Abstract

Embodied Transformation:

Tapping into the Nature of Emergent Learning

by

J. Adam Stibbards

MA, Lesley University, 2004

BA, Trent University, 1992

A Dissertation Submitted in Partial Fulfillment

of the Requirements of the Degree of

Doctor of Philosophy

Educational Studies

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Abstract

This dissertation describes a basic qualitative inquiry research study, regarding participant experiences of an emergent approach to teaching in higher education. Patterns in transformative meaning-making were a particular focus. Complexity theory was an orienting theory for the study, and was included in a theoretical framework which organized observation, interviewing, and the analysis of data. Participants were twenty-two (22) pre-service teacher education students, specializing in ecological literacy and consciousness. There were fifteen (15) female, and seven (7) male participants, with an age range of 22-33. Research methods included informal and semi-structured interview notes, field notes, and artifacts collected and analyzed to identify themes and patterns. The course being studied utilized an emergent design approach, in which participants played roles in "macro-models", which are analogous representations of ecological phenomena. Participants also engaged in a variety of other activities, and reflected on experiences. Macro-models encouraged intensive interaction between participants and were conducted in natural surroundings. A new term, "embodied transformation", emerged from the analysis of data to describe the dynamic learning process that participants experienced. A model was developed to visually represent embodied transformation, including growth in conceptual understanding, which occurred through linear and non-linear processes of disequilibrium, dispersal of old understandings, and coalescence of new and more adaptive understandings of key concepts. Conceptual understanding was not solely intellectual, but rather was rooted in the physiological, emotional, and psychological aspects of participant experiences. These dimensions caused changes in the intent and behaviour of participants as their understanding became personally meaningful and connected to the larger ecosystem. This process was recursive in that understandings, including discovering connections between concepts, were re-

visited on multiple occasions, becoming more complex and transferrable to novel situations as the course progressed. Embodied transformation is discussed as a natural learning process, evoked by the emergent design approach. The doctoral research project itself is discussed as a complex phenomenon, in which conceptual understanding of complexity grew through an unforeseen, recursive, embodied, and emergent process.

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Dedication

This research is dedicated to all students of higher education who have amassed a lot of information and are longing to engage with it in more meaningful ways. It is also dedicated to the Earth, our ecosystem, which desperately needs understanding, caring, and complexity thinking.

Acknowledgements

This research would not have happened unless my wife, Nicola Lyle, had said 'yes' when I told her I wanted to go back to school. She, and my daughters, Maya and Lily, have made countless hours available to me for processing and writing, and have offered constant support, for which I am forever indebted and grateful. My parents, Lawrence Stibbards and Joy Davey, were also instrumental in making space for writing, opening their home (which used to be the family cottage) for many writing retreats. I am also grateful to my dad for consistently calling to ask me how the writing was going, and to talk about teaching and transformation. Thank you Joy for providing such an amazing model of scholarly pursuit and achievement, and for your many words of wisdom and encouragement along the way. Many, many deep and rich conversations about meaning, learning, and change with my sister Kathryn, and my mom, Pat Watt, before her death, are woven through this work. Thank you Kathryn for listening – again, and again. Dear friends, Kathryn Loftus and Sharon Sidlar, hosted me during the research residency period, feeding me and generally putting up with long hours of my face hidden behind a computer screen. Thank you, to Finnegan, Fiver, and Bigwig who variously warmed my feet, gave an encouraging lick, and reminded me to get up, move my body, and go outside. I am also grateful to the 'Original Six' families in our community for their friendship, encouragement, and help in juggling busy lives with carpooling, kid-care, fixing the washing machine while I was away (thanks Reinout), and generally loving our family.

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helped to organize my thinking about embodiment and complexity. Dr. Connie Russell and Dr. Paul Berger were very helpful in navigating the program and doctoral process generally, and provided moral support along the way. Diana Mason was incredibly helpful regarding administrative issues. Over the years, several people have offered stimulating conversation about pedagogy, including; Tom Kondzielewski, Marilyn Watson, Howard Bloom, Kathleen Cameron, Jan Olsson, Annique Boelryk, Jan Oakley, Geraldine Vanderkleut, and Sash Querbach.

My heartfelt appreciation to the participants of this study. You were extremely generous to me in terms of time and openness about your experiences of emergent design. I felt very connected to many of you and to the group as a whole, and it was so fun to play with all of you. We went through a transformative experience together. The ending of my research was bittersweet in the sense that I knew an incredible amount had occurred, but at the same time it was very hard to let it go, knowing we would not be back together in that formulation ever again. I imagine many of you out there, teaching your classes with passion and terrific skill in creating opportunities for emergent, transformative meaning-making.

None of this, of course, would have been possible without Dr. Tom Puk, who has played so many roles for me in this doctoral process: creator of the emergent design process that I was so attracted to; mentor as I entered into the world of doctoral research; model as a facilitator in style and the setting of parameters; open ear for countless conversations about facilitation, complexity, emergence, and ecosystems; passionate advocate for emergent ecological education in our school systems; model in terms of ecological consciousness and sheer appreciation for the natural world and human embodiment; and friend. Tom, you are a unique, genuine being and I am lucky to have shared this time and experience with you. I see the Earth, and my time walking it, differently because of it. Thank you.

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Chapter 1: Introduction

Background

This dissertation is an account of a research study regarding the experiences of participants in an innovative, "emergent design" approach to education. This emergent design approach aims to leave course graduates with significant growth in concept development through experiences that provoke participants to make meaning in a non-prescriptive fashion, leading to transformative changes in perspective and action. In this sense, the approach is the expression of a progressivist philosophy of education, going beyond an essentialist, information-transmission approach to teaching. More on this distinction follows shortly, as well as working definitions for central concepts. This dissertation, though, is also a document that reflects the changes that occurred in me as a researcher and educator through the doctoral journey. That is, while observing what I came to call "embodied transformation" occurring in participants, so too was I being transformed. Attempting to draw some conclusions about the whole experience has continued to cause shifts and ripples in my perspective, and no longer do I expect to be able to report black and white conclusions about the process and experience of teaching and learning, but instead expect understanding to be a continuous, often unpredictable, and emergent process.

What follows is a brief discussion of the process that brought me to identify a research problem, followed by an introduction to the emergent design model which was the focus of my doctoral research, though a fuller description of this approach to teaching is offered in Chapter 2. The orientation to emergent design flows into a description of a sense of the initial research purpose as a response to the research problem, and then a brief discussion on how my understanding about the phenomenon and project changed, which led to a refined sense of purpose. The central research question is discussed next, which was similarly adapted over the

course of the project as my perspective shifted. Next is a discussion of teaching and learning philosophies and pedagogies, including clarification about how key terms are used in the dissertation. An introduction to complexity theory follows, which was employed as an orienting theory in my study of emergent design. The phenomenon of emergence from complex systems, though briefly discussed in this introductory chapter, is explored in further depth in Chapter 2. The remaining body of this introductory chapter presents the overarching rationale for conducting research into dynamics and experiences of the emergent design approach. The chapter concludes with a summary, and an overview of Chapter 2, which offers a literature review building toward a theoretical framework for the study.

Development of the Research Problem, Purpose, and Question

I came to this doctoral research already a believer in progressive approaches to teaching, though I was relatively unaware of the philosophical and pedagogical traditions underlying such approaches (an exploration of these areas follows shortly). Several years as a group facilitator and psychotherapist resulted in well-honed skills for setting up effective processes, paying attention to group members' experiences, and making necessary adjustments on the fly. When these skills were applied in my first university teaching opportunity many years ago, I observed the students becoming very engaged, demonstrating curiosity and a sense that what they were learning was meaningful. They were also able to successfully explore and answer complex case study questions on exams. Later in the course, they told me that they had not experienced anything like it in their undergraduate careers, and personally I could not remember any such teaching approach in my own undergraduate experience. Instead, I remembered lectures, and the fundamental expectation that students would memorize information in order to be able to

regurgitate it on exams. I also became curious about what was happening for students involved in these processes, in terms of how their interaction with each other and intrapersonal experiences were involved in the kind of learning I saw. This led to beginning to review scholarly works regarding progressive philosophies of teaching and learning. What follows is a brief exploration of the literature I discovered about progressive approaches to teaching, and their relative lack of uptake in undergraduate education.

What I first discovered is that it is generally accepted by researchers in higher education that progressive approaches to teaching lead to deeper forms of learning than information-transmission approaches (Åkerlind, 2008; Boyer Commission, 1998; Davis & Sumara, 2005; Knowles, 1980; Kolb, 2015). These deeper forms of learning are what University graduates need as they enter the "real world", including more and longer lasting retention of information, the integration of learning with existing knowledge, and the ability to apply it flexibly in unpredictable circumstances (Åkerlind, 2008; Boyer Commission, 1998; Davis & Sumara, 2005; Knowles, 1980; Kolb, 2015). Researchers have also demonstrated that teacher attention to concept change (as opposed to simply amassing information) significantly increases the likelihood that students will learn at a deeper level (Entwistle, 2010; Prosser, 2010; Trigwell & Prosser, 2004). Proponents of concept change oriented teaching practices suggest that educational contexts should include inquiry-based and experiential learning approaches, as they provide space for students to engage in the ways that are most effective for them as individuals. Further, these teaching approaches are generally thought to allow students to construct meaning rather than memorize sanctioned facts (Christensen Hughes & Mighty, 2010; Entwistle, 2010; Meyer, 2010; Wieman, 2010). Encountering these findings led me to understand that I needed to know more about the nuances of what deeper learning means. My initial examination, which is

explored more extensively later in the dissertation, suggested that deeper forms of learning include the development of "expert" understanding (Wieman, 2010, p. 176) of "threshold concepts" (Meyer, 2010, p. 192), the ability to innovate in the face of challenges (Gordon, 2006), and increases in confidence to meet challenges (Bandura, 2006). As alluded to above, I was most interested in exactly how students might be changed and act in a different and informed way, based on learning that was meaningful to them. My belief when starting the doctoral program, which I still hold, is that if we wish to graduate students who are able to understand complex societal issues in a sophisticated fashion and be discerning in their actions, we must offer opportunities to develop the abilities discussed above in higher education. But I also was becoming more aware of how little I knew about the dynamics that lead to such learning, both in terms of process but also the interaction and internal experiences of participants.

The publication of a collection of papers *Taking Stock: Research on Teaching and Learning in Higher Education* (Christensen Hughes & Mighty, 2010), and my subsequent visit to a conference based on the book, continued to enhance my desire to better understand progressive teaching approaches in higher education. *Taking Stock* was certainly not the first contemporary call for such collective reflection (Åkerlind, 2008; Boyer Commission, 1998; Britzman, 2003; Davis & Sumara, 2005; Knowles, 1980; Kolb, 2015), and the idea that learning should be more than the amassing of information was not a new one (Dewey, 1916, 1938; James, 1897/1984; Vygotsky, 1930-1934/1978), but the book and conference demonstrated to me that there is a contemporary push for progressive teaching in higher education. After reviewing evidence illustrating the advantages of more progressive, concept change focused approaches to teaching, it made even less sense to me than when I had begun that there was seemingly so little of it in higher education contexts, at least at the undergraduate level. There are many reasonable

explanations offered to explain the lack of uptake of non-lecture based approaches in higher education (Cuban, 1999; Knapper, 2010; Lagemann, 1997), including lack of funding for professional development, a focus in hiring practices on research skills and background while ignoring teaching abilities, a lack of awards and prestige associated with teaching, poor understanding or no awareness of research on effective approaches, and a historical pattern of seeing learning and education through an industrial, productivity perspective. Knapper's (2010) work took the opposite direction in reporting on the conditions that have led to successful change towards more progressive approaches, identifying administrative leadership and the experience of crisis as two major contributors. At the time, though, I believed there was another cause of the problem, not well identified in the literature, which was that descriptions of progressive approaches, and explanations of how they work lacked clarity and specificity (Entwistle, 2010; Lagemann, 1997; Wieman, 2010). My initial plan, then, was to address this gap through my doctoral research.

Research problem. The overarching research problem I identified, then, based on the experiences and early investigation of the literature as described above, was the following: *(a) there is too much lecturing, and too little progressive and innovative facilitation offered in undergraduate education, and (b) this lack is at least partially due to perceptions of these approaches as complex, that is, there is a lack of clarity and specificity regarding what to do and how it works.* I thought that my experience as a facilitator could provide insight that might lessen this impression of complexity for educators, and that perhaps my practical insight could be supported by research into my own teaching practice. A few small, informal research experiments led to the realization that I needed further training to pursue understanding of

student learning experiences with sufficient research rigor and understanding of the scholarly area. This proved to be an important decision, though I did not understand the level of my naiveté at the time. It was not until being deeply immersed in the research process that I began to develop a better sense of the complexity of the issue. Nevertheless, it was this drive to provide insight through rigorous research that led me to investigate doctoral programs. What follows is a brief description of Puk's (2010) emergent design approach, which became the focus of my doctoral research, as I believed its study would provide an opportunity to identify key features and experiences of progressive approaches, allowing me to address the gap I had identified in the literature.

Emergent design. Doctoral programs and supervisors in psychology (my area of earlier study) that I could find did not seem interested in examining progressive, innovative learning strategies, and so I began to canvas supervisor profiles in education programs. An intriguing possibility was to study Puk's (2010) pedagogical approach to an undergraduate, ecological education course. Drawing on elements of emergent design over the duration of the course, the aim is for students to fundamentally shift their understandings of ecological issues adopting behaviours more congruent with ecological lifestyles. It is important to state here that though I was and am very concerned about ecological issues, my main interest in studying Puk's approach was not its focus on ecological education. Instead, I was interested because the approach appeared to offer the possibility of studying a progressive approach to teaching, bringing my psychological perspective regarding crucial aspects of human interaction and experience to bear on the phenomenon. I was convinced, both through conversations with program graduates and the professor, and looking at written descriptions of the macro-models that formed the basis of

his pre-service teacher courses, that Puk's (2010) emergent design approach creates the kinds of opportunities for the type of learning that I was interested in studying. It is important to emphasize that I was not interested in evaluating any particular progressive approach, or comparing different approaches to determine which was better. Instead, I was intrigued to closely study an approach that offered the opportunity to observe what I considered the crucial mechanisms and experiences of my own progressive teaching and learning experiences, including: the sparking of creativity; a sense of fun, full engagement and immersion in the process; and a sense of community, including extensive activity and interaction. The emergent design approach appeared to include these features, and so gave me the chance to study what I wanted to know more about.

More detail regarding the approach is offered in the literature review chapter. In terms of understanding my initial decision to study this approach, though, it is enough to say that I believed there to be discoverable patterns in Puk's (2010) emergent design approach regarding learning dynamics and experiences for students. This was central to my research purpose, which is the focus of the next subsection.

Research purpose. At the beginning of my doctoral research, I believed the investigation of emergent design would allow me to address the research problem identified above. I wrote in my original research proposal: *Where the intention of information-transmission approaches is fairly basic (pass along a particular collection of information), and therefore measuring resultant outcomes is relatively simple (test ability to recall taught information), more sophisticated approaches and their outcomes are complex. My contention is that this complexity contributes to the lack of uptake of more progressive approaches in at least two ways. First, the*

terms "inquiry-based", and "experiential" learning are used to describe such a wide variety of actual teaching practices that the labels themselves have become vague in terms of practical meaning, and this makes it difficult for instructors to derive any usable patterns from the research to apply to practice. As Dewey (1938) says, without clarity regarding what we mean practically by "educative experiences", our terms are "reduced to a form of words which may be emotionally stirring but for which any other set of words might equally well be substituted unless they indicate operations to be initiated and executed" (p. 10). I entered the actual research, then, with the purpose of adding clarity to the understanding of what Dewey (1938) calls educative experiences. I set out aiming to clarify how to create these experiences and identify the features of this type of learning. I believed that a quantitative tool could be created, based on the identification of patterns in the emergent design approach and the educative experiences of students, which would subsequently allow educators to implement and evaluate progressive approaches with greater ease. This intention, and indeed my perspective as a researcher and educator, have been changed by the processes of research and writing themselves. It is now clear that my initial perspective was overly simplistic. Rather than developing a simplified way to explain and measure the features and experiences in progressive approaches, I discovered that it was actually my perspective on complexity that needed to change. More on this change in perspective will be discussed as the dissertation progresses. At this point, however, it is important to report that my essential research purpose shifted. Initially it was to *contribute to the uptake of progressive approaches to teaching in higher education through the description of patterns in emergent design and the learning experiences that emerge from this approach.* During the research, analysis, and writing processes, it shifted to *contribute to the description and explanation of processes and experiences involved in emergent learning*. This shift is

reflected in a change in perspective regarding the research questions which informed my inquiry over the course of this study; this is discussed in the next subsection.

Research question. The initial, central research question emerged out of my original sense of the research purpose, and was fairly general: *why and how do progressive approaches lead to deeper, desirable forms of learning*, *and what are the identifiable patterns in this kind of learning?* To some degree, this has remained as the central, informing question, but the focus shifted from the development of a simple-to-use instrument that would help educators implement progressive approaches, to a more complex perspective. This more complex perspective on the phenomenon led to a refined research question, which has three parts: *(a) what are the key features of the emergent design approach which contribute to emergent learning experiences, (b) what are the key experiences of participants involved in emergent learning, and (c) what is the relationship between the emergent design approach and the experiences of participants that lead to emergent forms of learning?* It is hoped that addressing this multi-layered question as fully and richly as possible will make a contribution towards addressing the identified research problem of the necessity of knowing more about the mechanisms, processes, and experiences that contribute to emergent learning.

What follows is a description of my early investigations into the problem of too much information-transmission and too little progressive teaching and learning in higher education. These investigations started the process of developing a richer and more coherent understanding of related issues, which subsequently led to the development of a refined understanding of the research problem, and refinements of the research purpose and question that are further discussed in the research rationale subsection to come. The next subsections of the introductory chapter are

a revisiting of the topics already raised, but represent a deepening, recursive exploration of these topics. Such recursive revisiting is itself a recurrent theme in the dissertation, and will be more explicitly discussed shortly.

Educational Philosophy and Pedagogy

Early examinations of literature on educational philosophy suggested that my university experience, both as a student and faculty member, was based in essentialism. An essentialist philosophy is rooted in the belief that there are key bodies of knowledge that should be directly taught to students (Ornstein, 2014). Ornstein (2014) suggests that essentialists, though willing to accept that bodies of knowledge can change[1], believe in external, objective, and discrete facts that can and should be observed, recorded, and transmitted directly to others through lecture or other similar information-transmission approaches. Essentialists believe in a "back to the basics" approach, where reading, writing, speaking, logic, hard work, memorization, and discipline are championed. When prescribed to by instructors and students, the essentialist approach appeared to me to lead to the ability to remember and regurgitate information, and sometimes to think about, compare, and contrast bodies of information in logical and critical ways. However, my observation was that the information was often not retained very long, and more importantly (or perhaps because) the information was often not meaningful to the learner in the sense that it did not seem to impact their lives outside of the classroom very much, or at all. Upon personal reflection, I was hard-pressed to think of how information I had learned as an undergraduate psychology student impacted my work in the field as a counsellor, psychotherapist, or facilitator.

[1] As distinguished from a perennialist philosophy championing central "great ideas" of Western civilization. In order to stay focused, I will not explore all major educational philosophies, but rather focus on essentialism and progressivism as most relevant to this research.

I contrasted this apparent lack of impact with my experiences as a graduate student, and observations of group members and students making meaning through encountering the world in workshops and courses facilitated in what could be seen as a progressivist approach, where learning experiences have a tremendous impact on real life. Ornstein (2014) suggests that learning, to the progressivist, is not about absorbing objective information that is transmitted from a teacher, but rather is rooted in the questions that arise for students through their encounters with the world. In this sense, learning is a process of making meaning out of experience, rather than the wholesale ingestion of already formed knowledge. This was the initial spur in terms of my interest in pursuing doctoral research – I was passionate about approaches that led to meaningful learning for post-secondary learners, and was curious about what was constraining this kind of approach in university settings.

Interestingly, as Ornstein (2014) points out, essentialism emerged as a reaction to progressivism in the early 20th century. The essentialist movement was based in the belief that students were not learning what they needed to through the progressivist approach, and were graduating without the information and skills necessary to be useful to society. I have wrestled with this concern as an educator and have through the doctoral process as well, that is whether student exploration and meaning-making can be trusted to arrive at crucial understandings they will need going forward into their vocations. More will be discussed on this tension as the dissertation progresses, but it is important to note here because though I lean more toward a progressivist approach, I also believe that there is an objective world that we must try to understand as accurately as possible, and so I do believe in facts. The potential consequences of climate change, for example, make it clear that if we ignore the facts we may compromise our future (Klein, 2014). My observations as an undergraduate learner, teaching assistant, and

professor confirm that though an essentialist philosophy, with pedagogical approaches favouring information-transmission, is limited, I am also concerned with the connection of learning to a real and external world. This is all to say that the issue is not black and white.

