum of 145 university students. In each course or section, definitions were collected over a period of two classes in order to not overwhelm the students at anyone sitting and not take up too much instructional class time. The author made sure that the specific definitions were administered prior to the concepts being introduced during the courses. Students were also required to turn off any electronic devices prior to writing their definitions on paper. Students were advised that they did not need to sign their names and that results had no bearing on their final course marks.

Concepts

The concepts being defined were the same ones defined in the 2010 study: the environment, sustainability, green (as in, for example, green energy, green economy), fossil fuels and entropy. The first four concepts are found either in Ontario Ministry of Education curriculum guidelines and/or teacher instruction, and/or textbooks as well as in media and everyday discourse. Entropy was chosen because it would be studied in the courses in which the teacher-candidates and graduate students would be enrolling.

Concept Analysis

For the purpose of making sure that the same parameters and practice were utilized and a fair comparison was made, the methodology used in the current study was also used in the 2010. This involved a qualitative content analysis (Graneheim & Lundman, 2003) in order to interpret and code the definitions. As a form of discourse analysis, the written text of the participants was parsed and categorized in order to

understand the mental representations the participants had (if any) for these concepts.

The methodological sequence followed was such that: a/ the teacher-candidate was required to respond to the prompt for each concept, “what is it?”, in order to provide a definition that indicated their understanding of the concept in question. These written responses became the “units of analysis.” Any concepts that were not defined were coded as such at this stage; b/ content areas within each unit of analysis were then identified and then c/ collapsed into “categories of meaning” and coded on the basis of

- (1) the number of similar and different criterial attributes and
- (2) the degree of vagueness in those attributes; d/ dominant themes were then formulated to signify “the thread of underlying meaning” found in each category (Puk & Stibbards, 2010, p. 464).

Discourse analysis is, by nature, subjective and always reflective of a degree of interpretation.

RESULTS

The Environment

As in the 2010 study, three themes emerged from the data analysis. The dominant theme, as defined by 37.4 percent of the responses, described this concept as being the natural world only—involving trees, air, water, soil, etc.—but humans were not included in this theme. This was the most dominant theme in both the BEd responses (39.5%) and the MEd responses (33.3%). In the 2010 study, the “natural world only” theme was also the dominant theme. In the current study, 22.9% of the responses stated that the environment was an “area” that involved a relationship between both humans and the natural world. Eighteen percent stated that the environment was the human “surroundings” that impact humans such as social relationships, education, health-care, etc. This is an older wording describing “one’s environment” rather than “the environment.”

However the third largest category of responses at 21.3% represented vague wording that didn’t actually define the concept, for example one word responses such as “the atmosphere” and “mother nature.” The fact that there are three quite distinctly different themes and the fact that the second largest theme involved vague, non-definition responses, this author would argue, is because the wording itself is dysfunctional. The definite article “the” signifies the grammatical distinction that there is a definite place called the environment similar to the Atlantic Ocean, the Alps, the City of Beijing. Thus, many people think of the environment as being a physical space—the wilderness, lakes, trees—but not the urban area where they live. This thinking is found in everyday language of media, education, books, etc., which often refer to the environment as being distinctly separate from the economy, education and healthcare. It helps create an atomistic ontology in which there are separate, distinct categories of human existence rather than understanding that everything is interconnected; that economy, education, health-care and daily living, no matter what physical and

geographical location an individual finds themselves in, is integrally intertwined with our relationship to natural processes. ‘They’ are really ‘one’. Unfortunately, little has changed in the discourse in the preceding fifteen years since the 2010 study.

Sustainability—The Humpty Dumpty Concept

This concept generated the most varied and distinctly different themes, even after collapsing a number of similar ones into a theme, with a total of 8! Thus, we might refer to it as the ‘Humpty Dumpty’ concept (refer back to the opening lines of this study), i.e., “it means just what *I* [emphasis added] choose it to mean, neither more, nor less” (Lewis Carroll, 1871, p. 188).

However, Alice’s response to Humpty Dumpty was, “the question is, said Alice, whether you *can* [emphasis added] make words mean so many different things” (Lewis Carroll, 1871, p. 188).