Teaching as facilitation. Progressivists generally view the teacher as a facilitator, whereas the essentialist teaching approach is generally based more on direct instruction, or information-transmission (Ornstein, 2014). Though I am more attuned to the progressive perspective, I still do believe that the facilitator has a vital role in directing learning processes, including arranging encounters with foundational and empirically-based information. As will be explored shortly, from a complexity perspective, facilitators bring their history to the situation, including their expertise. This plays a significant role in the complex process of what emerges in learning situations (Davis, Sumara, & Luce-Kapler, 2008). That being said, when discussing teachers or educators in this dissertation, they are meant to be understood as facilitators rather than information-transmitters, unless this latter approach is specifically being discussed. The influence of the facilitator in emergent design will be explored in greater depth as the dissertation progresses.

Learning as meaning-making. As already discussed in some detail, my position is that education must be aimed at much more than a purist form of essentialism would assert. The transmission of sanctioned facts and skills alone is less likely than progressive approaches to cause the student to integrate information into what they already know and make meaningful connections between their knowledge and the world around them (Christensen Hughes & Mighty, 2010). Also, in my view, education should prepare students for the many uncertain

situations that life invariably brings, which as Gordon (2006) suggests does not tend to occur through information-transmission alone. From a progressivist perspective, learning must include a student making meaning out of their experience, and must go beyond the memorization of sanctioned facts so that students can flexibly adapt their knowledge to the novel things encountered in the world (Ornstein, 2014). As a progressivist, then, in terms of the purposes of this dissertation, the terms learning and meaning-making can be considered interchangeable, that is, learning necessarily includes a student making meaning out of their experiences. The terms information-transmission as a teaching approach or the amassing of information as a learning outcome will be used if each is what is specifically being discussed.

Transformative meaning-making. The term "transformative meaning-making" needs attention, as it will be utilized throughout the dissertation, and then is later itself transformed in a fashion. It is a term that emerged early on in discussions with the facilitator of the emergent design approach I studied, in describing the learning I was witnessing in participants. The way that transformative meaning-making is used in this dissertation is something similar to Mezirow's (2000) transformative learning, which is a process of change in perspective through critical reflection on experience and assumptions. The key to transformative learning is that the student is actually changed through the learning process, and does not think or behave in the same way afterward. Therefore, to extend this to the term used in this dissertation, transformative meaning-making is beyond just meaning-making, or the gaining of interconnected knowledge that can be used flexibly as meaning-making is defined above. Transformative meaning-making implies that the student is fundamentally changed through the learning experience. Mezirow's (2000) philosophy, though, is focused on the rational aspects of learning, where transformative

meaning-making as I will use it is meant to connote meaning-making that includes emotional, psychological, cognitive, and behavioural components. In other words, when discussing transformative meaning-making, I mean learning that leads to changes in students on the level of how much they care about what they have learned, and how it changes the way they behave going forward, in light of how they have been changed by the learning experience. Much more about these aspects of learning will be explored in Chapter 2. Finally, transformative meaning-making, as will be explored throughout the dissertation, is an emergent phenomenon, and as suggested above the term itself transformed for me through the process. More on this later.

Emergence and transformation, two terms now used fairly extensively, are complex phenomena. Therefore, in order to explore their meanings, what follows is an introduction to the orienting lens of complexity theory. I encountered complexity theory as it is applied to educational phenomena early in my reading of the literature around progressive education. It provided an orienting perspective on the emergent design teaching approach that I was to study, as well as helping to organize my thoughts around the experiences and dynamics of the learning associated with emergent design.

Complexity Theory

A brief introduction to complexity theory is offered here, included at this point as an orienting lens through which to understand, (a) my initial approach to research of the phenomenon that is the focus of this study, and (b) the emergent changes that have occurred as the process continues. Complexity theory and its application to this research project will be further explored in subsequent chapters.

Complexity theory first emerged in the biological sciences to describe and explain phenomena that did not follow the types of mechanistic patterns easily explainable by cause and effect principles (Kauffman, 1995). In complex systems, the whole is more than the sum of its parts as all members of the system bring a unique history, have unpredictable and non-linear influences on each other, and through interaction the system itself is changed, forming new, usually more complex, wholes (Cochran-Smith, Ell, Ludlow, Grudnoff, & Aitken, 2014; Davis & Sumara, 2007; Kauffman, 1995; Mason, 2008, 2009). This means that complex systems are not amenable to simple (A causes B) or complicated (e.g., understanding the parts of a car engine) explanations of causality (Cilliers, 1998). The ongoing, inter-influential, interaction between members in a complex system leads to unpredictable outcomes because of the histories that each member brings to the system, as each member changes another (and in turn is changed), cascading effects occur that could not have been foreseen.

> A complex system is not just a form with more parts, but one that transforms itself as it experiences its world. Complex systems adapt and learn. In other words, and in contrast to the ahistorical natures of simple and complicated systems, complex systems embody their pasts (Davis & Sumara, 2005, p. 312).

Such transformation is not chaotic, however, in the sense that after such cascading change occurs, the whole system still tends to resemble what it was before (Davis & Sumara, 2005). For example, a human itself can be seen as a complex system. As an individual learns (members of the system, such as neurons, interact in new ways) they change, become something different than before, and yet the system remains a recognizable whole. This process in complex systems is one of self-organizing emergence, which is a crucial concept in terms of understanding the outcomes of the dynamics of a complex system. Kaufmann (1995) asserts that life itself is an

emergent phenomenon, the result of surpassing a certain threshold of number (of proteins), diversity and complexity. As in the example of an individual person, though other complex systems have this emergent property, whereby they change through mutually influential interaction, emergence tends to continue to result in cohesive systems, and systems that are most often more complex after emergence.

In terms of educational systems, complexity and self-organizing emergent phenomena can be viewed on multiple levels (Davis & Sumara, 2005). For example, a student begins a course with an organized set of thoughts which are then jostled and influenced by new input, leading to a self-organized new emergent whole in terms of understanding. So too does a class change and adapt as it passes through a particular school term, and yet it still comprises a recognizable whole (Davis & Sumara, 2005). Students as individuals and classes become new, often more complex, wholes through the educational process. Leaps of understanding are often unpredictable, though there are patterns in the process that can be observed as well. As alluded to above, there are many nested complex systems in educational contexts, and it can be difficult to determine where one complex system begins and another ends (Davis & Sumara, 2005). Educational examples of complex systems include individual learners (members considered to be the millions of cells that mutually influence each other) and classes that individual learners comprise, for example, members considered to be the learners, the teacher, the institution itself, and so on (Davis & Sumara, 2005).

When I encountered complexity theory as it is applied to education, it was clear to me that it was the ideal orienting lens through which to view the emergent design teaching approach. Emergent design, as already described, is aimed at creating spaces for interaction between system members leading to self-organizing, emergent forms of learning. There are other features

of complex systems that match central features of emergent design, such as the concept of recursion. In an educational context, the idea of recursion relates to the revisiting of concepts, problems, or situations on multiple occasions (Davis et al., 2008). Davis et al. (2008) suggest, with their concept of recursive elaboration, that growth and development in understanding occur each time similar patterns in experience occur, each time familiar situations are revisited. Though learners may be able to gain a decent understanding of new concepts, for instance, through first exposure, ongoing experiences allow the learner to gain more sophisticated understanding, often through viewing the concept from multiple perspectives, including how it intertwines with other, related concepts. As Jörg (2004) points out, however, we need further research and understanding about how this inter-influential, non-linear, and complex process occurs through such interaction.

Recursive elaboration also played a significant role in my own growth in understanding, and how it applies to my doctoral research will be explored in greater detail as the paper progresses. For the moment, however, one of the effects of such recursive emergence I want to highlight is how my perspective on the research project was transformed through the doctoral research process itself. I have come to realize that though the language of complexity was in my initial research plan (e.g., emergence, unpredictable, non-linear, patterns) the suggestion that the research could result in a simplifying tool reflects thinking about the phenomenon of emergent learning in a mechanistic way. Morin (2006) discusses this distinction as the difference between restricted and generalized understandings of complexity. In the restricted form, "… to some extent, one recognizes complexity, but by decomplexifying it." (p. 6). I was restricted in my plan to identify and isolate required ingredients and emerge with a quantitative recipe simple enough for all educators to understand and employ. As is evident in what follows, such a simplistic

recipe did not emerge, though several rich patterns certainly did. Morin (2006) suggests that a generalized perspective on complexity necessarily involves an understanding of the relationships between parts within the system, and the whole system, at the same time. Indeed, one of the many emergent patterns not originally anticipated was the way I was changed, the way my own conceptualization of complexity, and therefore this doctoral research project, re-emerged in a more complex form. At least one of the things that has changed is my understanding of the complexity of the problem, and more specifically the complexities of progressive teaching and the doctoral research process itself, and the kinds of learning that emerge from such activities.

As suggested above, complexity theory and its application to this project will be explored in greater detail as the dissertation progresses. What follows is the final subsection of the introductory chapter (notwithstanding the chapter summary) which describes the research rationale for the current study. While the research rationale is grounded in, and emerges from, the subsections explored above, it also recursively supports them, as the following chapters also have helped to develop a rationale for this research, even as it supported their emergence.

Research Rationale

In some way, my ambitions regarding this research study had become much more modest in scope, while at the same time my understanding of the phenomenon of interest has become steadily more complex. Where I began firmly tilted at the windmill of predominantly information-transmission oriented higher education, through the process my purpose has been refined to an intention to find out more about the complex dynamics and experiences of emergent learning. What has fallen away, in terms of research rationale regarding the understanding of education as a complex phenomenon, is the belief that my description and

explanation of the present research findings can be simplified, reduced down to component parts that could then be used in a formulaic way by other educators or researchers. Similarly, I feel much more modest about the potential impact of my work, no longer thinking that such simplification and definition could lead to uptake of emergent approaches where others have failed before. The research approach has also shifted so that now I now am more carefully focused on the attempt to describe both features (parts) and the whole of this phenomenon, including the dynamics between the participants and their surroundings, and how parts and the whole are changed through the emergent process. The rationale is that a description and explanation of the features and dynamics of emergent design and transformative meaning-making, will contribute to our collective understanding of progressive approaches to teaching and experiences of this type of learning, potentially being helpful to educators using, or aiming to use, similar approaches. My initial drive to pursue this work came from a conviction that there is a continuing need in the literature for the description and explanation of progressive educational approaches and experiences. It is my hope that this work can make a contribution to such understanding.

A related aspect of the rationale for this research is that sharing the richness and emergent change of my own experience will promote awareness of the depth and value of complexity in education and research. The research could be valuable in this way on two levels: (a) promoting the viewing of educational contexts as complex, helping to resist a reductionist approach to viewing education, (b) promoting the continued and further use of complexity theory as a research lens for education. As Jörg (2004) says, “Education, now, seems strongly in need of recognizing (emergent) complexity at work in practice and, even more, of the full understanding of such complexity.” (p. 128)

What follows is a summary of this introductory chapter, and a preview of the literature review chapter to come next.

Chapter Summary

This introductory chapter began with a brief statement regarding the two functions of this dissertation. First and primarily it is a report on a doctoral research study into the experiences of students in a course utilizing an innovative teaching approach in higher education. Secondly, it represents the process of transformation that occurred in me as researcher. This flowed into a description of the research problem, research purpose, and research question, including a brief description of the emergent design approach that is the focus of this dissertation research. The purpose of this research is not to evaluate or compare progressive approaches to teaching and learning, but rather to closely study the qualities and process of the learning experience within such an approach. As such, I located myself as an educator in the progressivist camp, with some nuances, and defined key terms and concepts. Complexity theory was explored as an orienting theory to the study of emergent design, including a brief statement about the shift in perspectives on complexity that occurred over the course of the study. Finally, a description of the research rationale was given, with a brief explanation of the process that led to a refinement of my understanding of what could be accomplished. To reiterate, the main rationale for this work is to contribute to an understanding the experiences of learners and the dynamics involved in emergent learning.

The literature review chapter to follow will focus on areas of research related to progressive approaches to teaching, learning as meaning-making, and aspects of human experience that are involved in such learning. As is explained at the beginning of the next

chapter, the review of literature is not meant to be comprehensive, but rather focuses on areas regarding the dynamics and experiences of learners in progressive approaches to teaching. I was particularly interested in some aspects of experience that were not regularly included in the educational literature I was encountering, including research on emotions, curiosity, play, and embodiment. This interest in areas not often connected in the literature required me to sew together several disparate avenues of inquiry, and also to make decisions about what not to include in order to maintain focus. The theoretical framework presented at the end of the literature review chapter represents this sewing together. The chapter begins with a discussion of educational literature related to meaning-making approaches, the nature of concepts, and conceptual change and growth. It continues with an exploration of literature related to the development, value, and qualities of engagement and embodiment as they relate to transformative meaning-making. This is followed by a further description of complexity theory, as well as a discussion about how complexity theory is and is not applied in this study. A more comprehensive description of the emergent design approach to teaching follows, which is included with the intention of rationalizing the fit between my research interests and this teaching and learning approach. Finally, a theoretical framework is presented, which represents the overall perspective I carried into the study of the processes, dynamics, and experiences involved in emergent learning.

Chapter 2: Literature Review

Overview

The following chapter presents a literature review and theoretical framework that were largely developed in the process of getting ready to conduct my doctoral research. There are additions and modifications based on recommendations from my research proposal committee, and also some discussion in the chapter regarding changes in perspective that occurred as a result of the research process. In terms of the review, there are certainly many other research areas that could have been followed regarding learning and experiential education, and indeed some argue that the literature review portion of a dissertation should be comprehensive (Boote & Beile, 2005). The current work, though, resonates with Maxwell's (2006) contention that a review of literature should be relevant rather than exhaustive, because its value is in offering a framework through which the phenomena of interest can better be viewed. Ravitch and Riggan (2011) support this approach, suggesting that frameworks are intended to guide the research process, but of course are often (if not always) incomplete in terms of representing the phenomenon of interest. The sheer amount of literature alone in the area of progressive approaches to teaching and resultant learning outcomes precludes a comprehensive review, in any case. But more influential, in terms of what is, and what is not included in this chapter, was my focus on the dynamics and experiences of learners in a progressive educational situation. I was not interested in comparing or evaluating the approach itself, but instead wanted to look more deeply at what was happening for learners as they went through the process of making meaning together. So, the literature review and theoretical framework that follow: a) are not meant to cover all areas of inquiry in experiential, and/or emergent learning, b) are intended to demonstrate the framework, or overall lens, with which I approached the study, and c) are not meant to prepare for or

represent an evaluation of emergent design or the development of ecological literacy. Instead, the literature review that follows covers areas of experience and learning that were of interest to me in entering this research process, directed at serving the research purpose of contributing to the understanding of complexity and emergent experiences in learning.

There is another layer of limitation to note regarding the following literature review. I came to later realize that the framework presented in this chapter represents a limited, or restricted perspective, as I had not developed a generalized perspective of the complex phenomenon of emergent design. However, this has not meant the review and framework to follow turned out to be without merit. Though I have been surprised and humbled through the research experience, the framework represented at the end of this chapter was integral in organizing what I observed, influencing how I experienced the phenomenon, and played a significant role in how I was changed. In addition, all of the concepts presented in this chapter remain important in my understanding of the phenomenon studied. In other words, none of the aspects of the framework I started with are in themselves problematic. Instead, it is the way I thought about these concepts that has changed. More on this as the dissertation continues.

Following from the rationale offered above, the chapter is broken down into the following subsections: (a) meaning-making approaches, including literature regarding constructivism, adult learning theories, and teaching approach, (b) the nature of knowledge and concept change, (c) the experience of transformative meaning-making, including explorations of aspects of engagement and embodiment, (f) complexity theory, (g) emergent design, and (h) theoretical framework. As discussed above, each subsection will include some orientation regarding its role in the framework, though a fuller integration is left to the final subsection when presenting the theoretical framework.

Meaning-making Approaches

I oriented myself generally in the progressive camp in terms of a philosophy of education in the introductory chapter. In this subsection regarding meaning-making approaches, the intention is to deepen the discussion around progressive education, and what Dewey (1938) calls "educative experience" (p. 7). Dewey (1938) distinguishes educative experience as being something more than the amassing of information, but also suggested we need to become much clearer about what such experience looks like and includes. The following discussion of meaning-making approaches is intended to contribute to the overall theoretical framework for the study in outlining seminal perspectives and research regarding these types of experiences. An argument could be made for a survey of experiential education approaches here, but I have not done so as I share Dewey's (1938) contention that meaning-making is the more central goal. In this Dewey (1938) wishes to avoid arguments about categories of experience and instead to stay focused on what is happening for the learner. As discussed earlier, this dissertation is focused on the experience and dynamics of learning rather than evaluation or comparison of particular approaches. This subsection, then, reports on theories and research that shed light on such experiences.

Dewey (1916) is a strong advocate of teaching that does more than pass along information through didactic lecture or the reading of texts. Dewey (1938) asserts "… that amid all uncertainties there is one permanent frame of reference: namely, the organic connection between education and personal experience" (p. 7). Dewey's (1916, 1938) central idea is that information passed down as fact from an authority-figure does not translate into meaningful knowledge for students. In other words, knowledge that is not connected to personal experience

will not be connected to an individual in any meaningful way, and therefore does not tend to make much of an impact. This is the basis of the argument of progressive educators to this day – that is, learning must be meaningful for the learner so that it makes an impact on their understanding of experience and actions (Christensen Hughes & Mighty, 2010).

Dewey (1938), however, cautions against creating either-or arguments when discussing traditional (lecture and text reading) teaching methods, and what was then a counter-movement of progressive educational models. Though he does stress the importance of experience in education, and troubles the relative absence of the experiential component in educational practices of his day, he suggests that there is a need for a new philosophy of education to underpin the progressive movement:

> We shall operate blindly and in confusion until we recognize this fact; until we thoroughly appreciate that departure from the old solves no problems. … experience and experiment are not self-explanatory ideas. Rather, their meaning is part of the problem to be explored. To know the meaning of empiricism we need to understand what experience is. (p. 7)

There is a need for greater clarity about what experience (that is educative) really is. As Dewey (1938) points out, some experience can actually be mis-educative. Other experiences, though offered by instructors with the best of intentions, may not mean much to students at all. In this, Dewey (1938) was describing the art of straddling the line between facilitating experiences that are educative in ways that are desirable to society (have authentic value), and letting go of control enough that personally meaningful student experiences can occur. In other words, on the one hand, it can be so-called progressive education that actually sets no (or too few) parameters, and calls any experience educative; on the other hand, it is the traditional approach which is so

prescriptive that it allows little room for personal meaning-making. Dewey (1938) believes that democracy is the model that should lead to educative experience for students, and this principle can be seen in many of the approaches to be described below, in that a central tenet of all student-centered approaches is a valuing of the student's exploration, thoughts, and descriptions of experience. However, our defining of what constitutes educative experience is still a work in progress, work that perhaps will never and should never reach a final destination.

Constructivism. Piaget (1973) and Vygotsky (1930-1934/1978), are seen as major early proponents of constructivist approaches to learning, though there are significant differences between their central ideas. The intention of including both together at this point in the chapter, despite their differences, is to highlight the importance of conceptualizing learning as an active, meaning-making process. Therefore, though there are many criticisms of Piaget's theories especially (see Lauenco & Machado, 1996, for a review) the intent here is not to evaluate or compare, but rather to give a brief overview of the idea of learning as the construction of meaning.

According to Piaget (1952), when children encounter new situations, one of two processes is engaged: assimilation or accommodation. Assimilation is the process by which new experiences are integrated into pre-existing schema (organized thought structures). Accommodation, conversely, is the changing of one's cognitive organization in the light of experience which is not able to be assimilated into pre-existing structure. Regardless of whether learning occurs through assimilation or accommodation, Piaget asserts that learning requires active construction on the part of the learner. They are not passive recipients of new knowledge, but rather are constantly connecting new experiences to pre-existing schemas, and indeed may

seek out and/or pay attention to particular stimuli because of pre-existing schemas. Therefore, according to Piaget, learning situations should be set up with this in mind, that is, children should be exposed to novel and challenging situations that cause them to reorganize their cognitive schemes.

Vygotsky (1930-1934/1978), as a social constructivist, emphasizes that individuals learn through the engagement with materials and other people. Vygotsky's (1930-1934/1978) concept of the Zone of Proximal Development (ZPD) has had great impact on educational policy, including a more recent focus on differentiated instruction (Ontario Ministry of Education, 2005). The ZPD is the space between where the student currently is, in terms being able to comprehend new things on their own, and what they could learn if they were aided by a "teacher" (which can be a text, peer, cultural artifact and/or immediate environment, as well as a formal teacher). Students learn through interaction with teachers, which allows them to construct more sophisticated and complex organizations of conceptual understanding. Though the intrapersonal dimension is still important in understanding how individuals learn, Vygotsky's emphasis is on the reality that the individual's level of understanding is not removable from context. Learning is constructed through the interaction of students and teachers and the intrapersonal processes that are stimulated by these interactions.

What is obvious in the work of both Piaget and Vygotsky is the emphasis on the active role of the learner in their learning. Their theories stress the histories that students bring to learning situations and the constructive meaning-making process of learning. Vygotsky (1930-1934/1978) emphasizes the importance of social context, which includes teachers playing a crucial role in learning through identifying the level students are at and could be with appropriate help. Where Piaget (1952) and Vygotsky (1930-1934/1978) focus on children and adolescent

learners, the theorists in the following section focus on adult learners. Contrasts and similarities are discussed.

Adult Learning Theory. Knowles (1980, 1989) offers several central principles in the education of adults, which he calls andragogy (Greek for "man-leading"), to denote differences with pedagogy (Greek for "child-leading"). The main assumptions of Knowles' (1989) conception of adult education are that: (a) adults need to understand the "why" of learning before they can/will learn particular content, material or behaviours; (b) adults need to be seen and treated by others (particularly educators in this context) as capable of self-direction and as aware of their own responsibility for learning in their lives; (c) adults come to learning situations with experience which is greater and more complex in quality than that of younger learners; (d) adult interest in learning is connected to what they have come to realize they need to know; (e) children and youths are subject-centered (in school) whereas adults are task or problem centered in their orientation to learning; and, (f) adults are more motivated by intrinsic motivators (than extrinsic) such as feeling good about themselves, increasing their quality of life through learning, being responsible, satisfied with their work and so forth.

These assumptions have not gone without debate, and as presented here represent a re-working of Knowles' (1970, 1980) original assumptions about adult learners based on some of the criticisms leveled at andragogy as a basis for understanding adult learning. For example, Houle (1992) questions some of the distinctions between adult and child/youth learners, including questioning whether children and youth do not come into learning situations with complex histories as well, and whether children and youth necessarily are (or need to be) subject-centered in school (that is, whether this is perhaps something imposed by society and the

educational system, rather than something that is pedagogically necessary). I would extend this question to ask about adolescent learners, and also to ask whether undergraduate or preservice teacher candidates should be seen as adolescents or adults. How different are their learning needs? More on this in the subsection summary, in terms of application to the current study. Merriam and Brockett (2007), while acknowledging the contribution of andragogy to understanding adult learning, also call for critical assessment of its veracity and applicability to actual adult learning situations, and suggest that there has not been universal acceptance in the field of adult education, or verifiable research that demonstrates that the assumptions of andragogy lead to gains that would justify such a common acceptance of the theory. These basic assumptions, however, have informed the practice of adult education to a great degree, and serve here as a foundation upon which many principles and practices in adult education have been built.

Brookfield (1988) suggests six principles of effective practice for facilitating adult learning: (1) voluntary participation; (2) mutual respect; (3) collaborative spirit; (4) action and reflection; (5) critical reflection; and, (6) self-direction. The connections to Knowles (1970, 1980) adult learning principles can be seen here, but Brookfield (1988) extends these principles to suggest particular actions that are desirable or necessary in working in an educational setting with adult learners. Brookfield's (1988) principles could be viewed as an amalgamation of several foundational theories on learning and education, stretching back to Dewey's (1916) emphasis on experiential, collaborative and meaning-based learning, and including: Knowles (1980) in the areas already examined; Rogers (1983), in terms of voluntary participation, mutual respect, and self-direction; Kolb's (1984) highly influential emphasis on experiential learning including action followed by critical reflection; Bandura's (1978) theory of reciprocal

determinism which suggests that true learning involves the mutual influence of cognition, emotion, experience and the behaviour of the individual (and therefore requires hands on experience); and collaborative learning methods, including small group work, jigsaw activities and so forth (Santrock, Woloshyn, Gallagher, DiPetta, & Marini, 2007). Student-centred approaches and teaching focused on the development of conceptual understanding in students also tend to utilize many of the same principles and activities, and are the focus of the next section.

Teaching approaches. Marton and Saljo's (1976) seminal work on developing an inventory to measure student learning approaches has led to strong evidence that the ways that students approach learning (surface or depth) plays a large role in the quality of their learning outcomes. Biggs, Kember, and Leung (2001) developed a shortened form inventory to measure student approaches to learning, which has been demonstrated to be statistically reliable and valid, and has clearly shown that there is a strong association between depth approaches to learning and higher quality learning outcomes, such as the retention of knowledge, the ability to apply learning in novel situations, and the motivation to pursue knowledge beyond course requirements. Prosser and Trigwell (1999; Trigwell, 2010; Trigwell & Prosser, 2004) have extended this work on student approaches to learning, to examine whether approaches to teaching can lead to students taking a more depth-oriented approach to their studies. Their "Approaches to Teaching Inventory" (ATI) is a well-validated measure of how teacher-centered or student-centered an instructor is. Teacher-centered approaches emerge out of the belief that the teacher and texts have expert information which should be transferred to students, with learning outcomes being solely determined by the quality of this transfer. Student-centered

approaches, while not dismissing the important role of teachers and texts, emerge out of the belief that students learn differently, even when in the same learning situation. It follows that attempting to engage students in an active role in their learning is superior from a student-centered perspective, as this allows for the flexibility of different learning styles to add to the classroom, and for students to engage with materials in their own way and at their own pace. Using the ATI, Trigwell and Prosser (2004) have shown that student-centered approaches to teaching are highly associated with depth approaches to learning in students.

Teacher-centred approaches are not always associated with more surface-level approaches to learning, however. In fact, as Prosser (2010) points out, the teacher's philosophy about what constitutes learning may have a larger impact on learner than whether their approach is teacher or student-centred. Teacher approaches focused on concept change tend to lead to deeper forms of learning, whereas approaches that are focused on information-transmission lead to the shallower forms of learning initially associated with a teacher-centred approach. It could be that the association between student-centred approaches and deeper forms of learning occurs because most teachers who utilized student-centred approaches are also focused on concept change rather than information-transmission. This body of research clearly indicates that information-transmission as a teaching goal is associated with shallow levels of learning. Finally, Entwistle (2010) conducts a thorough review of research into teaching and learning and effective practices, and Weimer (2010) offers a similar overview regarding higher education faculty knowledge of the research findings on effective teaching and learning. Entwistle (2010) and Weimer (2010) agree that progressive approaches to teaching lead to much deeper learning outcomes for students, including retention of knowledge, the ability to apply it in novel situations, and engagement with the learning process.

Summary. Seminal research and literature was reviewed regarding learning as meaning-making. Dewey's (1938) concept of educative experiences was presented as a way to think about the progressive aims regarding teaching and learning presented in this dissertation. Dewey's (1938) cautions regarding easy, black and white answers, and the loose use of terms without definition, were also invoked. The constructivist perspective, focusing on the work of Piaget (1952, 1973) and Vygotsky (1930-1934/1978), was presented with the basic idea that learning occurs when students encounter the world and make meaning of these experiences through integration with existing understandings. The work of Knowles (1980, 1989) was discussed, in addition to several other contributors to research and theory regarding adult learning. The basic premise that adult learners bring their history to new experiences, and that this history is highly important in what can and will be learned was emphasized. The work of Martin and Saljo (1976), Prosser and Trigwell (1999), Trigwell and Prosser (2004), Prosser (2010), and Trigwell (2010) regarding the focus of teachers was reviewed, including an examination of the research regarding teacher orientation toward the amassing of information versus concept change as what is important in student learning.

In terms of beginning to sew these theories into a theoretical framework for my study, each of the progressivist perspectives detailed in this subsection demonstrates that learning involves change in the learner beyond the amassing of information. This is a central assumption in the framework I used in approaching the research. I was interested in a teaching approach focused on the learning of concepts, where participants would bring a history, build upon the understandings they brought with them, and would develop through interaction with peers and their surroundings. In short, I entered the research process looking for learning that involved

active meaning-making, leading to changes in participants beyond the gaining of sanctioned facts. The nature of such change is the focus of the following subsection.

The Nature of Knowledge and Concept Change

There is extensive contention in the literature on concepts regarding what exactly concepts are, what they enable, and how they change. What follows is an exploration of some of this contested area, with the intention of providing, in the end, an understanding of how concepts and conceptual development were viewed in the theoretical framework I carried into the research. Before directly examining the literature regarding concept change and development, however, the first issue that needs addressing is actually two interrelated issues: what is a concept, and what exactly defines concept change or development, that is, what makes a concept definition better or worse? In order to explore these questions, a discussion regarding the nature of knowledge, or epistemology, is required. The following discussion is a crucial part of the development of a theoretical framework for the study, because the perspectives explored in the following subsection had a major influence on what I looked for in participants in terms of their learning. A description of this influence is included in the summary of the following discussion.

The nature of concepts. The first perspective, essentially positivism, is what might be called the wrong/right perspective on concepts. In other words, concepts are either poor/inaccurate or good/accurate depictions of external reality. Post-positivists, though different from positivism in the acceptance that all is not actually knowable, still believe in objective truth, and that untruths can been proven through falsification (Denzin & Lincoln, 2005). Much of contemporary science, educational practice, and cognitive psychology in general is informed by

post-positivist thought, though several constructivist perspectives have had a great impact over the past several decades (Doll, 2008; Lagemann, 1997; Von Glasersfeld, 1984). The positivist position is that learning through concept change involves an ever more accurate reflection of external reality, which is seen as essentially static and eventually knowable through scientific measurement. According to this perspective, we just do not know it all yet (Denzin & Lincoln, 2005). There are disagreements between positivist camps regarding the nature of this external reality, but a basic agreement that "true" knowledge equals an objective understanding of external reality. Post-positivists acknowledge that subjectivity impacts the understanding of the world in terms of how personal experiences influence what is researched and interpretation of results, and urge caution and awareness of such limitations when drawing implications from findings, but still see true knowledge as a representation of objective, external reality (Denzin & Lincoln, 2005). Davis and Sumara (2007) call this set of positivist and post-positivist perspectives correspondence theories, in the sense that there is a basic belief that knowledge corresponds, in a one-to-one fashion, to reality.

The basic theoretical underpinnings of constructivism will be briefly described here, as this perspective has also had a great impact on educational processes (Lagemann, 1997), and more specifically on the understanding of what concepts are, and how they change. Davis and Sumara (2007) view constructivist perspectives as belonging to a group of coherence, rather than correspondence, theories. Following Piaget's (1951) original term schemes, schema theory has come to dominate cognitive vernacular, meaning the organization of many representations of experience into coherent and useful mental structures, with concepts as their organizing principle. The basic distinction between constructivists and positivists is that knowledge, for

constructivists, as represented in schemas, need not have any absolute correspondence to external reality (Von Glasersfeld, 1984).

Von Glasersfeld (1984), a proponent of radical constructivism, distinguishes between match (positivist) theories of knowledge, and fit (constructivist) theories. In fit theories, there is no need for the key (knowledge) to match a particular lock (external reality), but rather it needs only to fit the lock well enough to open it. In other words, constructivist theories suggest that rather than needing knowledge or concepts to match external reality, what humans really need (and develop) are concepts which allow them to adapt to their environment. Constructivists believe in an active role in the construction of knowledge, that is, we are constantly generating meaning through the organization of schemas, though this active construction is often unconscious. It need not be so, however, in that if one realizes that a particular conceptualization is not adaptive, and can become conscious of what is not working, the concept can be consciously changed, which is a key point in understanding the constructivist approach to learning (Von Glasersfeld, 1984), in that education can then be conceived of as aimed at helping students become aware of the state of adaptability of their concepts.

In my review of many studies regarding the nature of knowledge, there are blurry boundaries between post-positivist and constructivist perspectives (Arnaudin & Mintzes, 1986; Chi, Slotta, & Leeuw, 1994; Thompson & Logue, 2006; Zhou, Nocente, & Brouwer, 2008). For instance, though few contemporary researchers would subscribe to the notion of a rigid one-to-one correspondence between external reality and conceptualization, the dominant body of educational research utilizes the term misconceptions, and talks about change (from poor to good), when examining the development of concepts (Arnaudin & Mintzes, 1986; Chi, Slotta, & Leeuw, 1994; Thompson & Logue, 2006; Zhou, Nocente, & Brouwer, 2008). The term

misconception implies that there are wrong or false conceptions, though some might argue that it is simply used to denote that a particular concept is not useful, that is, does not match the lock(s) it is intended to open.

Instead of post-positivist vs. constructivist, Åkerlind (2008) distinguishes between the cognitive perspective, in which concept understandings are viewed on a continuum of desirability, and the phenomenographic perspective, in which concepts are seen as "logically related in a nested hierarchy of inclusiveness" (p. 636). The latter simply means that conceptual understanding relies on the building up of networks of connections between concepts. For example, my understanding of how plants make food is connected to and reliant on my understanding of sunlight as energy, rain, and the nutrients in soil. These concepts are themselves nested in larger and larger concepts, for example ecosystems, the Earth, and the Universe. A concept such as sunlight as energy has nested within it the understanding of other concepts, such as particles and waves. The essential idea is that understanding is dependent on relationships.

Two other constructivist approaches relate to Åkerlind's (2008) distinction in their focus on relationships as the basis of conceptual understanding. Bruner (1971, 1996) emphasizes the role of culture and society in education, and in the construction of concepts more specifically. In particular, Bruner (1996) points to Vygotsky's (1930-1934/1978) notion that doing precedes what we traditionally think of as knowing (and in fact is a type of knowing), and that doing (enacting/procedure) is integral to imagery, and symbolism (language). These three types of representation are organized into conceptual categories, each heavily influenced by culture. According to Bruner (1996), therefore, knowledge cannot be thought to be separate from cultural influence, or objective. Vygotsky (1930-1934/1978) is described as a social constructivist,

because of his emphasis on interaction in the process of learning and conceptual change. Though somewhat less directly focused on culture than Bruner, Vygotsky (1930-1934/1978) sees all surroundings as potential teachers, through relationship.

In terms of knowledge and concepts, complexity theorists, like constructivists, are interested in how useful, or adaptive, a particular concept is in a particular situation (Davis & Sumara, 2007). Concept growth is a process in which old concepts are enhanced, made more sophisticated, through experience, either by adding new features to the concept, or by making connections to other existing concepts, to handle newly encountered situations (Fabricatore & Lopez, 2014). So, rather than wrong/bad concepts being discarded in favor of new/good/right concepts, growth is the development of what already exists (i.e., the historical context of the complex system and its parts informs what will come, as unpredictable as it may be). However, unlike constructivist theory, with complexity theory more than just human social systems are stressed, that is, interrelationships in the natural world, including humanity, are what lead to the emergent phenomena of concepts (Gabora, Rosch, & Aerts, 2008). Complexity theory, then, provides a bridge between rigid correspondence theories and radical constructivist theory. Gabora et al. (2008) state that:

> …it is when stimuli in the world come to be understood in conceptual terms that they acquire the weblike structure and self-organizing dynamics characteristic of *ecology*.… Concepts … do not represent the world in the mind, as is generally assumed, but are a participating part of the mind-world whole. Therefore, they only occur as part of a web of meaning provided both by other concepts and by interrelated life activities. (p. 95)

Puk and Stibbards (2011) present the Growth Schemes model[2] as a way to classify the sophistication of student definitions of concepts, and also a method for the analysis of the criterial attributes of concept definitions in terms of lifelong learning. There are four classification levels for concept definitions. Criteria for evaluation are listed below:

Level 1: Unacceptable: Immature: these included concepts for which no definition was provided and definitions that were either vague or incorrect.

Level 2: Minimally acceptable: Limited maturity: this level is characterized by definitions that contain one viable criterial attribute rather than a system of interconnected attributes. At this level (and the next two), the focus is not on whether the definitions are right or wrong, but rather at what level of emerging maturity of meaning they are constructed.

Level 3: Enriched: Enriched maturity: this level is characterized by definitions of increased maturity, as exemplified by a partial system of viable criterial attributes.

Level 4: Exemplary: Robust maturity: this level is characterized by definitions that contain a mature, coherent system of viable, interconnected criterial attributes. Mature is used here in the sense of the meaning that might be expected at the level of education under study.

It is important to note the increasing sophistication between the different levels that reflects enhancement (Åkerlind, 2008), rather than change. In providing an objective perspective on the process itself, but also a critical and reflective awareness of the subjective origins of the term

[2] Based on Puk (1997) and Robinson, Ross, and White (1985)

itself, an Exemplary definition offers a description of an external process and critical commentary on human behaviour. In other words, the Growth Schemes model suggests an epistemology that does not prioritize objectivity or subjectivity, but rather sees both as inseparable parts of a conceptual ecology and has emergent properties in terms of the development of concepts, but also conceptual understanding, which is seen as having a much wider-reaching impact on the thinking of the learner, rather than the relatively simple changing of a single concept definition. The process of such development is the focus of the next section.

Concept change. Posner, Strike, Hewson, and Gertzog's (1982) highly influential Conceptual Change Model (CCM) suggests that science teachers need to ensure that concept development in students is accommodation rather than assimilation, as the latter means that pre-existing and naïve conceptualizations of reality endure. Accommodation, for Posner et al. (1982) requires the creation of situations in which 1) the original, naïve concept is seen as inadequate, that is, the individual is dissatisfied by the original concept 2) a new conceptualization is understandable and plausible, and, 3) the new conceptualization is more powerful than the original. Criticisms of this model focus on the lack of explanation of the role of motivation, affect, and social factors in concept change (Pintrich, Marx, & Boyle, 1993; Zhou, 2010). Strike and Posner (1992) themselves have criticized their original model as too cognition-focused, and have argued, along with others, for the need of a model that includes a description of the role of motives and emotions in conceptual change.

Gregoire's (2003) Cognitive-Affective Model of Conceptual Change (CAMCC) is an attempt to integrate older cognitively based models (such as the CCM) with models that incorporate the role of motivation and affect, such as dual-process models that examine both a

cognitive (systematic) and affective (unsystematic) role in attitude change. The CAMCC also integrates Fazio's (1986) model of the impact of attitudes on behaviour change, and Lazurus' (1991) perspective that goals and objectives also influence what is noticed in the environment. The basic difference in the CAMCC model is that it may explain why students, when confronted with the inadequacy of their existing conceptions may not change them for a better concept, due to affective or motivational factors. In other words, emotions or motivation such as fear or apathy may lead to a lack of concept development. However, though viewing themselves as constructivists, Posner et al. (1982) and Gregoire (2003) still present models that fit into the right/wrong perspective in that old, wrong, concepts are replaced by new, right ones.

Åkerlind (2008) offers the phenomenographic idea of *incomplete*, as opposed to *wrong*, in terms of concept development, and *expansion* rather than *change*. Because concepts are seen as nested hierarchies, rather than on a scale of desirability (the cognitive perspective), concept development is not about getting rid of misconceptions, but is instead a process of expanding one's awareness of the variability of a particular concept. In terms of learning, expansion of concepts means being exposed to potentially new relationships a particular concept has with other concepts. This connects well with Vygotsky's (1930-1934/1978) theory of concept growth through the Zone of Proximal Development (ZPD) in the sense that where the student currently is, in terms of concept sophistication, is not seen as wrong, but rather as the stepping off place. Vygotsky's (1930-1934/1978) notion of the zone of proximal development includes the teacher (though this can be a text, peer, cultural artifact and/or immediate environment) 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. This is not to suggest that the individual is not important in understanding concept change (e.g., influence of

previous history through schema, etc.). The emphasis instead is on the reality that the individual's concept understanding is not removable from the context they exist in. Vygotsky's model allows for, emphasizes, this reality. Still, though, the focus of both phenomenography and Vygotsky's ZPD model is subjective (though interconnected) human experience.

Conceptual Understanding. Extending Vygotsky's (1930-1934/1978) notion of teacher, Gabora et al. (2008) insist that the role of context must be explicit in any model that attempts to explain the ways humans employ concepts. They suggest that rather than identifiers, concepts are "bridges between mind and world that participate in the generation of meaning" (p. 84). This is because context can be demonstrated to change the way concepts are employed. They are not static, rigid structures, but rather are at best, as the Exemplary category asserts, flexible enough to negotiate the interrelationships inherent to ecological reality (Puk, 1997).

Gabora et al. (2008) also focus on the flexibility of concepts in terms of their ability to create meaning in many different contexts, terming this an "observer effect for concepts" akin to the issue in quantum mechanics of entities that are not defined until made concrete, often in research studies through measurement (p. 99). Gabora et al.'s (2008) ecological theory of concepts, a complexity approach involving self-organization of complex systems (including concepts and context), weaves together the central aspects of correspondence and coherence theories, in that both external realities and creative construction coexist and are mutually influential. Meaning in this model cannot be known until specific, concrete situations manifest, as the interplay between concepts and contexts leads to emergent and unpredictable outcomes. The ecological theory of concept growth and development, then, not only includes attention to accuracy and utility, but emphasizes the interactive and inseparable (objective/subjective) nature

of sophisticated concepts. Conceptualizer *and* context are acknowledged, as well as the inter-influential relationships between all parts of a system in the process of meaning-making.