It is interesting to note that Lewis Carroll (i.e., Charles Dodgson) was an academic working in a university. As a mathematician, he may have been expressing his exasperation through the voice of Alice, with his perception of the undisciplined language of his time when he wrote these words. The eight themes for sustainability include:

- (1) keeping things the same,
- (2) something we can reuse again in the future and it lasts a long time,
- (3) choices with little to no effect on the environment,
- (4) less negative effects on the environment,
- (5) saving natural resources,
- (6) related to survival on earth,
- (7) perfect conditions with no bad changes, and
- (8) living within our means and avoiding errors.

The theme (2) with the highest number of individual responses at 25% was “something we can reuse again in the future and lasts a long time.” Some of these themes, such as “perfect conditions with no bad changes” (2%), don’t represent anything remotely possible given earth’s geological history. However, the category that scored the highest was vague responses at 39%; almost four out of every 10 responses! Examples of vague responses included “the act of conserving [sic]”, “reducing your means to be environmentally conscious” and “the way in which an environment is able to sustain and maintain progress and life.” Thus, not only is there no one dominant consistent definition of this word in the teacher-candidates’ minds, most didn’t have any kind of a definitional response. There was very little substance to the words students use. And there was also little difference in the total number of vague responses between the BEd (36.7%) and MEd (39%) students’ responses.

Green

There were five themes for this word:

- (1) less impact on the environment [presumably, less compared to non-green actions] and being mindful of the environment,
- (2) actions that benefit the environment,

- (3) healthier lifestyles,
- (4) producing energy efficiently, and
- (5) a mental state of thinking about the environment.

An individual who thinks of green as involving healthier lifestyles and another who views green as producing energy efficiently, would appear to have very different meanings for this term. However, these five themes only represented 37 of 134 student responses! Ninety-seven responses (72.4%) were in the vague category. In other words, when listening to conversation that involves the word green, almost three-quarters of these students may have all kinds of disconnected, fleeting words swirling in their minds, yet most perhaps assume that their interpretation is similar to everyone else's (more on this in the discussion section). Examples of vague responses included "something eco-friendly", "being environmentally aware", "alive", and "nurturing." There was little difference in the number of vague responses between the graduate responses (77%) and the teacher-candidate responses (71%).

Fossil Fuels

There were seven varied themes for fossil fuels:

- (1) carbon-based fuels made by natural processes over long periods of time (9 responses),
- (2) materials produced over long periods of time,
- (3) provide energy from dead animals and plants,
- (4) fossils from remains of creatures,
- (5) chemicals for burning,
- (6) energy that originates underground, and
- (7) energy from petroleum.

All seven of these themes represented 19% (44 of 142 responses) of the total responses. Non responses represented 7.7% of responses. The largest category by far was vague responses with 61.2% (87 responses). Examples of vague responses included "biowaste of organisms and plants", "cannot be recreated", "non-renewable resource", "coal that is burnt for energy", "fuels from fossils." Quite often examples of fossil fuels are given such as coal as the only response. However, examples are not definitions. They don't tell us anything about the category of fossil fuels. It might seem surprising to the reader that a word that is in the common, almost daily vernacular of media and general public conversation, is so poorly understood. However, the results more importantly speak to the lack of disciplined language in the K-12 schooling and university degrees (more on this in the discussion section).

Entropy

Once again, entropy produced the highest number of non-responses, i.e., 71.5% or 98 of 137 responses. This is very similar to the 2010 study, when non-responses represented 73% of the total responses. However, there were also 23 (16.8%) vague responses in the current study. An example of a vague response was "heat" and "the principle of disorganization." While these results are not unexpected, as this is a complex scientific topic, it is a critical concept in understanding one of the most fundamental forces that influences earthly existence as well as the universe. In

addition, there were six themes from the few responses (16, 11.6%) that provided definitions. These varied themes included:

- (1) the rate of imbalance,
- (2) rate of disorder,
- (3) universal force that degrades energy,
- (4) unavailability of thermal energy in the system,
- (5) chaos, chaotic energy, and
- (6) amount of disarray of a system.

Summary of Results

After fifteen years since the 2010 study on concept development, the results are remarkably quite similar. There were no consistent, shared definitions for all five concepts provided by the teacher-candidates. In the responses that were provided, definitions were quite varied and, in many cases, opposite meanings were given. However, the largest category of responses in three of the five concepts were either vague, sustainability 39%; green 72.4%; fossil fuels 61.2%; or no definition was provided: entropy 71.5%.