Wieman (2010) asserts that progressive approaches to teaching at the post-secondary level tend to lead to expert-like understanding of disciplinary and interdisciplinary material, whereas information-transmission approaches have been shown to lead to novice-like understanding. The crucial difference seems to be that information-transmission approaches lead to knowledge that is not integrated into larger organized schemas, whereas expert-like development of conceptual understanding is epitomized by an understanding of the ways in which pieces of knowledge are interwoven parts of a whole body. Information-transmission, therefore, results in the inability to apply knowledge except in contexts that very closely resemble that in which the information was learned (e.g., to regurgitate for exams) whereas expert-like knowledge can be adaptively applied in novel, challenging situations. Meyer's (2010) work with disciplinary threshold concepts examines a similar issue. Though all experts in a particular field can identify crucial concepts within their disciplines, information-transmission approaches to teaching do not lead to the transfer of understanding of these concepts to students. Instead, in order to learn the threshold concepts in a particular discipline, Meyer (2010) has shown that experience in application of ideas is necessary. In this way, students naturally encounter both the specifics of particular concepts, and their interconnection with other concepts. In other words, expert-like understanding of threshold concepts emerges through exploration.

Mature conceptual understanding, then, is not something that is developed through information-transmission, but rather requires more sophisticated learning approaches, in which students can interact, make mistakes and co-construct new understandings that are connected

with other disciplinary concepts. Growth in conceptual understanding is therefore an emergent phenomenon.

Discernment. Discernment can be seen as emerging from conceptual understanding, in the sense that when someone understands the complex interrelationships between concepts, they also begin to understand how these concepts are used differently, and for specific purposes, by societal entities. For example, Puk (2010) suggests that ecological discernment is "the ability and willingness to see through the fog of greenwashing" (p. 341). In this sense, Puk (2010) is pointing out that though someone may understand the meaning of a concept such as sustainable in a more scientific sense, and understand its connection to other ecological concepts, they are also able (and willing) to see how it is used by corporations and institutions who have a particular agenda. Often the agenda is focused on maintaining a positive public image of caring about ecology, when in fact their practices are mostly ecologically harmful. Discernment, as used here, could be seen as congruent with what is often meant by the term critical thinking, and yet this latter term suffers from over-application, and therefore it is hard to distinguish what is really meant when we say someone is thinking critically. Discernment, instead, is meant to clearly indicate an ability to penetrate surface-meanings of terms, and to identify motivations behind their application to activities.

Summary. This subsection began with an examination of different understandings of the nature of knowledge, and concepts in particular. After contrasting several different perspectives, the idea was presented that concepts can be viewed as representations of external phenomena which become more and more useful the better they represent such phenomena, though such

representations need not be seen as objectively accurate in the positivist sense. This is the perspective that I carried into the research. In other words, I was looking for participant experiences whereby as their representations became more useful, they became more complex, through the interconnection with related concepts, so that growth in understanding could be seen as a process of learning about how different concepts are interconnected. In terms of the theoretical framework utilized in this study, flexibility in applying knowledge to unique situations demonstrated sophistication in conceptual understanding, as did the ability to be discerning in the interpretation of experiences. I was looking for such growth in conceptual understanding, focused on how such understanding develops through meaningful encounters with the environment surrounding participants. Further I wanted to know about the qualities of experience that exist with such growth in conceptual understanding. The following subsection examines research in several areas of experience related to the kind of learning I have referred to as transformative meaning-making.

The Experience of Transformative Meaning-Making

As has been discussed in some detail, I began the doctoral program with an interest in learning as a phenomenon that is about more than the simple amassing of information, and therefore had explored several branches of theory about such learning, including Mezirow's (2000) approach to transformative learning. However, I saw Mezirow's approach as limited to an intellectual understanding of learning. I brought a psychological perspective to the research, and so was very interested in examining learning as something more than intellectual in nature. What follows is an exploration of several areas of research literature I examined in pursuing a richer understanding of the psychological and physiological contributions to experiences of learning.

This subsection is followed by a summary which includes preliminary information about how these areas of research were sewn into the theoretical framework that informed the perspective with which I entered the research.

Engagement. It is generally agreed in theory and research on experiential and inquiry-based learning that engagement is a by-product of such approaches, as students are able to utilize their personal learning styles and plug into information and resources that are of personal interest (Christensen Hughes & Mighty, 2010; Entwistle, 2010; Kinzie, 2010). Therefore, understanding the experience of engagement is an important component in describing the experience of transformative meaning-making that is invoked by the emergent design approach. To measure engagement, we often ask students about their involvement in particular activities, as with the National Survey of Student Engagement (NSSE; 2010) that is so currently popular in North American institutes of higher education (likely because of such high correlations between high student engagement scores and retention levels). The NSSE (2010) asks students to rate their involvement in several areas of undergraduate life and counts these as markers of engagement, and also to rate their satisfaction. This gives us an indirect picture of student experience.

In order to get a better sense of what the experience of engagement is actually like, that is, in order to understand what is actually happening in transformative meaning-making, it is necessary to examine the hallmarks of someone who is fully engaged.

Empathic community. Dewey (1938) stresses the central role that social interaction plays in education. Social interaction is also central to Vygotsky's (1930-1934/1978) approach to education as a "Social Constructivist" (Santrock et al., 2007). These are just two of the examples

of theories that have provided the underpinning for theory regarding collaborative learning. However, collaborative learning is a term that is used for such a wide variety of activities its meaning is somewhat difficult to discern. And, collaboration between learners does not necessarily require a sense of community. For example, cliques can form in classrooms within which there is ample collaboration, and yet as a whole, the class is unlikely to share a larger sense of collaboration in the learning process. For this, community is necessary.

A key aspect of emergent phenomena is the interaction of the members of a complex system (Davis & Sumara, 2007). In terms of the complex system of a class, the students and professor are key members, but at the same time their surroundings are important (e.g., indoors or outdoors), and it must be remembered that a particular class is a system embedded in the larger system of the university, society and so on. However, in order for this to occur, a sense of community must be nurtured between students in a class, and as Puk (2010) suggests, it takes time to develop trust, and students must be given the opportunity to have experiences which sponsor the building of such trust. Puk (2010) focuses on two aspects of the development of community, inclusiveness and empathic concern between members of a course. Research on empathy has accelerated greatly over the past 10-20 years, alongside the boom in research in positive psychology (Rifkin, 2010). Rifkin (2010) suggests that the emphasis on aggression and opposition in human history reflects more of an interest in novelty than a solid critical examination of human hard and soft-wiring. In fact, Rifkin's (2010) analysis suggests that humans are wired for empathy, which only needs an appropriate environment in which to develop quite naturally.

During my master's degree, I was an intern at a retreat and study center for personal growth and therapeutic group work, which focused on the development of community. Having

empathy for others, according to this approach, requires that each member of the community has goodwill for others and accepts other community members as they are, rather than trying to change them (Stibbards, 2004). Note that acceptance does not require agreement, as Rogers (1983) points out, and goodwill does not necessarily mean liking. Instead, having empathy for those we dislike and/or disagree with means trying to put ourselves in their shoes, on a feeling or emotional level, out of a genuine respect for their right to be an individual (Stibbards, 2004).

The development of an inclusive and empathic community is not an easy task. In my experience it takes significant role modeling and attentiveness to what is occurring on the part of facilitators, processes that encourage interaction, and understanding of others, and patience (Stibbards, 2004). Much more will be discussed in terms of the role that interaction plays in the change and growth of a complex system, in terms of the theoretical framework I carried into this study. For the moment, however, the focus for this subsection on community has been on the importance of empathy between members as it creates a safe environment for taking risks. The next aspect of experiences of engagement to be discussed, curiosity, is a feeling that requires such a sense of safety, if it is to be sparked.

Curiosity. Research regarding curiosity, though having a long history (Berlyne, 1960; Fowler, 1965; James, 1897/1984; Kashdan & Silvia, 2009; Loewenstein, 1994; Piaget, 1952) is relatively sparse when considering the central role that curiosity plays in the learning process. Much research about curiosity has focused on determining exactly what curiosity is: a drive (Berlyne, 1960); dependent on cognitive appraisal of context (Loewenstein, 1994); a motivational/emotional state (Litman, 2005); the same as interest (Kashdan & Silvia, 2009) or something connected with interest, but distinct (Engel & Randall, 2009). Defining curiosity

remains an area of controversy and (curious) exploration, and of course the absolute delineations between theories and researchers are an exaggeration (Reio & Callahan, 2004).

Berlyne (1960, 1978) is generally considered to be the path-breaker for modern conceptualizations regarding curiosity. Berlyne's (1960) main theory emerged out of the Behaviourist paradigm, and therefore followed basic drive theory that was used to explain the foundation of motivation for all behaviours. Essentially, curiosity was seen as a primary drive, caused by an aversive state (arousal caused by information deprivation), which triggered exploratory behaviour, and if information was successfully gained, reward was experienced due to terminating the aversive state. But Berlyne (1960) also challenges earlier drive-based theories, which asserted that curiosity, similar to other drives like thirst and hunger, is internally based, and activated to achieve homeostasis (Loewenstein, 1994). Instead, Berlyne (1960), proposes that curiosity is externally triggered, caused by stimuli that appear to conflict with each other or are incongruent with past experiences, including stimuli that are complex, novel and/or surprising. These sorts of stimuli would cause activation of the curiosity drive and heighten arousal. Berlyne (1978) also suggests that there are different kinds of curiosity, epistemic curiosity, present only in humans and defined as the desire for knowledge itself, and perceptual curiosity, defined as exploration stimulated by external novelty, which fades as exposure is prolonged. This is a vital distinction, that has led researchers who followed Berlyne (1978) to debate whether both epistemic and perceptual curiosity are really both curiosity (one factor) or whether they are separate constructs.

At around the same time as Berlyne (1960) offered his drive account of curiosity, incongruity theories of curiosity emerged that were decidedly cognitive in nature (Loewenstein, 1994). Piaget (1952), in terms of curiosity, focuses on a child's need to make sense of the world.

Piaget (1969) asserts that curiosity is central to the processes of assimilation and accommodation, in that curiosity is the mechanism that is triggered when humans encounter the unexpected. The idea of incongruity as a cause of curiosity, whether behaviourally or cognitively explained, is well supported by research (Berlyne, 1960; Kashdan & Silvia, 2009; Litman, 2005; Loewenstein, 1994; Piaget, 1969). Though it is quite clear that humans are motivated to explore surprising situations or information that does not fit with expectations (incongruity), questions remain. Do we always get curious and explore in the face of the unexpected? Do all people respond with similar levels of curiosity in the face of similar incongruities, or, to ask this another way, does a stimulus provoke the same level of curiosity in all people that encounter it?

Loewenstein (1994) proposes that curiosity is triggered by "information gaps", which is similar to incongruity theories, except that he specifies that we must know what a person wants to know, and thinks they know, in order to understand the gap. In other words, a subjective measure of the gap is necessary to advance understanding of information gaps and their contribution to curiosity. A "feeling of knowing" (FOK) was measured through asking participants to rate, after being asked an information-based question, whether they 1) knew the answer, 2) the answer was on the "tip of their tongue" (TOT), or 3) did not know the answer. Loewenstein (1994) predicted that the stronger the FOK, the stronger curiosity would be (though curiosity should be low or non-existent if someone already knew the answer). His research supports this hypothesis in that participants who reported the answer was on the tip of their tongue also reported higher levels of curiosity about the answer than those who reported not knowing the answer at all. In other words, too large an information gap may not trigger curiosity at all. This finding has important implications for education, namely that creating incongruity is central to sparking curiosity, but that too much incongruity can actually cause students to

withdraw. Having a sense of where students are in terms of their learning, then, becomes important, and creates challenges for facilitators, as different students are likely to have different levels of knowing, and therefore the offering of specific information may scare off some students, bore others, while still others may become curious.

Though I have suggested that the research literature indicates patterns in terms of sparking curiosity, an obvious question remains, that is, does curiosity foster learning? Loewenstein (1994) found that higher self-reported curiosity about particular facts led to better recall of these facts, than recall of information that had not sparked participants' curiosity. Kang et al. (2009) also found a positive correlation between high self-reported curiosity, activation of reward centers of the brain, and better recall of material. Ainley, Hidi, and Berndorff (2002) sought to explain the sequence that combines interest in a particular topic and learning outcomes. Essentially, their findings indicate that interest in a topic leads to affective response, which leads to persistence in learning. Reio and Wiswell (2001) found that higher levels of trait curiosity correlated with higher job performance in a work-place. They theorized that curiosity-related activities such as information-seeking both directly enhances job performance (though improving knowledge relevant to tasks) but also indirectly improves performance through the social connections that are strengthened through the information seeking and exploratory processes sparked by curiosity. This connects with research examining the relationships between curiosity, emotional intelligence, and social functioning.

Perhaps the strongest argument for curiosity as integral to learning is that when we are genuinely curious about something, it is intrinsically meaningful to us, and we are therefore much more likely to remember what is learned and integrate it into our understanding of the world. Piaget (1969) and Vygotsky (1930-1934/1978) argue forcefully that learning is a

constructive act. We must be actively engaged in learning in order to integrate what is learned into existing schemas about the way the world works. In other words, learning must be meaningful to the individual as learning is a meaning-making process. Ryan and Deci (2000) stress the importance of intrinsic motivation to learning at a deep level, and saw curiosity as a fundamental part of the intrinsic motivation to learn. Kashdan and Silvia (2009) point out that humans may be predisposed to seek pleasure and enjoyment, which tend to be associated with familiarity and comfort, rather than growth. It could be suggested, then, that curiosity as a motivational force, mitigates this migration toward the familiar, therefore promoting growth through intrinsically rewarding exploration. Levitt et al. (2009) examine depth curiosity, which they align with Berlyne's (1960) epistemic curiosity dimension. They found that long-lasting curiosity about specific areas for participants was dependent on emotional valuing of the area. In other words, curiosity is sustained when we care about something, and in turn, sustained curiosity leads to depth of knowledge of what we care about, because our curiosity leads us to explore the area in depth. Interestingly, participants described this depth curiosity as pleasurable and internally motivating (rather than aversive). In fact, participants reported wishing they could spend more time exploring their area of interest, a point which Levitt et al. (2009) connect to the potential role of curiosity as a motivating force in learning.

As Gordon (2006) points out, preparing children, youth, and young adults for uncertainty and ambiguity is important because the real world that they will enter after school seldom has easy answers. Facing the unknown, the ambiguous, the uncertain, is difficult (for teachers as well as students), Gordon (2006) admits. But preparing students for the reality of such gaps is one of the vital jobs of education. As several of the above-mentioned researchers argue, curiosity is only invoked when the gap between what is known and what is not is not too great, and the closing of

the gap of information requires resources of information, including teachers (Vygotsky, 1930-1934/1978). Curiosity requires a sense of safety to explore, which includes a sense that one will not be punished if they make mistakes or come up with the wrong answer. This is clear from attachment research (Bartholomew & Moretti, 2002; Bowlby, 1969), and also in educational research (Kashdan & Yuen, 2007; Roman & Kay, 2007). So, educational policy based on curiosity research would include the offering of information by teachers to provide background and direction, but also would require teachers to leave open gaps in knowledge, in order to stimulate curious responses in students.

Further curiosity research is warranted on several fronts. Evidence is needed to more clearly demonstrate whether epistemic and perceptual curiosity are actually both part of a larger construct, or whether they are separate processes, and if so, what the relationship between them is. Most centrally in terms of its contribution to the theoretical framework for this study, I entered with a desire to know more about the sparking of curiosity and its role in the dynamics and experience of emergent learning. Examining research regarding play, which is next, provides related material having to do with engagement in the fabric of the my theoretical framework.

Play. Sociologist George Herbert Mead (1896) focuses on the "coordination" of organisms that occurs spontaneously through repeated play behaviour, which undoubtedly influenced later perspectives, presented below, on the benefits of play. Mead sees play as an inherent behavioural pattern, and coupled with the coordination that occurs through spontaneous interaction with one's environment, as the "…principle upon which education should be conducted…" (p. 145). This is a striking claim and, but for a few exceptions, is not an idea that is promoted for education beyond the very early years. I hope to establish, though, that play

should be seen as an attitude or state that reaches far beyond the imaginative or physical activities that we commonly ascribe to it, particularly because the literature only minimally addresses the role of play in adult education.

For both Piaget (1951) and Vygotsky (1967) imaginative play has a very particular role in cognitive development. However, there are considerable differences between theorists, and a major criticism of Piaget's (1951) stage theory, particularly, requires mentioning at this point. Where Vygotsky (1967) saw learners as developing at different paces, and generally being ready for learning whenever the gap between where their own readiness to learn is bridged by a teacher (the ZPD), Piaget (1951) saw learning as governed by stages based on age. This age and stage-based theory has been largely discredited by research findings (Lauenco & Machado, 1996). In their review, Lauenco and Machodo (1996) describe research showing that children quite clearly develop at different paces and that the strict delineations between stages suggested by Piaget do not exist. Piaget's (1951) theory about play is not presented here, therefore, as a definitive developmental perspective, but rather because of his basic premise that play is an "as-iffing" activity which contributes vitally to cognition and learning, which does mesh well with Vygotsky's (1967) and other theories of play to be examined.

Piaget (1951) sees play as essential to the development of figurative thought in children (not formal, rational, logical thought, but the precursor to it) which demonstrates that the child is moving beyond simple representation of sensory stimuli, and is beginning to be able to separate thought processes from what is immediately before them in the external environment. Piaget (1951) sees play as autotelic, in general, (meaning that play activities are ends unto themselves, and are not activities that are imposed from outside the child), but he questions whether play could be truly conceived of as autotelic when its far-reaching benefits, in terms of development,

were so clear. He sees play as having a fundamental role in resolving conflicts between established schema and incongruent stimuli experienced by the child, through the development of the ability to construct new learning through the taking on of new roles. Assimilation in play, to Piaget (1951), is the process of transforming the world (experiences) to fit with pre-existing conceptions. Through imaginative play, the world is transformed to deal with conflicts and frustrations the child has with the way that the world is, and who they are in relation to that world. Through trying out of different roles in imaginative play (roles for a child, for example, playing mom, or roles for an object, for example, a stuffed animal as a student in an imaginary classroom) knowledge is gained about others' experience of the world and relationships. But this experience of others, for example, getting a chance to feel what it is like to be mom, is not the most important thing that play does in terms of cognitive development. Piaget (1951) argues that imaginative play signals that children have developed schemas that are sophisticated enough to let them abstract the meanings of external stimuli. This figurative knowledge, this playing with what is to construct new meanings, is the precursor to logical, rational thought, for Piaget. In other words, it is the conflict a child feels with an experience that does not fit with their pre-existing knowledge that leads them to distort reality to match their expectations (through imaginative play), constructing new meanings and understandings through this process, which forms the basis of more sophisticated abstract, logical, and rational thought later in life.

Vygotsky (1967) agrees with many of Piaget's (1951) understandings of the importance of play, including that imaginative play is the process of abstracting the real meaning of outer objects, which leads to the higher cognitive abilities of logical and rational thought later in life. Vygotsky (1967) describes this as the separation of thought from objects, the ability to separate sensory input from meaning, and believed this is a vital step in cognitive development. Vygotsky

(1967) suggests that play creates the ZPD, in that the child is taking a step beyond their present level of development through acts of imaginative play. Smilansky and Shifatva (1990) suggest that social pretend play does not display only figurative cognitive processing, but is more complex and cognitively advanced, including orientation, organizational, arguing and social skills not described by Piaget (1951). Dansky and Silverman (1973) demonstrated that childhood imaginative play develops several cognitive abilities related to creativity, including; flexibility, curiosity, spontaneity, and interest in approaching divergent non-play tasks.

Reynolds and Jones (1997) extend the Piagetian idea of figurative thinking in play to suggest that play is representational and allows children to directly understand, through role-playing, meanings that they have not previously been able to represent. Instead of play forming figurative thought processes (Piaget, 1951) that lead to abstract and logical thought processes later in life, Reynolds and Jones (1997) suggest that play activity is representational itself, and undergirds all later types of representation, including language, writing, painting, and so forth. This is very closely connected to Vygotsky's (1930-1934/1978) sense of language as representation. For Reynolds and Jones (1997) play is an emerging representation of ideas, and play provides protection so that "masterpieces under construction" can be experimented with.