DISCUSSION

1. In the Ontario K-12 curriculum guidelines there are few comprehensive, consistent definitions of the concepts featured in this study, even though the words themselves are included.

There is no specific focus nor value on the critical role that understanding definitions plays in meaning-making. There are no methodologies provided for teachers to emphasize concept development in these curriculum guidelines. There are no models for the self-directed development of concept definitions by students to help them explore for themselves the quality of meaning provided in the material they read or listen to in conversations (a more in-depth review on instruction of concepts can be found in Puk and Stibbards (2010, 2011, 2012) and Stibbards and Puk (2011).

The grade 11 and grade 12 *science curriculum guidelines* document (Ontario Ministry of Education, 2008) does list fundamental concepts to be taught in the two environmental science courses. However, in the specific expectations (i.e., objectives) for each course, there is no mention of acquiring definitions for these and other concepts included. Instead, a few specific expectations state that by the end of the course, students will "use appropriate terminology", e.g., "relating to the environmental impact of human activity, including but not limited to carbon footprint, carbon neutral, biodegradable, biodiversity, carrying capacity, sustainability, and invasive and native species" (p. 168), etc. However, appropriate terminology can be easily **used** in any scenario without understanding what the concept **means**. There is no emphasis in the Ontario curriculum guidelines on defining the critical attributes of, for example, "biodiversity" and "sustainability."

Similarly, in the *geography curriculum guidelines* (Ontario Ministry of Education, 2013) expectations state, for example, that students should "use the concepts of geographic thinking when analyzing and evaluating data and information,

formulating conclusions and making judgments” (p. 72), and “apply the concepts of geographic thinking when analyzing current events” (p. 73). Once again, one can “use” concepts and “apply” concepts without necessarily knowing what they mean.

However, in the previous set of *environmental science curriculum guidelines* (Ontario Ministry of Education, 1988), requiring students to define key concepts was a requirement in most curriculum units, e.g., “explain the meaning of the terms aerosol, dust and mist”; “describe the meaning of threshold limit value” (p. 43); “explain the meaning of the terms pollination and in-line meaning” (p. 45). An emphasis on concept meanings eroded in the series of curriculum guidelines from 2000 to the present. It is important to note that the three concepts of the environment, sustainability and green did not exist at that time of the 1988 curriculum guidelines!

2. As stated earlier, rather than creating a distinct curriculum guideline for ecological literacy, K-12, as was recommended by many advocates, the Ontario Ministry of Education chose instead to ‘integrate’ environmental education into all courses K-12.

After the 2010 study (Puk & Stibbards, 2010), the Ontario Ministry of Education produced two documents called *Environmental education scope and sequence of expectations, grades 9-12. A resource guide* (2017a) and *Environmental education scope and sequence of expectations, grades 1-8 and the kindergarten program. A resource guide* (2017b).

As is stated in both documents,

“... the Ministry of Education has ensured that environmental education is included in all grades and in all subjects of the Ontario curriculum, as appropriate ... The scope and sequence resource guides for kindergarten to grade 8 and grades 9 to 12 identify these embedded expectations with the aim of assisting teachers in bringing environmental education into the classroom and every subject area and discipline” (Ontario Ministry of Education, 2017b, p. 3).

On the surface this might appear to be an effective policy. However, it is important to note that these documents are resource guides, not curriculum guidelines. Secondly, the expectations in these documents were taken from each existing curriculum guideline in each subject area. There is no environmental education curriculum guideline! These expectations are simply sprinkled as content into biology, physics, mathematics, etc.

3. Regression from meaning: Vague or non-responses

The first three concepts of the environment, sustainability and green were used extensively in defining each of the other two concepts. They have become the ‘mean’ in this and the 2010 study that the teacher-candidates use in defining each concept, and no doubt in their conversations. For the sustainability responses, the terms such as “to sustain”, “green”, “environmental effect”, “environmental consciousness”, “the environment”, and “environmental” were used in the definitions for sustainability 34% of the time (i.e., 45 out of 132 responses). Rather than using criterial attributes that might be distinct to this concept, variations of

environmental and green were used instead. For green, terms such as “environmentally friendly”, “no harm to the environment”, “environmentally aware”, “living positive for the environment”, “sustainable”, “environmental consciousness”, and “sustainability”, were used 53.7% of the time (i.e., 72 responses out of 134 total responses). These three words have become the mainstay in the teacher-candidates’ discourse, representing a form of “ecological linguistic reductionism” (Puk & Stibbards, 2010, p. 472).

4. Regression from meaning: The source

Regression from meaning involves moving away from the value and practice of ensuring in-depth understanding of the concepts we use to shallow, surface level meaning-making. The user becomes disenfranchised from meaning-making. The limitation with these three concepts as the mainstay in general discourse is that not only are there no consistently shared definitions for these terms, there was also a significant number of vague responses (i.e., responses that did not contain criterial attributes) and a significant number of non responses (i.e., no firm understanding of the concepts). The implication of this phenomenon in both the current study and the 2010 study is that when we ask teacher-candidates to solidify and externalize what meaning they have for these concepts, we find that the words they use are like opaque shells that we can’t see through to determine if the user has a firm understanding of the words they are using. Invoking the words the environment, sustainability, or green by the user may obfuscate a lack of knowing to the receiver. The opaqueness protects the user from being exposed and, in reverse, exponentially provides the user with a patina of appearing to be articulate. Only when we ask the user to define the words that they use continuously do we find that those shells, i.e., words, are in fact often empty of meaning. They serve as opaque empty shells.

However, we must keep in mind one critical point about these two studies. BEd and MEd students are products of their schooling! In regard to the BEd students, they have experienced at least fourteen years of public education interacting with Ministry of Education curriculum guidelines (as reviewed above), and another four years of Ontario university education in their first degree. The results are not the fault of the students, they are simply products of their schooling.

One example of regression from meaning might be found in one university’s notion of definitions. A “survey to guide sustainability priorities and plan” sent out to the university’s community, states the following:

“Defining sustainability—for the purpose of this survey, sustainability is considered in a pluralistic and inclusive way, encompassing human and ecological health, social justice and equity, Indigenous rights, secure livelihoods, workplace well-being, and leadership for vibrant communities. It is a complex term as its meaning can differ from place to place and from person to person” (Office of Sustainability, 2025).

The implication is that because sustainability is a “complex term”, no definition is possible nor required. Rather, we should allow each person to create their own meaning from simply the

name. More specifically, there is no need for disciplined language. To follow this logic we shouldn't bother to define photosynthesis or entropy or diversity, or the difference between equity and equality, etc., because these are complex terms and they mean different things to people in different places. However, as Glavic and Lukman (2007) concluded about the sustainability field, "the multitude of definitions causes much confusion about their usage, since the meaning of some terms is either sloppy or similar, or is only slightly different from one another" (p. 1875).

As Donmez and Gulen (2023) emphasize, "how models of concepts are developed in the minds of students in a classroom environment and in higher education is an important question" (p. 58). It is even more important to realize that teacher-candidates will potentially be instructing their own students. The 2010 study and the current one suggest that if teacher-candidates don't have a firm understanding of key concepts, they may eventually be limited in their ability to teach such concepts to their students. "Pre-service teachers who have more content knowledge tend to help students more to construct scientifically accepted knowledge" (Puk & Stibbards, 2010, p. 58).

We should not forget that language influences perception. We might respond to the implication made in the university statement above with something Galileo is reported to have said about concepts and meaning-making: "Names and attributes must be accommodated to the essence of things, and not the essence to the names, since things come first and names afterward" (Drake, 1957, p. 92). This might remind us of the need for a disciplined correspondence between the name of a concept and the underlying essence/criterial attributes of that concept; and that deriving the emphasis of the underlying essence/meaning should always be the priority rather than an emphasis on the name. Effective communications between people require us to clearly express the underlying essence of a concept that is being shared.

5. Concept definitions as the initial stage to deep learning

It is important to emphasize that concept definitions provide an initial stage of understanding of the meaning within the concept. They provide a solid starting point to effective meaning-making. But knowing and understanding the concept definition is not the end-point to meaning-making. As Robinson et al. (1985) and Puk (2024a) have indicated, further stages of a thorough elaboration of a concept would include conceptual model building, comparison, correlational, causal, decision-making and design provide increasing depth and "elaboration" of understanding after each successive stage. A seed eventually ends up as a plant. It is the critical first stage. The mature plant can't exist without that first stage. Concept development proceeds in a similar manner. However unlike the seed/plant analogy, misunderstanding of a topic can proceed without first acquiring the meaning of words. This misunderstanding, based on faulty, immature assumptions will often lead to erroneous conclusions, and misdirected and disconnected action.