Evolutionary theory and research about play has a long history, stretching back to the pioneering work of Groos (1898, 1901), who influenced the deferred benefits of play theories (play as progress) of both Piaget (1951) and Vygotsky (1967). Evolutionary researchers (see Burghardt, 2005; Pellegrini, Dupuis, & Smith, 2007) agree with Piaget (1951) that though play activity is engaged in as an end unto itself, it also has many deferred benefits. Essentially, evolutionary researchers have been interested in the costs and benefits of particular behaviours, in terms of inclusive fitness (the ability of an organism to pass along its genes), and so play

becomes a particularly fascinating topic of study, as the immediate benefits of play are not overtly apparent (Pellegrini et al., 2007). This has led researchers (Burghardt, 2005; Groos, 1898, 1901; Pellegrini, Horvat, & Huberty, 1998) to theorize that there must be deferred benefits to play, because there is substantial cost involved, including the energy used in play and risk of injury, the time taken for play that is not then available for food foraging, and the danger of predation that is heightened because animals' attention during play is focused on the activity. Evolutionary theorists suggest that play is behaviour provoked by the original learning instinct, in that animals are able to practice specific behaviours that they will need later to survive and perpetuate their genes, but through play can do so safely (Pellegrini et al., 2007). For example, young or juvenile animals denied the access to rough and tumble play with their peers show deficits in sexual and social behaviours as adults (Pellis & Pellis, 2009).

In addition to being direct practice for specific behaviour patterns that will be important later in life, experiences of play lead to the ability to be innovative (Bjorklund, 2006; Pellegrini et al., 2007; Spinka, Newbury & Bekoff, 2001). In other words, not only can specific social, food gathering/hunting and sexual behaviour patterns be learned through play, but players learn, though the experience of play itself, to be innovative when encountering future novel situations. This is a key value of play as a mode of learning in higher education, as dealing with the unexpected is a vital skill in meeting the challenges of an uncertain world (Gordon, 2006).

Neuroscientists have demonstrated that play is an instinctive behaviour, which is initiated in the brainstem (the oldest part of the brain) which is the same area which regulates other basic instincts like hunger, thirst and sexual instinct (Pellis & Pellis, 2009). In fact, Pellis and Pellis (2009) have observed that play and food deprived rats (in particular, during the juvenile period in which play behaviour appears to be crucial in terms of deferred benefits) will play before eating,

upon being returned to their regular social context, where food is readily available. Panksepp (2007) has demonstrated that play has immediate benefits as well as deferred ones. Play reduces stress levels, which has crucial impacts on many other cognitive processes central to the learning process. Panksepp (2007) has also shown playing increases the ability to regulate emotion in the longer term, that is, play is a behavioural pattern that leads to the maturing of the cognitive process of emotion (and stress) regulation. When learners are able to regulate emotion and stress, attention is available for important cognitive processes that are central to learning, such as planning, decision making, making evaluative judgements, and creative/divergent thought processes. Jensen (2005) reiterates these points in making the connection between the ability to regulate emotion and the educational benefits of enhanced social functioning and the ability to handle unexpected occurrences. Evolutionary researchers have suggested that play occurs only in childhood, and for some species during the juvenile phase (but not into adulthood), because these are the phases of development in which protection and resources are provided by parents and, in some cases, community (Burghardt, 2005; Pellegrini et al., 2007). Jensen (2005), in presenting brain and play research with education in mind, points out that play allows children to make mistakes without negative, even lethal, consequences. In other words, play does not appear to be specific to childhood and juvenile periods because play is a developmentally phase-specific activity, as is suggested by Piaget (1951). Rather, play happens during these periods because this is the only time that most animals can afford to play. During the adult period, play is generally not safe, as no one is providing resources and protection and so the individual must do so themselves.

To summarize, imaginative and social play are seen as crucial at a particular time of life because they lead to benefits later, creating a shoulder for higher cognitive processes to stand on.

Reynolds and Jones (1997) suggest that the process of playing with emerging representations does not end in childhood because adult representation is play, too. Vygotsky (1967) also alludes to the fact that play does not end in childhood, but rather transforms from overt, imaginative activity to become more the underpinning of conceptual dynamics, which is highly relevant to the theoretical framework of this study, as I am focused on understanding the dynamics and experience of emergent learning of concepts. Research and theory regarding imagination and learning is the focus of the next subsection.

Imagination. Weininger (1988) discusses the as-if quality of imagination in children, which has obvious parallels to Piaget's (1951) and Vygotsky's (1967) sense of imaginative play, which has just been discussed in some detail. Weininger equates imagination and pretend play. The cognitive ability to abstract external reality and imagine alternatives, make connections with other experiences or concepts, and have access to an array of responses beyond mere reflex, is arguably the key to the meaning-making process. Egan (1990, 1992) also argues that the imagination is a type of cognitive capacity that allows us to make sense of experience, in other words, make meaning. Egan (1990) suggests that in order to make meaning we tend to imagine narratives of our experiences, which tends to connect us with the affective domain, which will be discussed shortly. Egan (1990) also warns against making nouns out of dynamic events or capacities, and so I need to further state that when using the term imagination, I do not mean a static thing, but rather a dynamic capacity. The discussion of imaginative play as an as-iffing quality, and Egan's (1992) view of imagination as a sense-making capacity, clarifies the value of creating experiences in which students are stimulated to try out new roles and create narratives to

explain what is occurring, as is designed to happen with macro-models in the emergent design approach (Puk, 2010).

When students are given the answer, learn to expect it and feel uncomfortable when it is not forthcoming, the meaning-making process has been subverted (though still may occur, despite the dampening effects on the imaginative). Instead, pieces of information are often rehearsed and filed for later assessment, but they lack a connection that is meaningful for the individual, and therefore are unlikely to be useful in real life (Gordon, 2006). As explored in the previous paragraphs, to imagine is to connect experience with one's own understanding of the world and our experiences in it, which provides a perspective on the experience of emergent learning which will be sewn into the theoretical framework for this study.

Summary. Csikszentmihalyi (1990) defines the experience of flow in many ways that match what has been discussed regarding curiosity, play, and imagination. Flow, first of all, is an experiential state, only identifiable through direct inquiry as to an individual's internal state. One person could experience flow while looking at bacteria through a microscope while another would be extremely bored. For Csikszentmihalyi (1990), the state of flow is indicated by the complete engagement of the individual in whatever it is that they are doing. When a person is in a state of flow they wish to continue the activity, and want to return to it later if they must stop. Boredom occurs when an individual feels that they have a skill level that is higher than the challenge presented, whereas anxiety is provoked when the challenge presented is greater than the individual's perceived skill. In situations where an individual does not feel challenged but also does not see themselves as skilled, apathy blooms. Flow occurs when the challenge an individual experiences is high, but they also feel that their ability to meet the challenge is high.

Csikszentmihalyi (1990) also discusses the autotelic nature of flow experiences. In other words, curiosity, play, imaginative, and flow experiences do not require extrinsic motivators because they are engaged with for their own sake. Flow can be conceptualized as a state of full engagement, and also as a descriptor of the individual who, sparked by curiosity, has entered into an interactive activity with an attitude of playfulness and imagination.

In terms of contribution to the theoretical framework used in this study, I drew heavily on the literature regarding these aspects of engagement in looking at participant experiences when they were engaged in roles. Macro-model experiences, especially, involve acting as-if participants are different parts of a system, and so lend themselves to new perspectives (Puk, 2010). Further, this research on engagement led me to look at the dynamic processes through which participants grew in conceptual understanding. I looked for empathic interaction, curiosity, play, and imagination, and the ways that all of these worked together as part of larger learning patterns. Detail on these aspects of the theoretical framework will be discussed at the end of the chapter.

Emotion, feeling, and embodiment. It is potentially awkward to separate a discussion of emotion and embodiment from the previous section on engagement, as emotion, feeling, and embodiment seem inextricably entwined with the experiences of being engaged, aloof, or apathetic, which were discussed in the preceding section. However, early in the process of assembling a theoretical framework, it was important to delineate aspects of experience, and so the separation between engagement and embodiment that exists here is a representation of that initial perspective. In those earlier stages I was focused on the importance of emotion and the embodied experience as crucial, and was aware that we often skip over these when looking at

learning, instead valuing only the intellectual domain (Wood, Wood, Boyd, Wood, & Desmaris, 2013). As Damasio (2003) says:

> We often fail to notice [the centrality of feeling in our experience] because the mental images of the objects and events that surround us, along with the images of the words and sentences that describe them, use up so much of our overburdened attention. But there they are, feelings of myriad emotions and related states, the continuous musical line of our minds, the unstoppable humming of the most universal of melodies that only dies down when we go to sleep… (p. 3).

So, emotion and feeling are explored next, followed by significant attention on the literature regarding embodiment and learning.

Emotion and feeling. Though there has been an increase in the research literature on emotion over the past 20 or so years, emotion has been a largely neglected area of research in both psychology and education, where the focus has been isolated on rational cognitive processes (Feldman & Dinardo, 2009; Wood et al., 2013). In order to begin this subsection, first the meaning of the words emotion and feeling must be established in terms of how they are used in the literature, and how they will be used in this dissertation. Following this will be an exploration of more recent research which examines the importance of emotions in learning, and then a brief discussion about how this literature contributed to my theoretical framework upon entering the research process.

The James-Lange theory of emotion is known as the oldest theory of emotion, which for lack of other theories was influential through the 20th century. James and Lange independently

suggested that emotion actually follows behaviour (Feldman & Dinardo, 2009; Wood et al., 2013). For instance, crying causes sadness, smiling causes happiness. A serious limitation with this theory is that someone may cry when happy, or smile when sad. Schacter's two-factor theory of emotion asserts that both physiological arousal (e.g., increased heart-rate) and cognitive appraisal of the arousal (e.g., heart-rate is increased because there is a bear nearby = fear) must be present for an emotion to occur (Feldman & Dinardo, 2009; Wood et al., 2013). Schacter also emphasized the role of others in influencing our appraisals of physiological arousal. For example, if my heart-rate is raised because I am watching a scary movie, but others are laughing, I may appraise this physiological arousal as excitement rather than raw fear.

Damasio (1999, 2003, 2012), however, stands out as a primary contemporary scholarly champion of the argument that emotions, feelings, and embodiment (and their inter-related nature) play a vital role in cognitive functioning and consciousness itself, refining and extending earlier theories and definitions based on his research. Damasio (2003) and Damasio and Carvalho (2013) point out that though the terms emotion and feeling are often convoluted in traditional literature, feeling should be defined as the basic experience of pain or pleasure, where emotion is based in physiological experience and other bodily influences. In other words, though not always consciously apprehended, feeling is the bedrock of mental experience, where emotions are more primarily physiological events. Where emotion can often be observed through external cues such as tears or facial expression, feeling is a personal experience that must be expressed to be known to the outer world. Damasio (2003) suggests that "Emotions play out in the theater of the body. Feelings play out in the theater of the mind" (p. 28). Damasio and Carvalho (2013) demonstrate that emotions precede feelings, which precedes consciousness. In other words, it is the process of first experiencing the physiological reaction to an event (largely

processed in the old mammalian limbic system), and then interpreting them (largely in the pre-frontal cortex, the so-called executive center of the brain) that leads to a sense (feeling) of pleasure and/or pain. In more current research, feelings as defined by Damasio (2012) tend to be seen as part of cognitive appraisal, whereas emotions are seen in a similar way (Kim & Pekrun, 2014).

Kim and Pekrun (2014) suggest that researchers have now firmly demonstrated that emotions impact learning through inter-influential relationships with cognitive processes, decision-making, and motivation. In terms of cognitive processing and decision-making, Damasio (2012) describes how emotions are ongoing processes which underlie human conscious experience, and are therefore fundamental. Kim and Pekrun (2014) more specifically suggest that emotions can either speed up or slow down cognitive processing, can alter a person's ability to remember information for better or worse, and in fact can actually change the way information is stored so that it may be recalled or not depending on mood congruency between the formation and recall of memories. Though there has been quite a lot of research regarding the role of motivation in learning, researchers have only more recently begun to examine how emotions and motivation may have interconnected influences on learning (Kim & Pekrun, 2014). For example, Cho and Heron (2015) show that motivation and learning strategies, constructs long believed to be central in successful learning, did not predict academic achievement without the addition of emotion as a variable. Headrick, Renshaw, Davids, Pinder, and Araújo (2015) demonstrate that emotion, long believed to be a distraction in sport skill development, plays a vital role and should be included in any planning for dynamic and successful learning strategies. Though these studies are preliminary, and more research is needed to support and refine conclusions, it is clear that we ignore emotion and feeling as central aspects of learning at our peril. More will be discussed

regarding the role of emotions and feelings as part of the theoretical framework for my study as the chapter progresses.

Embodiment. Puk (2010) suggests that the body, mind and surroundings act in mutually influential ways through interaction and experience, while at the same time emotions contribute to the overall feeling experience of what is occurring. This assertion is supported by Stephen, Dixon, and Isenhower's (2009) neural imaging findings that many levels and layers of the brain and body interact during cognition, including sensory, motor and emotional processes. Damasio (2012) stresses the important role of sensory experience in emotion, which leads to feeling, which is a crucial and always present aspect of our mental state. This is closely connected with the concept of embodied cognition, a relatively recent area of theory and research which questions traditional notions of cognition as a purely rational process, separate somehow from the body and parts of the brain which are more focused on sensory and motor processing (Calvo & Gomilla, 2008; Coello & Fischer, 2015; Shapiro, 2014).

Embodied cognition, though not in reality a unified theory, can be seen as a loosely affiliated set of research projects and theories that have been challenging traditional perspectives on cognition and the mind for the past 20-30 years (Calvo & Gomilla, 2008; Coello & Fischer, 2015). Calvo and Gomilla (2008) suggest that traditional cognitive theory, which has held sway since the late 1950's in terms of our understanding of the mind, follows a basic sandwich metaphor, where inputs (sensory data) and outputs (motor signals) are the pieces of bread, which are essentially separable from the meat of the sandwich which is the mind. Embodied cognition theories are supported by a growing variety of research which suggests that this delineation between sensory, motor, and executive functions is illusory, and that instead the body, with its

sensing and acting capability, is an inseparable part of cognition overall (Coello & Fischer, 2015; Shapiro, 2014). The implications are wide-reaching, as old (almost Cartesian) notions of the mind as existing within the brain, with inputs and outputs being essentially unimportant as to the constitution of the mind, are not congruent with findings coming from areas as developmental psychology, philosophy, artificial intelligence research, and cognitive neuroscience (Coello & Fischer, 2015; Moseley, Kiefer, & Pulvermüller, 2015). Instead, more recent research suggests that inputs and outputs are part of a dynamic, interwoven and self-organizing system (Moseley et al., 2015). Perhaps most importantly, that which stimulates the senses and is acted upon (the outer world), also has a large role in mind, though this last, and other theoretical claims of embodied cognition researchers are much in contention (Wilson, 2002).

In a seminal review of embodied cognition literature, Wilson (2002) critiques the loose use of the term embodied cognition, suggesting that researchers use this term to mean a variety of different things, some of which are supported by research where other assertions are not. Though she is skeptical about the theory alluded to above, that the outer world plus organism must be seen as the unit of mental activity, rather than the organism only, Wilson does concede that evidence about embodied cognition claims that: 1) cognition is situated, meaning it takes place in the real world rather than in abstraction, and inherently involves sensation and action; 2) cognition is time pressured, meaning we must understand thinking in terms of real-world situations and time pressures; 3) we offload thinking onto our surroundings wherever possible, (e.g., writing notes); and, 4) cognition is action based, meaning thinking is based on encountering and solving real-world problems. Wilson also contends that there is strong evidence that when thinking "off-line" (away from a particular context) our brains access and utilize the same motor and sensory pathways that fire when we are physically engaged in a

context. Further, any learning situation that engages the body is likely to result in memories that are stronger and have greater influence, due to the emerging fact that we access motor and sensory pathways when later thinking about and processing learned information (Moseley et al., 2015). This finding likely explains the well-known enactment effect (Nyberg, Persson, & Nilsson, 2002) whereby recall of information is stronger when learners physically do something rather than just hear or see instructions at the encoding stage.

There is a related movement in developmental research (Smith & Gasser, 2005; Thelan, Schoner, Scheier, & Smith, 2001) that links the interaction between movement, surroundings, sensory and motor processing, and the self-organizing dynamics of complex systems in the development of understanding and consciousness in infants, which is a process of development that continues throughout life (Thelan et al., 2001). Thelan et al.'s (2001) research demonstrates that the initial reaching and grasping activities in infants show the same neural activity as later perceptual, planning, deciding, and remembering activities. In other words, initial experiences and later cognitive activity share the "same analogic dynamic language" (p. 1) - compelling evidence that what happens regarding the interaction of the body and surroundings during learning has a huge impact on later processing and thinking.

Maturana and Varela's (1987) seminal writing on the biological roots of cognitive understanding foreshadowed these research findings and likely stimulated many conceptual and research explorations of the idea of embodied cognition. Maturana and Varela (1987) call the self-organizing capacity in all living entities "autopoiesis", which refers to a system that is capable of maintaining itself through ongoing re-creation and organization. This self-organizing (emergent) capacity is, of course, central to complexity theory. Maturana and Varela (1987) assert that biological structures evolved over time, carrying histories forward with them that

shape this self-organizing capacity. Organisms live within environments, which includes other organisms and constant interaction, though Maturana and Varela (1987) are careful to emphasize that each organism is to be seen as a separate, cohesive whole. However, a "structural congruence" is necessary in order for both the organism and environment to be able to continue to function. The autopoietic processes that occur in organisms and their surroundings cause necessary adaptive changes in each other, in the sense that organisms and environments are provoked through constant interaction to change in order to maintain their cohesiveness. An example of this would be a rise in atmospheric temperature causing an animal to shed fur earlier. These sorts of successful adaptations are restricted in scope, though, by the structural realities of both the organisms and their environments. In this sense, according to Maturana and Varela (1987), humans are "structurally coupled" with the environments (including other organisms) we have evolved within. Even though we are operationally distinct from our environments (i.e., are cohesive wholes in ourselves) the coupling that occurs due to constant inter-influential exchanges between organisms and their environments mean that our autopoietic strategies are reliant on at least some level of stability in the other members and parts of our ecosystems. Change must happen incrementally over time in order to allow organisms and environments to make self-organizing adjustments, especially if the underlying structure is pressured to change. Severe changes in one or the other can cause the autopoietic process to break down, which results in adaptive failure, that is, the loss of the ability to self-organize. For example, scientists are currently warning the world that global atmospheric temperature is rising so rapidly that many species are not/will not be able to adapt as their structures cannot change quickly enough to match the structural changes happening in their surrounding environments (IPCC, 2015). However, change is normal, is always happening, and according to Maturana and Varela (1987)

"ongoing structural change of living beings with conservation of their autopoiesis is occurring at every moment, continuously, in many ways at the same time. It is the throbbing of all life" (p. 100). Change is not in itself destructive, and these changes in our structure, our self-organizing adaptations provoked by other organisms and our environments, is the learning process itself. Maturana and Varela's (1987) main point regarding learning, then, is that it is a natural process of change based on experiences of embodied interaction within our environments, which is congruent with many of the theories discussed so far, and lends some biological insight into the embodied cognition perspective. According to this perspective, the effectiveness of learning approaches relies on their ability to tap into the natural, biologically-based autopoietic processes that are stimulated through interaction in and with our environments. In terms of the setting of learning parameters, it is interesting to note Maturana and Varela's (1987) point that environments should not pressure organisms past the point that their structures can adapt to. In applying this insight to contexts where educators want to provoke change and more complex self-organizations based on embodied experiences, we therefore need to be mindful of how big the gap is for students.

Summary. This review of emotion, feeling, and embodiment literature illustrates that research has accumulated to the point where cognition, thinking, or mental activity is no longer viewed as existing in a vacuum surfeit of emotion, feeling, sensation and action. There are feeling tones, visceral emotional states, rich sensory qualities, and bone, ligament, tendon and muscle actions inherent in our experience. Emotions, feelings, and felt sensations quite clearly play an inseparable role in learning, though much more research is required to increase our understanding of this role. To get closer to a description of transformative meaning-making

requires that we consider the fundamental nature of these components of learning experiences. In terms of the theoretical framework for this study, I entered my research looking particularly for the contributions of emotions, feelings, and felt experience to learning.

In the following subsection, complexity theory is explored in greater detail, especially as it applies to theoretical framework for this study. Where the topics of the subsections in the literature review thus far have represented components and dynamics for this theoretical framework, complexity theory provided more of an overview, an orienting perspective for viewing the emergent learning process as a whole.

Complexity Theory

The role that complexity theory plays as an orienting theory for my research is clarified in this section. In discussing complexity theory, I will also highlight some ways it is not applied, and explain why other related theories were not employed as lenses for this study. Also, the shift in my own understanding of complexity, and therefore my own sense of orientation toward the study through the lens of the theory, is further explored in this section.

As discussed earlier, complexity theory itself emerged as a way to describe and explain biological systems, for which more linear and mechanistic descriptions and explanations were not adequate (Kauffman, 1995). The phenomenon of self-organizing emergence in complex systems is the primary reason I initially wanted to use complexity theory when beginning the doctoral research process, because it gives a framework for understanding the meaning-making process in students, both as individuals but also as a whole. Complexity approaches to learning rely on students to make meaning when they encounter the world, and this meaning-making process relies at least partially on what they bring to the table, just as emergent outcomes

partially rely on the histories brought to the system by actors in a complex system (Davis et al., 2008). Interaction between students is highlighted when seeing learning as a complex phenomenon, as are the inter-influential relationships in complex systems that lead to emergent phenomena (Jörg, 2004). Jörg (2004) offers a "Generative Complexity Theory (GCT)" (p. 123), which attempts to model the inter-influential nature of learning contexts in which students are allowed to freely interact with each other, suggesting that this modelling could explain the self-organizing and unpredictable nature of emergent learning. It is this change aspect of emergence, the tendency of complex systems and their members to become more complex through self-organizing and emergent change, that ultimately makes complexity theory a required orienting theory for the present research.

In discussing the role that complexity theory plays in the theoretical framework I carried into my research, Cochran-Smith et al.'s (2014) examination of the ways complexity theory can be used in research is helpful. It offers insight into how I have and have not used complexity theory. Firstly, I have used complexity theory as a lens in an attempt to avoid reductionist, linear sorts of descriptions and explanations of the phenomenon studied, which Cochran-Smith et al. (2014) suggest is the main way complexity theory is used in education research. Complexity theory offers more than just a way to avoid reductionism, however. What I have grown to recognize through the process is that while I may have begun with using complexity theory as a lens, including using emergence as a metaphor to describe transformative meaning-making as a kind of learning, it has ended up playing an even larger role. I have come to understand that beyond being a metaphor, the emergent design process, which I participated in, and the doctoral process itself, were complex phenomena themselves. Emergence occurred, in my fellow participants, in myself, in the group as a whole. So, in a sense, while using complexity theory as

a lens through which to observe the phenomenon, I was also observing and experiencing the complexity of learning. Though this must necessarily be left as more of a focus for sections to come, I have come to see this doctoral study as a lens for viewing complexity and emergence, as well as the other way around, that is, the concept of emergence being a lens for viewing the phenomena. Jörg (2004) calls for further research to more fully explicate the reality that learning is based in such complex interaction. My observations and experiences of complexity in this study may contribute to such explication.

It is also important to clarify and rationalize what I have not used in terms of complexity theory, and other related theories. Cochran-Smith et al. (2014) suggest that complexity theory can be used to challenge conceptual understandings of teacher education, and/or to transform approaches to better meet the complex realities of learning and teaching. I have not utilized complexity theory in these ways, though it is possible that some of the findings of this research project could contribute to these two aims in future research. I have not attempted to incorporate more mathematical models of complexity either, such as dynamical systems theory (Nicolescu & Petrescu, 2013) or other kinds of complex computational models (Miller & Page, 2007), because these are beyond the scope of this project. In terms of chaos theory, complexity theory is a better fit for social phenomena, though the two are often (mistakenly) thought to be the same, or at least very similar. There is one main reason complexity theory is a better lens for social phenomena: in chaos theory, though the component parts of a system can interact in non-linear ways, and therefore this interaction can result in outcomes that appear chaotic and challenge our linear causality ways of thinking about the world, these components and the results of their interactions have known properties, and therefore (though chaotic) are deterministic (Kellert, 1993). Though almost always impossible in reality, if the initial conditions of chaotic systems are

known, outcomes can be predicted (Kellert, 1993). Complex systems, in contrast, result in unpredictable, emergent outcomes no matter how much we might know about the initial conditions (Kauffman, 1995). In complex systems, because of the interaction of components with unique histories, prediction of specific outcomes is not possible. We must observe to know what will happen (Kauffman, 1995). My research and experience of the process demonstrates that the interaction between a group of students, a professor, a participant-researcher, and learning artifacts in a variety of locations, is quite clearly a complex (rather than a chaotic) phenomenon. In some way I may have originally been looking for an emergent design recipe, though non-linear in nature, and so perhaps was actually thinking of learning environments as chaotic rather than complex. It has been post-research and analysis that my own understanding of complexity has developed sufficiently to understand that any theoretical framework for a complex phenomenon must involve unpredictability, and therefore must involve room for encountering the unforeseen.

Summary. Complexity theory, overall, has provided an invaluable lens through which to observe the phenomena of emergent design as a teaching approach and the transformative learning that emerges from this approach, in non-linear, recursively elaborated, and unpredictable ways. Though often unpredictable in terms of sequence, timing, et cetera there are patterns in both the teaching approach and the learning outcomes, and the description of such patterns is a main focus in the analysis and discussion chapters to come. My perspective on this lens of complexity theory shifted, though, over the course of the study, so that what was a fairly restricted perspective moved into a more generalized understanding of complexity itself, and of the phenomenon I studied as well. Instead of looking for isolated themes, I grew to understand

that both the parts and the whole needed attention simultaneously. I grew, too, to expect the unpredicted, and to hold more loosely to any particular plan for the direction the research would take. On a metaphorical level, my lens went from two-dimensional to three-dimensional in that a narrow focus on only one aspect of the process would not, on its own, lead to understanding. Finally, I also grew to recognize that while complexity theory provided an orientating perspective for my observations, my observations were of complex phenomena.

The shift in my perspective regarding the application of the orienting lens of complexity theory echoes and adds to the earlier descriptions of meaning-making approaches and the nature of concepts and conceptual development. The following section is intended to show how emergent design appeared to me to embody the dynamics of a complex system, leading to meaning-making experiences for participants. Because of this, I was eager to become immersed in its study.

Emergent Design

The following overview of Puk's (2010) emergent design, and description of a macro-model as an example of the approach, are offered here to demonstrate why I was so interested in the opportunity to study the model in action. If it is not clear already, the following description should illustrate how the emergent design model offered me the chance to examine a progressive approach to learning that included opportunities for conceptual development through engaging and embodied experiences. As has been clearly stated, my intention was not to evaluate the approach for its efficacy, but instead to be immersed in the experience while also closely watching and listening to other participants so that I could learn more about their experiences of this approach, and witness key aspects that contributed to an emergent kind of learning. The

description of the approach and macro-model example are followed by a deeper examination of complexity theory, and then an overview of the larger picture theoretical framework that informed my study.

Overview of the model. After researching the approach, my view was that Puk's (2010) emergent design incorporates many teaching approaches to facilitate transformative meaning-making in students. Central to the overall approach are ecological macro-models, which are analogues of real-world phenomena. An example of a specific macro-model follows below. My understanding of how emergent design is intended to create transformative meaning-making for students, however, developed to include the recognition that each macro-model should not be seen as a separate, stand-alone entity, separate either from other macro-models or other processes that are used during the course of an academic year. Though each macro-model offers students the opportunity to engage with crucial ecological concepts and issues, the intention is for emergent design to be viewed as a larger process. What I came to later understand was that the students, macro-models, facilitator, and natural settings within which classes occur, are all meant to be part of an eco-system, a complex system. As in complex systems, it is expected that all components of the emergent design ecosystem bring histories, educational and otherwise, that impact what will occur in any given moment. As the components interact, they influence and change each other, which leads to changes in the entire system, as each member goes forward to influence again. Emergent design also attempts to facilitate learning independent of the facilitator's direction, after initial parameters are set up. Instead, it is through interaction, and the meaning-making undertaken by each student, that learning occurs. Learning, as is consistent with complexity theory, is not predictable in emergent design, and predictable outcomes (e.g.,

learning very specific bits of information) are not the intention. Instead, emergent design is aimed at setting up opportunities, within both the microcosm of a particular class and the macrocosm of the whole year, for transformative meaning-making in students. Emergent design works on a basic sense of trust that patterns of learning emerge from such a process, though the details are not predictable. These patterns of learning are intended to involve the concepts which have been explored thus far in the chapter, including concept change, the growth in conceptual understanding and discernment, curiosity, play, imagination as a dynamic capacity, emotion and feeling, and embodiment. After describing the macro-model example in the following subsection, a theoretical framework for the study is offered, which sews together these concepts more specifically with the emergent design approach and complexity theory.

The Macro-model learning process.[3] I will describe Puk's (2010) "Water Usage Barrels (WUBS) Macro-model" as an exemplar of the macro-model approach, in that each macro-model has been developed based on basic requirements regarding components and dynamics. In developing macro-models, Puk (2010) suggests that instructors need to consider: topic, sources of inspiration, planning and design, level of complexity, parameters of the playing area, the audience, inclusiveness (no one is out during the model), resources, and refinement (p. 129-130).

The WUBS macro-model should take place beside an accessible water source, like a river, from which students can draw buckets of water. The macro-model employs a large barrel with several holes of differing sizes drilled through its sides, meant to be an analogue of the Earth's supply of water, and human usage of water. Larger holes represent agriculture usage

[3] Refer to Puk (2010) for comprehensive list and description of all macro-models.

(65%), middle sized holes represent industrial usage (25%), and smaller holes (10%) represent home usage. Typically, there are three barrels for a class of 24 students, with eight students being assigned to a team responsible for one of the barrels. The class initially is asked which sectors use water most to least. They are told what the holes represent, and are tasked as a team to both 1) fill up the barrel using pails (also with small holes in them to represent entropy, which is the loss of energy through usage, in this case through evaporation, leakage, etc.), and once the barrel is filled, 2) to keep the water in the barrel for five minutes, using only body parts, as a model of conserving water. When this time is up, they are directed to estimate the percentage of the water conserved.

After all of the water has drained out of the barrels, a debriefing session is held, during which several questions are raised, within a context of student discussion, intended to guide students toward thinking critically about the application of what they learned during this experience to global and local water usage issues. Typically, students discuss the need to address agricultural usage, how to make metaphorical holes smaller to increase conservation of water (as a society and individually), and how to reduce the use of water in general. Students tend to have a fun time in filling the barrels and trying to plug the holes, but also tend to start feeling the strain of the task during the conservation period, and so typically also want to discuss their physical experience. Sometimes students make connections between the physical strain they have experienced and the amount of energy required to both access and conserve water in the real-world. Practical solutions are then discussed, through encouraging students to apply knowledge gained in the ecological literacy course, other courses, or in other areas of their lives (Puk, 2010).

Summary. After closely examining Puk's (2010) emergent design approach it was clear to me that it would offer the opportunity to study learning as a dynamic meaning-making process, as was my intention. As I continued to read and write about the topics surveyed in this chapter, a fuller perspective began to develop in terms of what I would focus my attention upon when the actual study began. The next subsection describes a theoretical framework, a sewing together of the literature which has been reviewed, and represents this larger perspective.

Theoretical Framework

In this chapter, several areas of literature related to learning as a meaning-making process have been reviewed, including examining aspects of the experiences of such learning. In presenting the theoretical framework in this subsection, the intent is to sew together these areas of literature, and present a coherent picture of the perspective with which I began the study.

I began with an interest in learning that is beyond mere information-processing, and instead is a process of meaning-making. As presented in the literature, there is a long tradition of progressive theorists behind the idea that learning should be about meaning-making, (Dewey, 1938; Knowles, 1980; Piaget, 1973; Vygotsky, 1930-1934/1978), and there are continued calls for more progressive perspectives in contemporary education (Boyer Commission, 1998; Christen Hughes & Mighty, 2010; Entwistle, 2010). However, there is a continued need for clearer description of what such approaches and learning experiences actually include (Dewey, 1938; Davis & Sumara, 2005, Jörg, 2004). Following from this need, the nature of meaning-making is a central focus for this study, including an examination of what concepts are, how they change, and what is involved in growth in conceptual understanding. Based in the literature reviewed in this chapter, my theoretical framework included notions of concepts as useful and

nested representations of the world (Åkerlind, 2008; Gabora et al., 2008). In terms of the theoretical framework, conceptual understanding is seen to grow, emerge, and mature through ongoing and recursive interaction with the world, as understanding can only be considered useful within real-world contexts (Åkerlind, 2008; Gabora et al., 2008). Complexity theory offers an orientating perspective for several of these ideas, such as interaction, emergence, and recursion, and therefore the description of my theoretical framework turns there next.

Since complexity theory offers an orienting perspective for the kind of development of conceptual understanding I was interested in, a central focus for the study was to look for the kinds of dynamics expected of a complex system. Firstly, I was looking for how the unique histories of the actors, or members, in the system influenced interactions and outcomes (Davis & Sumara, 2005, Jörg, 2004). I was also very interested to see how recursion would play a role in interactions and the potential growth in conceptual understanding that might emerge from the re-visiting of understandings over time (Davis et al., 2008, Jorg, 2004). Since the emergent design approach I was studying purposefully revisits key concepts and themes during the course through macro-models and other activities, I expected to see participants deepening their understanding for core concepts and making links between related, central ideas, through inter-influential exchanges with each other and their surroundings (Jörg, 2004). In other words, I expected that the mature understanding of key concepts which would emerge in participants would include the recognition of connections between key, threshold concepts. Jörg's (2004) GCT offers a model to the framework for understanding how such recursive, inter-influential interactions could lead to self-organizing, emergent outcomes for participants in the study. Though such outcomes from a complex system are unpredictable (Jörg, 2004) in terms of specifics, the framework I carried into the study predicted that mature and useful conceptual understanding should emerge since

participants were interacting with natural, real-world surroundings, (as well as with each other), and models that were analogues of real-world phenomena.

As reflected in other literature review topics, I also wanted to investigate specific, inner experiences of individuals within the types of interactions described above. While Jörg's (2004) GCT describes the basic nature and outcomes of complex interaction, I wanted to observe the nature of such interaction as well. Aspects of such experiences sewn into my theoretical framework, and that I therefore particularly looked for during the study, were the roles of empathy in community, curiosity, play, imagination, emotions, and embodiment. The framework led me to look for the development of empathy in interactions and the group as a whole as time went on, if interactions were going to be generative of the kind of learning of interest (Rifkin, 2010). I expected to see curiosity sparked, especially in situations within which participants felt supported by their peers and the overall environment (Kashdan & Yuen, 2007), and even more so when they were stimulated to close a gap in their understanding (Berlyne, 1960; Kashdan & Silvia, 2009; Litman, 2005; Loewenstein, 1994; Piaget, 1969). The framework also led me to look for play and imagination as main activities that participants would employ when fully engaged (Jensen, 2005). The as-iffing, imaginative quality of role-playing was expected to be a main, natural process through which cognitive understanding would develop in participants (Egan, 1992; Pellegrini et al., 2007; Pellis & Pellis, 2009; Piaget, 1951; Vygotsky, 1967). Finally, in terms of embodiment, the literature clearly indicated that I should be watching for the integral role of emotions in participant learning (Cho & Heron, 2015; Damasio, 2012; Headrick et al., 2015). Since research demonstrates that cognition should not be viewed as solely an intellectual act (Calvo & Gomilla, 2008; Coello & Fischer, 2015; Shapiro, 2014), my framework also included the perspective that along with emotion, I should be carefully watching for sensory

aspects of experiences of learning. Maturna and Varela's (1987) concept of autopoiesis can be seen as a thread used to sew together all of these aspects of my theoretical framework. It is based on biological, self-organizing, inter-influential roots to learning and change, and so could be seen as a complexity theory, as well as complimenting the literature included in this chapter regarding conceptual development, engagement and embodiment.

In concluding this section on the theoretical framework with which I entered the study, a few words are necessary in terms of its limitations. Though I had done a fair amount of reading on complexity theory and considered it a vital orienting theory in my framework, after completing the study and analyzing data, I came to recognize that my expectations for the patterns to be observed were somewhat mechanistic and simplistic (Morin, 2006). What I observed and experienced in this process, in other words, led to a much more complex understanding of emergent learning, but this was not, initially, a part of my theoretical framework going into the study. I failed to (at least fully) foresee the impact of participating in the process myself, and therefore neglected to include changes to the perspective of the researcher in my original framework.

The summary to follow first reiterates what has been covered in this chapter, and ends with a brief description of what to expect in the next chapter regarding methodology.

Chapter 2 Summary

Several strands of theory and research have been introduced which played integral parts in giving me a perspective with which to approach my research into emergent design and transformative meaning-making. The chapter began with an exploration of research and literature in seminal areas of meaning-making approaches, including constructivism and adult learning theory. The nature of knowledge, concept change, and conceptual understanding were discussed next. This was followed by an exploration of several key aspects of the experience of transformative meaning-making, including; empathic community, engagement, curiosity, play, imagination, emotion, feeling, and embodiment. Each of these topic subsections included some description regarding how they applied to the overall theoretical framework for the study, though full description of the framework came at the conclusion of the chapter. Next was an examination of the ways in which complexity theory was and was not applied in this dissertation, as well as a rationale for not using other related theories as lenses. Emergent design, including a macro-model exemplar, was described next to show how this approach provided the opportunity to study experiences of transformative meaning-making. Finally, a theoretical framework, which sewed together the areas explored in this literature review chapter, was described.

The chapter to follow regarding methodology begins with an overview of the methodological philosophy which guided this study, and then describes participants. A list of key research questions, a description of research methods, and an explanation of the approach to analyzing data follow. Limitations are acknowledged, and ethical considerations are discussed.

Chapter 3: Methodology

Overview

In the following chapter, I first explore the methodological underpinnings of this study. Next will be a description of participants, research questions, research methods, and the data analysis process that was followed. A discussion regarding limitations and ethical considerations concludes the methodology section. Just before getting to these subsections, however, a brief explanation of the changes to the initial research methodology is required, as well as a rationale for this inclusion of discussing my original plans.

As discussed in Chapter One, the initial plan for this research project has been altered, because during the research, data analysis, and writing processes an awareness emerged of the depth of the complexity of the phenomenon being studied, and indeed the complexity of the dissertation process itself. The research design section that was in my original research proposal has been included in this dissertation (Appendix A), as an artifact of an emergent process that shows the formulaic aspects of the originally intended approach to the research project. At that time, I was looking for something that balanced qualitative and quantitative methodological poles, and so looked to a mixed-methods approach. However, what I discovered was that the aim of finding reliable and valid quantitative factors in emergent learning as initially planned, embedded in the qualitative data, was unreasonable. Instead, while continuing to base the study in gathering qualitative data, a shift was made away from a mixed-methods approach to a basic qualitative inquiry methodology based in complexity theory, which rejects reductionist thinking, while also offering rich description of experiences and provisional explanations of whole phenomena.

As has been discussed, the history that members of a complex systems bring has enormous impact on the dynamics and emergent outcomes that occur (Davis & Sumara, 2005; Jörg, 2004). This dissertation should therefore include some of the history of the evolution of my methodological approach, as it is a document which represents the emergent outcomes of my doctoral research process. What follows is a brief description of this process of development and emergence of the methodology and methods that underpin this doctoral research study.

Methodological Approach

The research process began with the premise that a methodological approach which did not champion subjective or objective perspectives was required, as both participant experiences and external components and dynamics were part of the phenomenon to be studied. Also, I wanted to gather as many types of data as possible, allowing for a thorough exploration of the complex phenomenon of transformative meaning-making. This held true throughout the process in terms of the essence of the desire to gather sufficient, and various kinds of, data. My perspective on the data changed, though, through the participant researcher, data analysis, and writing stages of this dissertation. I started out thinking of patterns as something that could be separated out for discrete analysis and measurement, and though an analysis has been completed with the qualitative data gathered, it became clear to me that the pieces on their own are sterile. Aspects of emergent learning appear to be inextricably intertwined with each other, and so a methodology is needed that represents this. The process has not changed my belief that patterns exist and can be described, however, just that the patterns are not quantifiable in the ways I had initially planned.

So where I started with complexity theory as an orienting theory and a mixed-methods approach, I shifted through the research process itself to believe that only a qualitative methodological approach would be appropriate in representing the data. As Morin (2008) suggests, such a shift in methodology and method during the research process can be seen as the outcome of being truly open to the phenomenon being studied. Morin (2008) states that the method teaches the researcher as much as it informs the research process, and that a significant aspect of research on complex phenomena is the shift in the researcher towards complex thinking. In my view, the process of research altered my approach from one of thinking about complexity to complexity thinking (Alhadeff-Jones, 2013).

Many researchers have contributed to the work of examining how complexity theory can be used as a lens in examining complex phenomena, but at the time of proposing my research, many of these were unknown to me. Cochran-Smith et al. (2014) suggest that critical realism is the grounding epistemological underpinning for complexity theory as a methodological approach, and though I was working with a critical realist underpinning for my research, I had not actively connected it with complexity theory. Cochran-Smith et al.'s (2014) work to put critical realism together with complexity theory as a methodological approach has been very helpful, as it allows for both description and explanation of complex phenomena. In keeping with critical realism as a methodological underpinning, Cochran-Smith et al. (2014) suggest researchers can examine complex phenomena for causal and/or generative mechanisms that can lead to non-linear, complex, emergent outcomes. So research from a complexity theory perspective need not be only descriptive, but explanative too, though descriptions and explanations must avoid reductionism. Researchers must pay attention to context and other specifics about the phenomenon. And in examining data for causal mechanisms, the growing and

changing whole must be understood as more than the sum of the parts of the system. From this approach, it is impossible to derive meaningful, discrete quantitative measures from qualitative data, as initially planned. As soon as a researcher creates a Likert-scale measure for transformative self-organization, for example, the qualities, timing, multiple contributors, and unpredictable non-linear quality of emergent phenomena of self-organization would be lost (Alhadeff-Jones, 2012). From a complexity-based methodological standpoint, then, developing a quantitative instrument does not make any sense, and so once I awoke to complexity thinking, the idea of creating such an instrument was abandoned.