6. Progression in meaning: How should definitions be presented through instruction?

Vygotsky (1987) had a particular affinity for definitions. "To Vygotsky, word meaning is the appropriate unit of analysis

for studying the development of consciousness, which he equates with the development of concepts ... People reveal the degrees of abstraction that they have achieved in their thinking" (Smagorinsky et al., 2016, pp. 1401-1402). This latter point is crucial to understanding what degrees of abstraction teacher-candidates have for key ecological concepts. However, Vygotsky also believed that teaching scientific concept (also interpreted as "academic" concepts, Smagorinsky et al., 2016, p. 1403) definitions in isolation through what he referred to as "direct instruction" was "fruitless" (p. 170), resulting in learning the word rather than the concept. Instead, the learner needs to connect a concept definition to the external world through a combination of formal instruction, experience, reflection and practice, integrating it through mindful activity. "A modern theory of conceptual change framework suggests that students need to increase, re-categorize and reorganize their cognitive structures to reach a more scientific understanding" (Donmez & Gulen, 2023, p. 57). Vygotsky (1987) described this process as a "twisting path" (p. 156), as it takes more than just memorizing the words in an academic definition in order to fully internalize and understand it.

In regard to the teacher-candidates in this study, once the definitional responses have been collected, the author teaches the definitions through "ecological macro-models" (Puk, 2021, 2023, 2024b, 2025; Stibbards & Puk, 2011). They experience the concept in natural surroundings through experiential learning. Ecological macro models are analogous activities during which the participant (i.e., teacher-candidate) plays a component of the concept. For example, in the activity for biodiversity, the macro model is conducted in a treed area on campus. A student is either a potoroo, truffle, eucalyptus tree, bacterium or human. Each student is assigned to one of these organisms, designated by colored t-shirts. The four non-human organisms must find each other in the treed area and form a foursome representing a biodiverse ecosystem in Australia. When they do so they then hold onto the same rope as they move through the area trying to stay away from humans. Humans chase these other organisms and, if caught, they are led to the outside parameters of the playing area. This displacement of an organism signifies a weakening and potential loss of biodiversity. Two other roles of disease and fire also cause disruptions as they chase all the different organisms. During this experience, teacher-candidates/organisms are discussing with each other, trying to make sense of what they are experiencing. As Smagorinsky et al. (2016) emphasize, "... thus learning to teach [is] an inherently social experience" (p. 1406). Thus, internalizing concept definitions is also best acquired through social interactions.

Back in the classroom, after the activity, we draw out from the teacher-candidates through a dialectical discussion what they observed and then subsequently create a definition for biodiversity and other featured concepts for each ecological macro-model.

CONCLUSION

Ausubel's (1968) famous maxim regarding the role of prior knowledge in teaching and learning states that:

“The most important single factor influencing learning is what the learner already knows. Ascertain this and teach [them] accordingly” (p. vi).

Meaning-making is the essence of communication. Until educators at every level of schooling ascertain what understanding students have for basic concepts prior to instruction, we may in fact simply be making false assumptions about their grasp of the robust nature of the meaning within the words that are used during instruction and discussion. Concept definitions are the building blocks of intellectual activity and purposeful action. They allow for meaning-making within the individual, of their external world and effective communications between others.

Recommendations

1. It can be argued that the lack of concept development and the de-emphasis on knowing what words mean is systemic in education, at least for the teacher-candidates and graduate students in this study. Thus, many of the recommendations in the 2010 study still apply to today:
 - a. create a distinct, connected, compulsory subject area K-12 for ecological literacy,
 - b. emphasize in those courses inclusion of concept definitions for key concepts in a disciplined manner,
 - c. provide instructional strategies for concept development including strategies for students to learn how to be self-directed in formulating their own concept definitions, and
 - d. provide compulsory courses in ecological literacy in teacher training that focus on knowing how and being able to teach concept development.
2. At all levels, create an atmosphere and understanding that language development, particularly in this case of ecological concept development, requires a disciplined approach (Abbott, 2002) rather than a loose, careless approach that would infer to the learner that words, concepts and concept definitions are unimportant in communications. On the contrary, the meaning of concepts matters!

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