In terms of research methodology, then, my approach in the end is basic qualitative inquiry, with aspects of a number of different qualitative approaches informing the work. My initial focus on the qualitative side was ethnography, but since culture was not the explicit, primary focus of my research, the project does not seem to qualify as ethnography (Creswell, 2008). An ethnographic sensibility still informed the work, however, as: a particular phenomenon was explored in detail; data collection tools were relatively unstructured; the focus was to explore and describe a social phenomenon in as much depth and detail as possible; and data analysis was intended to be primarily verbal (rather than statistical) with the intention of deriving meaning from the collected data (Atkinson & Hammersley, 2007). Similarly, though the approach matches some aspects of case study, my status as a participant researcher does not fit with the requirement of this approach to utilize it only when able to avoid the potential manipulation of research participants (Yin, 2003).

Since there are many passages in the data which reflect my experiences within and as a part of the phenomenon being studied, and since I was changed and altered through this emergent design process, some might argue that this research is auto-ethnographical. As

Richardson (2001) says in discussing auto-ethnography, "people who write are always writing about their lives," (p. 34). Richardson is arguing that in a sense all research writing is auto-ethnographic, that is, the writer is in the work, whether overtly or not. Even the post-positivist researcher who refuses to use "I" in their research writing is obvious in their work in what they have chosen to study, in the methodological approach they have selected, and in the writing tone they utilize. Though I agree with Richardson's (2001) basic premise, I do not see this present study as auto-ethnographic in the sense that I am not treating my experiences as the primary or only data, which is generally a feature of auto-ethnographic research in general (Ellis & Bochner, 2000). Additionally, the data of my own experience is not to be systematically analyzed, per se, through this personal lens, as it likely would be with an auto-ethnographic approach (Ellis & Bochner, 2000). Instead, my experience is shared to shed light on patterns of participant experience, which can occur because of the "insider" status of the participant observer (Jorgenson, 1989).

Similarly, this research project does not conform to a more pure form of narrative inquiry as a research method, in the sense that there is not an analysis of the stories included as data using the systematic lenses that narrative research would likely employ (Chase 2005; Connelly & Clandinin, 1990). Though there are certainly aspects of narrative in the field notes and reflections that are shared as part of the data, the way this data is included and used is in line with the shift in perspectives on participant observer approaches discussed by Tedlock (1991). Rather than attempting to stay the cool and removed observer of phenomena, an approach favoured by those who fear participation in a culture will lead to losing objectivity, the immersed participant observer presents the narrative of both "Self" and "Other" as crucial data in understanding the

phenomenon (Tedlock, 1991). In discussing this change in approach to qualitative research representation, Tedlock (2000) says there has been:

> … a shift from participant observation to "the observation of participation" (Tedlock, 1991), in which ethnographers have experience and observe their own and others' co-participation within the ethnographic scene of encounter. The shift entailed a major representational transformation in which, instead of having to choose between writing a memoir or autobiography centering on the self or a life history or standard monograph centering on the other, the ethnographer can present self and other together within a single narrative frame. (p. 464-465)

Though it has not been my intention to analyze the data from a specifically narrative perspective, in the end the data, from both Self and Other, does suggest a narrative arc of transformation, though this is stated here more as a foreshadowing of what is to come, rather than as a statement that my approach in terms of method is narrative in nature.

In the end, I am content to state that my methodology has been a basic qualitative inquiry, and that my approach to this study overall has conformed to Morin's (1992, 2008) requirement that the researcher refuse to simplify, and instead must wait for the methods that best represent the complexity of the phenomena they study.

Participants

Participants were twenty-two (22) students enrolled in courses for pre-service teacher candidates with Environmental Science as a teachable subject at Lakehead University in Thunder Bay, Ontario. There were fifteen (15) female, and seven (7) male student-participants, with an age range of 22-33. Upon entry into the courses, seven (7) candidates had undergraduate degrees

in science, eight (8) had degrees in geography, and seven (7) had degrees in social sciences. Participants were selected because of their status as students in the emergent design course. They were given the right to participate in the research or not, without coercion, and their instructor did not know whether or not they had consented to participate (see Appendix C).

Research Questions

What follows are the original doctoral research questions, and the short paragraph that preceded them. In general, the questions are still topical, and helped focus me in the role of participant-researcher, guiding early questions for participants. As I suggested was likely to happen in the following paragraph, new questions emerged over time, and original questions were refined, which later led to more specific questions for more formal interviews with participants. The asking of research questions is, of course, an ongoing and emerging process. What follows is the original introduction to the research questions section, and the original questions, from the research proposal document.

Though I believe that having a set of guiding questions is important for a research study, I am also aware that questions are often refined during the research process, and new questions can arise because what is discovered does not fit within expected parameters. My informing questions at this point include:

- *What do students experience when immersed in an emergent design learning approach?*
- *What are the key features of transformative meaning making experiences?*
- *What is the role of the parameters set in macro-models in facilitating transformative meaning making in students?*

- *How are emergent outcomes related to changes in behaviour, especially in this particular case, changes toward more ecologically-congruent behaviours?*
- *How do emergent outcomes develop in terms of timing, linear vs. non-linear et cetera? How does the order of macro-models influence learning?*
- *What is the role of empathic community?*
- *What are the roles of curiosity, play, and engagement?*
- *What is the role of embodiment in learning, especially in this specific case as it pertains to learning in natural surroundings?*
- *What is the role of emotion and/or feeling in learning?*
- *What is the role of imagination, in terms of meaning-making?*

Research Methods

As a participant observer, I did not attempt to stand outside of the group and be an objective observer, but rather was fully immersed in communicating with members, participated in course activities, and used my own experiences as part of the research data (Creswell, 2008; Jorgenson, 1989; Tedlock, 2000). Field notes were derived from informal and semi-structured interviews with participants and my participant observation. Informal interviewing allows the qualitative researcher to avoid limiting the field of inquiry (Fontana & Frey, 2005) and it was important that initially, interviewing was not heavily structured or overly-influenced by me. This allowed themes to emerge from the initial experiences, and questions were developed based on these themes later in the research for more structured interviews (Atkinson & Hammersley, 2007).

Artifacts were also collected, including educational materials, objects from the natural world, and other creative forms of expression (Atkinson & Hammersley, 2007). Participants agreed to share reflective journal entries, and this ended up being a very rich source of artifact data. In a sense, these journals could be seen as another type of interview data, as they represented participant responses to questions that were intended to invoke a reflective response after course experiences. However, they also included illustrations, doodles, and random thoughts, and since they were hand-made, also lent a tactile type of insight about the participants that would not have been available if I had only had access to direct interview data. As represented in the analysis section and appendix, participants shared drawings and songs that were created as part of the course, and these creative expressions similarly lent perspectives on their experiences that would not have been available strictly from interviews or observations.

An interview guide was developed, based on data collected from the early more unstructured time described above, for more formal interviews conducted toward the end of the study. Interview guides allow the researcher to be consistent in their approach to interviewing with different participants, utilizing the same order and generally similar wording with each question (Creswell, 2008; Fontana & Frey, 2005). Seidman (2006) also suggests that an interview guide helps organizationally with the analysis process, in which participant answers to particular questions are compared to establish the presence or absence of themes in their experiences. These interviews, though more formal, were still semi-structured in the sense that an immediate coding of interview answers was not conducted, open-ended questions were still asked, and participants were encouraged to expand upon answers and add anything that they believed was important, where relevant (Creswell, 2008). Relationships were successfully developed with many of the study participants, and they certainly wanted to know what my

intentions were for the research, and to hear more from me about research results toward the end of the study. It was challenging to be authentic while at the same time avoiding seeking the right answers for my research purposes, which is a common response from participants that a researcher has developed a relationship with (Fontana & Frey, 2005; Seidman, 2006). I believe this was adequately accomplished, as many answers were not expected, and at times the struggles of participants were expressed, which leads me to believe they were genuine, in general, with their responses to my questions.

Creswell (2008), Fontana and Frey (2005), Seidman (2006) and others assert that interviewing is crucial to most qualitative research projects, and that the skill with which interviews are conducted determines the quality of data that will be collected for later analysis and interpretation. The creation of good questions increases the likelihood that participants will have a good understanding of what is asked, whereas vague or poorly worded questions can lead to confusion and/or different understanding of questions amongst participants. The focus of questions, and their order, are also important, as asking more general and less personal questions first allows participants to settle into the interview, where more specific questions later in the interview allows the researcher to gather data that closely pertains to what they wish to find out about participant experience. I believe my experience as a psychotherapist and educator were great aids in conducting interviews, as I have had long practice in some of the subtler, yet no less important, skills that a interviewer must have in order for the process to go well. Rogers (1983) suggests that for a participant to feel relaxed in an interview, and therefore be more likely to offer genuine information about their experience, the interviewer must be able to demonstrate that they are actually listening and are genuinely present, which is accomplished through eye contact, non-verbal cues that show attentiveness, and an internal authenticity which comes

through in the overall bearing of the interviewer. When information is shared, interviewers must be able to demonstrate empathy regarding the participant's experience, which essentially means that interviewers must be able to (to some degree) put themselves in the participant's shoes on a feeling level, which requires the ability to move beyond one's own perspective. At the same time, some level of neutrality is important (Creswell, 2008) in the sense that the researcher should not be trying to steer the participant in a particular direction, or interpret what they are saying in ways that serve expectations. Interviewers must be diligent about collecting information that is as accurate as possible in terms of what participants are actually reporting, being aware of possible "investigator effects", while at the same time being cordial, respectful, and appreciative of participants (Berg, 2004).

Data Analysis

There were two steps to the dissertation data analysis process, though each step was recursive in nature, in the sense that the later step, and the writing process itself, required a continual return to earlier analyses. As Seidman (2006) suggests, the early stages of analyzing data include either marking or labeling themes in transcripts or notes taken from interviews. As the process of research and data collection commenced and evolved, I began to identify passages from interviews that seemed significant, and used the "tried and trusted method" of cutting up transcripts and moving them around into thematic groups (Russell, 2003, p. 129). Once the early themes emerged, more structured questions were created based on these themes. These more structured questions were used as a template for interviews, though a semi-structured rather than fully structured format was used (rather than a strict following of the specific question I had created). The questions that emerged are included in Appendix B. I wanted to stay open to being

surprised all the way through, including hearing information from participants that would not have been heard if pre-determined questions were stuck with rigidly. As Fontana and Frey (2005) suggest, the analysis of qualitative data is an ongoing process, and so as expected, further questions emerged after the initial research questions were devised, and so the examination of whether new data that emerged fit into existing themes, and/or whether new themes were emerging, was continued. After the initial semi-structured interviews were complete, a thematic analysis of this data was conducted, using the same process described above to develop the interview guide. Both sets of data were then examined, plus any further data that was collected after the interviews, to identify overarching themes, and significant sub-themes within them.

As described in earlier sections, upon completion of this process, I became aware that this breaking down process both 1) left the process seemingly incomplete as the parts without the whole did not appear to appropriately represent the phenomenon, and 2) made it apparent that any attempt to create a quantitative instrument from these parts was not possible in the sense that such an instrument would not be validly measuring what is important in such a complex phenomenon. Instead, a second level of analysis was conducted, with the intention of including the individual themes that had been extracted, but describing them as more a part of a whole. This is included as Analysis II - Wholes, and includes four "meta-themes" which describe significant aspects of the whole picture from four perspectives. To find these meta-themes, themes from the first analysis were examined, as were my own and other research participant descriptions of experiences. The meta-themes brought together several of the themes from the first section of analysis in an alive and dynamic manner.

Limitations

Though I began the research with concerns about the generalizability or transferability of my data, these fell away in favour of representing the complexity of the data collected with what Denzin and Lincoln (2005) would call "ecological validity", that is, fully representative of the unique phenomenon being studied. This does leave some concern about the value of this research to other researchers and/or educators in terms of utilizing emergent design. As addressed earlier, a deep and thick description of context specific phenomena, and also the identification of patterns in these specific contexts, hopefully allow the reader to find information or stimulate their own insights about what may be applicable to other situations.

Another potential limitation is that my presence as a researcher changed the way that the dynamics of emergent design usually work. This was, of course, impossible to determine as no one can conduct research without having an impact. It is worth considering what effects my presence caused in this complex system, though, which will be examined as the dissertation continues. A related issue is that my interview questions may not have been effective in helping participants to express themselves about their experience, and/or that I misinterpreted their meaning. This is a similarly unavoidable potential issue (Fontana & Frey, 2005), but should be considered when weighing my description of the phenomenon or any conclusions that are drawn about emergent design. In the end, a researcher must trust that well-worded questions and careful recording of answers will speak to the research questions of interest, and keep in mind the inherent uncertainty that exists in interpreting such data (Seidman, 2006).

The inclusion of my own experiences as a researcher as part of the data of course raise specific questions of subjectivity, though as already thoroughly presented, many researchers contend that the subjectivity of the researcher is present no matter the approach (Denzin &

Lincoln, 2005; Morin, 2008; Richardson, 2001). From the qualitative perspective, the best a researcher can do is to describe what they see, hear, and experience as faithfully as possible, and also let the reader know, as faithfully as they can, about the lenses through which they are approaching the study, data, and writing process. I have tried to do all of these things to the best of my ability.

Ethical Considerations

This research has been conducted with full Research Ethics Board (Lakehead) approval. Participants were informed of all of their rights, as per the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans* (Public Works and Government Services Canada, 2005) including; the right to participate or not participate without coercion, the right to withdraw from participation at any point in the study, the right to refuse to answer any question, information regarding confidentiality how their data will be stored, how the data will be used, and how to find out more about the study and/or outcomes of the study. Students who did not consent to participate in the study were not interviewed, and no data was collected that includes their personal information.

Participants were explicitly informed that the instructor in no way knew whether they consented to participate or not. Students were introduced to the study and invited, without coercion, to participate, with each being given covering letters and consent forms. All forms and data, as per Tri-Council guidelines, were kept in a locked cabinet, and will be for five years following the study. No data was collected or kept from students who do not consent to participate in the study. I offered to share the findings of the study with any participants who wished to see them, and provided a contact email address on the covering letter for this purpose.

Approval was necessary and given from Lakehead University's Research Ethics Board for this research. The application package is included in Appendix C.

There were several issues addressed due to the nature of the relationships between myself (graduate assistant, researcher, doctoral student), my supervisor (course professor, doctoral supervisor), and research participants (course students). These issues were fully addressed in the ethics approval submission in a manner that satisfied the research ethics board. The most important issue was that students did not feel coerced in any way to participate in the study, and as described above, a process was put in place to ensure their right to informed consent. Another potential concern was that I may have felt compelled to report only on positive data, as my supervisor is also the course instructor. Though it was important to acknowledge this possibility, and to keep it in mind through the doctoral process, there were two factors that mitigated some of this concern. The first was that my research was not intended to be evaluative of the program. In other words, I was not concerned with whether or not the approach worked, per se, as it was clear that the opportunities for emergent learning were present in the course. Instead, I was interested in what happens in terms of participant experiences. Secondly, I had already had enough experience with my supervisor when conducting my research to know that, though he certainly is passionate about his teaching practice, he is a person of great integrity when it comes to facing and reporting on the truth in the research process. As his co-researcher before the dissertation phase of my research, I saw him confront what is actually happening without putting a positive spin on events in an attempt to make himself look good. In fact, my experience has been one of a relationship in which we both deeply question and discuss phenomena and our interpretations in an ongoing fashion.

In the final analysis, the research of innovative approaches to learning often requires practitioners to study their own courses (Cole & Knowles, 2000), and the types of ethical concerns raised above should preclude such research, as long as proper attention is paid to mitigating the potential for students to feel coerced to participate. In addition, all graduate students must face the biases and stances of their supervisors when conducting graduate research, analyzing data and writing. Though the potential issues addressed above required ongoing attention, I am confident that they were appropriately negotiated, and that my doctoral research and dissertation reflect a deep sense of ethical integrity.

Chapter 4: Analysis

Overview

What follows is first a traditional qualitative analysis, in which the data is broken down into themes and subthemes so as to try and better understand what occurred. Selected quotes and other pieces of data are utilized to illustrate and represent themes as they are presented. Short-form versions of participant names are used to protect anonymity.

Before beginning, a brief report on the difficulty experienced in separating out what are quite obviously interrelated and interconnected themes. The old adage "the whole is greater than the sum of its parts" fits here. Drawing definitive lines between themes does not accurately reflect the natural phenomenon observed, participated in, and felt. There was a dynamic, interactive, and interwoven quality to the experience that defies separation. Many participant experiences are, in fact, demonstrative of more than one theme or subtheme which will become obvious through the analysis to follow. On the other hand, being able to shine a focused light on particular aspects of the experience is potentially helpful in terms of understanding potential patterns of experience in this emergent approach. In the second analysis subsection, the themes and subthemes covered in this "Analysis I – Parts" sub-section will be re-examined as nested aspects of a larger, interwoven, complex system. So first a taking apart, in order to potentially see different aspects of the whole more clearly. The hope is this will lead to understanding that whole in a deeper way, once all of the parts are put back together in the "Analysis II – Wholes" section and Discussion chapter which follow this first section of qualitative analysis. For information regarding macro-models beyond what is described in the following sections, refer to Puk (2010) for a comprehensive list and details of models.

Analysis I - Parts

To begin the analytic process, as discussed above, the themes to be described exist as parts of this larger dynamic system. A quote from a participant captures this larger, unbroken theme: Al. said that she kept talking to everyone about the class during the study, but could not make herself understood, in terms of the changes occurring within her:

> My mother [an educator] would say "it's just a class", but I knew and I know that it wasn't just a class and it isn't over yet. I will continue to learn from this experience for a long time to come and the connections that I made this year cannot easily be broken.

The larger theme, then, before being broken down, is one of ongoing emergence through connections, a theme of somewhat mysterious transformation, and never-ending evolution. And so we start from there, and enter into this particular ecosystem to examine parts of it, interaction between the parts, and changes over time through this interaction of the parts.

I have chosen to report the data in this form as, to some degree, each of the main themes appear to rely on the preceding theme, for example, depth of engagement has an important impact on depth of learning. Similarly, I have chosen to report the themes in an order that, to some degree, reflects the process I observed in terms of when in the study the following themes typically predominated. For example, I discuss "Categories of Learning" last as it tended to follow the rest of the reported experiences, whereas early responses to "Challenge" generally marked the beginning of a process of growth. It is important to note, however, the recursive nature of emergent learning, that is, there is not really a distinct beginning (all learners bring a history with them) and no real end to learning from this perspective. In general, viewing learning from a complexity perspective requires an ability to hold the tension of such seeming paradoxes, and I feel such a tension as the following data are reported. At appropriate times during this first

Analysis section, I will point out themes and subthemes that were particularly difficult to separate, or see as separate.

In terms of the structure that follows, I first provide a framework for the breakdown of the themes, subthemes, and further subcategories in Table 1 below. I then enter into a more detailed analysis of the data within each category, and finally provide a summary of the data which has been presented. Participant data that came in response to structured interviews are noted as such.

Table 1

Analysis I: Qualitative Themes and Subthemes.

Theme 1: Challenge, Conflict, and Struggle

A. Challenged by new experiences or information
    i. Resisting full participation
    ii. Resisting the dissolution of illusions
    iii. Emotional responses
    iv. Wrestling with dissonance
    v. Inspiration

B. Ambiguity
    i. Setting up process vs. instruction
    ii. Complaints about ambiguity
    iii. Acknowledgment of validity of ambiguity
    iv. Embracing ambiguity

Theme 2: Engagement

A. Community

   i. First steps in building of community

   ii. Connections made through interactions

B. Curiosity

   i. Curiosity caused by process

   ii. Cultivating an attitude of curiosity

C. Play

   i. Fun and playfulness

   ii. As-iffing

D. Imagination

   i. Creative expression

   ii. Envisioning, planning, problem-solving

Theme 3: Embodiment

A. The Felt Experience

   i. Kinesthetic impacts

   ii. Natural surroundings and learning in place

   iii. Emotional impacts

B. Embodied Cognition

   i. Preference for embodied learning

   ii. Complexity and the emergence of understanding

Theme 4: Categories of Learning

A. Concepts
    i. Concept Growth
    ii. Conceptual Understanding
B. Complexity thinking
    i. Discernment
    ii. Sense of responsibility
    iii. Making plans and changes
    iv. Application to teaching

Theme 1: Challenge, conflict, and struggle. One of the themes that stood out most clearly early in the course of the study was the experience of challenge, conflict, and struggle in participants. Two main subthemes were identified within this larger category of experience, with each of these further broken down into further subthemes, as follows:

Challenged by new experiences or information. Old ideas, beliefs, patterns, and opinions were challenged by new experiences and information. This subtheme can be further broken down to include different ways that participants dealt with these types of challenges, as follows:

Resisting full participation. Early in the semester, especially, some resistance to fully engaging with the course was present. Though most study participants seemed ready to endure some ambiguity and novelty with activities, some were more hesitant. I imagine the rabbits living in cages on the farm in the novel *Watership Down* (Adams, 2013), unsure as to whether they want to leave the safety of the cages when gnawed loose by the wild rabbits, afraid of leaving the known for adventure and freedom.

I observed one example of this on the first day of class, in which the instructor did not wait in the assigned classroom, but instead left me to hand the class a letter, a map, and a compass. The letter contained a greeting and instructions about how to come and find him. Many members of the class, after looking over the map, quickly put on coats and went outside (after I had assured them I would be locking the classroom door once everyone left). A few participants, however, were more hesitant, and probed me for more information about what was happening, though I had been instructed to say nothing further about what was occurring. Eventually, all participants went outside, where the bulk of the group was waiting. It was interesting to note that the participants that were more hesitant had not graduated from the Outdoor Recreation program, and therefore were perhaps less prepared for this type of activity. By the same token, however, the Outdoor Rec students did not wait for, coach, or encourage the hesitant students, but rather left them on their own. This is noteworthy, perhaps, because the leadership that might be expected from graduates of this program was not evident on the first day of class.

Resistance to full participation became less and less common as the semester continued, which suggests that such apathy was a product of the educational history students brought to the class and/or early hesitancy based on lack of a sense of familiarity or trust of an emergent design.

Resisting the dissolution of illusions. Participants sometimes justified their behavior (regarding an ecological issue that was raised by a macro-model) and/or pointed out the many reasons their own behavior could not change despite the issue.

After one of the initial macro-models, Entropy of Food Consumption – Grain vs. Beef (Puk, 2010), there was a fairly long reflective discussion, including one point where a participant challenged the basic analogue itself (this macro-model, too, will be featured in further sections of this analysis section), seemingly resistant to having his illusions about meat challenged. In this macro-model, water represents the energy of the sun, and two teams have different tasks based on whether they are in the cow-eating or grain-eating position (they do not know what the situations represent before the task and switch roles after completing the task the first time). The cow-eating situation requires teams to first fill a large bucket (representing grain) from the river (which is on campus) with one hole in it (to represent entropy) and then, when full, to take water from this bucket to another bucket (cow) that is halfway to the final destination bucket (human). They can only take the water to the human bucket once the cow bucket is full, and it contains holes, as does the human bucket (both to represent entropy at these stages). The task is complete when the human bucket is full. The grain-eating condition removes the middle bucket, which makes it much, much easier and faster to fill the human bucket.

After the macro-model, Ka. wrote:

> As a kid from a beef farm it is very difficult for me to say I won't eat beef anymore or to endorse others to not eat red meat. I do however recognize the major ecological issues that arise in the way in which we are currently putting our money and resources into a flawed system. I've always been an advocate for eating local and supporting rural farmers

> and this macro-model has further reinforced how important it is avoid the mass market factory farms.

It is fascinating to see how the information from the macro-model is transformed for this participant to have a negative connotation for factory farms but leave the positive perspective on local farmers intact. Though grazing, grass-fed farming techniques may mitigate some of the entropy difference between eating grains and beef, and there are other ecological issues with mass farming practices that are not shared with smaller local farm practices, it is still quite clear that eating grains directly is a more efficient use of energy, whether farmers are local or not. Ka. clearly was not ready to integrate this information into her worldview at that point in time, since it conflicted so directly with her the beliefs instilled through her upbringing.

After the Entropy of Food Consumption macro-model, Mi. wrote:

> It is always fascinating to observe the power and delicacy of the natural world, as it maintains a precarious balance entirely on its own, even in the face of Man's [sic] destructive nature. Life always finds a way. … For my part, I will continue to enjoy chicken wings, a good steak once in a while, and wear leather jackets. I will also continue to appreciate and enjoy this beautiful planet of ours, and remain aware of just how much change we have already done.

In her reflective journal, Ac. wrote that though she enjoyed the Strip Ecology macro-model so that students could actually see where their clothes came from:

> ….when you get to the store with good intentions and look in your wallet, I often have to change my mind due to the fact that I have a budget and need more than one thing while at the store. And just for argument sake, many of the Canadian companies aren't even owned by Canadians anymore. At this point, it is not feasible for me to set myself a goal

or make any changes to my purchasing habits.

After a trip to the local recycling plant, we had a chance for reflection as a class, and began to talk about what the plant manager had told us about the business. One of the things the manager had said was that the majority of the cardboard was now being sold and shipped to China, as that is where the best price could be had. The instructor asked the class to reflect on what that meant ecologically, and some members began to speculate about the impacts of packing and shipping cardboard from Thunder Bay to China, especially noting the carbon gas emissions and ocean pollution produced by container ships. As this conversation continued, and we all took in the implications of this new knowledge, Re. burst out that it was ridiculous that we were questioning whether recycling is a good thing. She said that she had been involved in getting recycling enhanced in her hometown, and asked, "do you want us to just go back to throwing everything out?" After this Kingfisher trip, I reflected on her response and the conversation that surrounded it, however, writing:

> …early in the campfire time, when we talked about reflections of a couple of fieldtrips (landfill and Recool), a conversation exploded about environmental issues in general. It started with recycling, but quickly moved on to corporations, citizen responsibility, food issues, economic activity in general, et cetera. It seemed to finally slow down after a few students implied that they were overwhelmed with what is not being done, the illusions behind what they thought they were doing, and one student talking about trying to be thoughtful about our own actions without thinking everything needs to change at once. My impression was that they'd been needing that conversation. Our hike back the next day was incredibly fast, and they had tons of energy for the trophic energy macro-model in the afternoon.

So, even though Re. had a very difficult time accepting the implications of what we had learned, there seemed to be something invigorating about this particular conversation.

Emotional responses. Students had emotional responses, including sadness, guilt, and fear, in facing the seeming intractability of some issues/human behaviours that they were exposed to in the course. Below are several examples of these types of reactions. This subtheme reflects a reality setting in regarding the weight of the issues dawning in the consciousness of students in the following examples:

Da. said: "To be honest, the concept behind this macro-model [Greenhouse Gases] is so large that it is a bit overwhelming on the individual level." After the visit to the dump, Re. wrote that she was feeling terribly conflicted. The piles of garbage were horrible to her:

> …but the one thing I couldn't stop thinking about were the animals. … The dump was a zoo. Dozens of bald eagles, hawks and other birds in trees, circling above the trash, soaring everywhere. …Was the experience in encountering these beautiful, majestic, incredible birds beautiful, majestic, or incredible? Well, no, I was at the landfill. The Canadian geese were swimming in the mercury, heavy metal, leachate pond for goodness sakes!! … The shock to my system at seeing these mysterious birds, so out in the open, completely unafraid and gluttonous.

After the Entropy of Food Consumption macro-model, Ca., who graduated with a B.A. in Biology, wrote: "After participating in this macro-model I tried to make a biological cycle involving humans. Unfortunately, I am having great difficulty completing any cycle involving humans because of our unsustainable practices and lifestyles." And after the Greenhouse Gases macro-model Ki. wrote:

> I'm finding it hard to distinguish between compromise, balance, excuses, guilt… For sources like medical equipment or fire extinguishers, what is a person like me to do? Am I allowed to pick my battles or if I let even one thing go am I supposed to feel morally culpable? As you can see, this class gives me a lot to think about.

Re., after the Entropy of Food Consumption macro-model, reflected: "The thought that 2700 lbs of grain that are consumed by a livestock cattle in order for me to have the choice to eat that cow frightens me." Similarly, La. reflected:

> [Reading] Blue Gold is making me question my water use but the concept of virtual water was completely new to me. I felt very defeated after this macro-model. Damned if you do and damned if you don't. There is no easy answer in my life right now. Canning is not an option. I don't have the space. And if agriculture is the biggest consumer of water, then only foraging would be best.

After the Water Usage Barrels (WUBS) macro-model, Am. reflected that she,

> was astounded to find out that it takes roughly 3000 Gallons of water to produce one pair of blue jeans. Every time I open up my closet and see 6 pairs of jeans in front of me I can't help but think about how I have contributed to the depletion of about 18000 Gallons of the world's water resources.

I wrote the following, after one of the initial macro-model experiences with the participants. This is not only a good example of the emotional responses students encountered, but also shows some of the connections participants were making. These responses foreshadow some of the shift in attitudes and behaviours that followed:

> On the way back I talked with a student who I had not talked with before, and though it became obvious that she was going a different direction at the half-way point, I think she

> would have stopped to talk with me for even longer than we did. The impactful things for her were the blue-jeans, but then her thinking about what else to wear, if stuff like Northface clothing doesn't biodegrade. She echoed what others have said, that the macro-models make the information sink in more deeply, make her consider what to do with the information, whereas knowing things just as info doesn't really make her think about making changes. She said, whispered almost, that she doesn't believe we should go without meat, when talking about the macro-model the week before, but that she had been thinking about how to get grass-fed meat since. She said she saw a cumulative aspect between the macro-models, that is, that she could see the connections between energy and water use and wasteful practices, but that one of the things that this did for her was to make her feel more and more overwhelmed.

Each of these examples show the experiences of powerful emotions that were both essential to the changes in attitude and behavior that occurred for the participants, and also were overwhelming at times and led to participants searching for cognitive and behavioural compromises.

Wrestling with dissonance. It was common throughout the time of the study to observe participants continuing to wrestle with the dissonance between their former understanding and the new information and experiences. The theme suggests that ecological literacy does not come without a price, in this case, the breaking of old, reliable understandings of the world and our place in it. For example, after the Entropy of Food Consumption macro-model, I had conversations with several students about their own eating habits, and students also wrote extensively in their reflective journals about this topic. On our walk back to the classroom, S.

asked me whether I ate meat, and after I had answered, she told me about her eating habits. She began by saying "I already eat vegetarian one night a week and try to buy meat at the farmer's market. But now I'm wondering if I should try to cut back more. But I love steak!" It was clear that she was wrestling with the new information about the amount of energy required to produce a relatively small amount of meat (compared to grain).

Jo. wrote: "I have wanted to cut back on my meat intake for some time for health benefits. After the macro-model I was able to realize that the ecological benefits to reducing meat consumption are bigger than I previously thought." Similarly, Ki. reported that she had known earlier about the,

> energy demands of raising cattle for food. Last year I told myself I would reduce my meat consumption. It worked for a while but I know that my body works best with a high protein diet. So while I don't eat steak every night, I put the issue away. The problem is that we are so removed from food production, we can shut out those ideas of energy consumption because we only hear about it, if that. … We're so resistant to change. Even the open-minded still use habit and ritual to get by. But the macro-model made the point easier for me to accept.

Ki. continued to write about the impact of this experience, and how its embodied nature had impacted her. This part of her reflection will be included in the analysis section on embodiment.

After the Strip Ecology macro-model, in which students identified the location each piece of the clothing had been manufactured in, Ka. reflected:

> …many of my ecological choices are based on the cheap life of being a student and clothing is no exception. Sometimes I think about where my clothing has come from,

> however it has not been a major deciding factor in my purchases. I think after this macro-model I will be more aware when shopping of where the clothing comes from. I will start checking tags, and it may help me decide between items.

After the Entropy of Food Consumption macro-model, Kat. wrote about her inner conflict between values from her upbringing and the new ecological information she was encountering:

> My current behaviours are a reflection of my upbringing, of course; but they should also be a reflection of my education. Someday soon I hope to reconcile these warring factions and find a balance that doesn't deny my heritage but embraces ecological realities.

Participants, then, were confronted in an ongoing way with the consequences of their own, and society's behavior, and wrestled with what to do. The above subcategories, including this one of wrestling and bargaining with their own dissonance, were common, especially earlier in the course. As time progressed, participants began to change their perspectives, intentions and behavior more easily and wholly, as briefly reflected in the next subtheme, and then focused on in the final thematic section of this analysis.

Inspiration. Before leaving this section on being challenged by new information, it needs to be said that while experiencing challenge, conflict, and struggle, many participants were also inspired at the same time by the information and experiences they had. This will be explored in depth in the later section on learning and behaviour change, and so I will not be analyzing this type of data here. However, it does need to be pointed out that participants (including myself) often expressed keen interest and inspiration about concepts and ideas that were presented through the macro-models and other course experiences. I felt, and saw on the faces of my fellow participants, a sense of child-like fascination routinely during the course.

Ambiguity. Emergent design, by its very nature, intentionally creates ambiguity for learners. One area of ambiguity that arose during the macro-model experience was the trouble some participants had in understanding how they would translate what was happening in the course to their own teaching practice. Participants wrote and spoke about the ambiguity they experienced in the emergent approach taken by the instructor, at times comparing it to other courses and professors who often seemed to use linear, concrete strategies regarding instructing the teacher candidates about teaching particular subjects and material. This subtheme is broken down below in terms of how students handled the ambiguity of the emergent approach.

Setting parameters vs. instruction. The first data in this section on ambiguity come from my own observations of the instructor setting the parameters for two different macro-models. Rather than telling students what they need to know, or on the opposite end of the spectrum, abdicating one's role as teacher entirely, emergent design sets up situations in which learners come into active and dynamic contact with key concepts, often playing multiple roles within, in the case of this course, natural systems. Here then, are two of my experiences of the instructor setting the stage for emergent learning.

The very first day of class, after giving the students a letter from the instructor and shadowing them as they followed the directions to find him waiting beside a stream, we stood in the pouring rain, listening to a poem read from across the stream. The day before, in the sun, and with much less water rushing along, the instructor had taken me to this place to look for and clear obvious hazards. We walked up and down the small river, picking up glass and cans, moving sharp sticks and rocks along the path the students would take for the Salmon Run (Puk

2010) macro-model. In this macro-model, participants are given a t-shirt to wear, with different colours indicating different roles. The large majority of participants play the role of salmon, whose job is to run up a river which is northwest of the campus, while avoiding other participants who play the role of salmon predators (bear, fisherman, eagle, etc.). The river itself was fairly full after a good rain, but still runnable, with quite deep spots providing challenges for the salmon. I wrote the following after this experience:

> At one point he [the instructor] asked "Now why do you think I do this [the Salmon Run macro-model] first? How does it fit in with the overall process, why is it the beginning?" or something like that. I am still pondering this, part of me wanting to look in the text to see the principle behind this particular macro-model, but a stronger part wanting to sit with the unknown and see somewhat through the students' eyes. I noticed myself thinking that it was strange in a way that we were altering, if only slightly, the natural state of the river so that the students could have a safer experience. I understood, liability and caring and all, but still thought it was interesting. The beginnings, perhaps, of seeing the setting of parameters that he does, and not just talking about it.

In later discussions about this experience, we discussed what exactly natural meant, and that we, as instructors, are of course part of nature and the ecosystem in which we teach. It is no coincidence that the main theme of the Salmon Run macro-model is the inter-connected reality of natural systems. The role of instructors in parameter-setting, as part of the learning ecosystem, has become a crucial aspect of my thinking about emergent learning, and will be discussed in more depth in the discussion section.

After another early macro-model experience, the Entropy of Food Consumption and WUBS, I wrote about a post macro-model discussion that emerged about ambiguity and later teaching intentions:

> I thought the most interesting one was a student who asked what to do with younger students who might immediately rebel against an implied message to eat less meat based on the experience. The instructor said that he was not implying they should eat less meat, that this was merely a scientific fact that it took much more system energy when cows are involved. The student rephrased it, making it clear that she didn't say he was saying that, but that students might feel that this was the implication. He agreed, but wanted to separate the fact from the implication. Then, though, he went on to say that there are serious issues that need discussing, with relatively few solutions. This then is an important theme, how to leave that room open when we, as instructors, are people too. How do we deal with the very real power situation that exists in the teacher-student context, when we are trying to leave room open for students to construct their own meaning?

I remember asking myself, after this experience, how much I had really been trusting the process of making one's own meaning in my own teaching practice, as I had felt the desire to lay it out more clearly for the students, or to have it more clearly laid out for me. These themes, the tension between intended learning and personal meanings, and trusting the emergent process, became central to me over the course of research, and fit here with the overarching theme of setting parameters.

Following the opening day outside, after the Salmon Run macro-model, we had our opening classroom discussion. After this class, I wrote the following:

> Perhaps the most impactful thing, to me, that the instructor said was that he sees his main responsibility to be to set up contexts which give the students opportunities to make their own meaning. Several times he reflected back to students, at their questions, that it was up to them to make decisions about what they would do with the opportunity, that he wasn't going to specify much for them, and that this was a professional year, so soon they would be needing to make these calls for themselves anyway.

In others words, the meaning of lessons is not universal, not only in terms of key concepts, themes, and so forth, but also not in terms of teaching practice. Each of us takes what we take from the same external experience, and it transforms us uniquely (or does not).

Complaints about ambiguity. Some students, at least at first, simply complained about the ambiguity and suggested it should be changed to a more concrete information transmission style. In this research study it was clear that some students have come to expect specific and concrete answers in response to their payment of tuition and presence in a classroom. The following report from one particular student illustrates this response. In answering a structured interview question, Ka reflected:

> I did not like the ambiguity. I didn't work well with it. In the Soils macro-model, for instance, I wasn't sure of my role, or of anyone else's role, really. Because of the complexity of the game, perhaps having us study our roles in advance would have been helpful…. Also, I kept wondering how students would react to the confusion created by the ambiguity.

Later, Ka. also said:

> I was already well educated about complexity in this context. What I was really hoping to

> master, as much as possible, was how to teach students about this complexity. And because I, myself, was very confused during and after some of the macro-models, I didn't finish the program with a concrete knowledge of how to teach students about these concepts.

So, she wanted concreteness about complexity, especially how to teach it, and never was quite able to make the connection between her lack of mastery and lack of understanding of complexity. She was never able to recognize that in order to understand ecological complexity and how to teach it to later students, she needed to let go of her routine bar-pressing behaviour, to stop looking for the concreteness she had come to expect in the educational system. This was a very unusual case, in terms of where she finished the course. It is included here only because more participants reflected this kind of resistance early in the course, but stopped pressing the bar earlier in favour of engaging ambiguity, as reflected in the subcategories described below.

Acknowledging the validity of ambiguity. Other participants acknowledged the usefulness of ambiguity, on a theoretical level at least, but struggled with it on a somewhat ongoing basis. I imagine a person testing the temperature of the water in late spring; pulling their foot back quickly as it is cold. Jumping in, the air being knocked from your lungs, though you might know this is an incredibly renewing thing to do, is frightening. I began to wrestle with my own discomfort with negative student reactions to ambiguity. After the first day of class I wrote:

> There is very little information shared, really, compared to other classes, which was a point the instructor pointed out when asking me to reflect and I didn't touch on this. His point, I think, is that the focus should be on experiences that provoke thinking, that the experience should be first, rather than thinking about things before experience. The task

> for the facilitator, then, is to set up experiences that will indeed provoke thought, and perhaps experiences that are likely to provoke certain types of thought, or thought patterns, though this is unpredictable in terms of specifics. He is very confident about the processes, or appears to be, anyway. But it seems rather lonely and hard to put into words. When you're in it, it seems obvious, I guess, like with psychotherapy. And what is my resistance to going there too much? Am I afraid? Do I want (too much?) to stay in the concrete myself?

Other participants described their experiences with this: Jo. said that he was:

> … not very familiar with the style of teaching in the course, the uncertainty of it. I am used to a structured environment. I am trying my best to come to grips with the parameters of the course, and think I will succeed at it. I have always loved the unknown, and life would be dull without it. We [the class] are all university educated individuals, so I think we should all be knowledgeable and mature enough to accept situations where the outcomes are uncertain.

Note that at this point, Jo. was still talking about embracing ambiguity in a theoretical sense, but wrestling with the idea of leaping in.

Br. also expressed some discomfort with ambiguity, though also some excitement, while suggesting the potential origin of her more negative reaction to it:

> Initially I found the ambiguous nature of the lessons exciting, yet sometimes frustrating. I think I found them frustrating because of my previous educational experiences. In traditional schooling the nature of lessons, especially in university is mostly in the form of a lecture.

As in the earlier metaphor, the familiar, the known, the habituated actions and expected

responses, are powerful. And yet most students could see, sense, and intuit some importance to the ambiguous nature of emergent design, even while feeling the discomfort.

Embracing ambiguity. Finally, some reveled in this approach, spoke about the need for responsibility on the part of the learner and the advantages of being given the freedom to make one's own meaning, and actively wrote and talked about the meaning of course activities and how this would affect their future teaching practice. Most of the students who had some experience with the first two subthemes in this category did not always have a negative experience of ambiguity, and many participants shifted in their experience of ambiguity over the course, struggling earlier, and coming to embrace it as time went on and they experienced making their own meaning rather than being instructed. In answer to a structured interview question, Am. reflected:

> The ambiguity changed over the course in that I began to embrace the sometimes because I was so used to structure and all the information being presented to me when learning. But, as I got familiar with the instructor's use of ambiguity to teach, I became to realize the benefits of such learning experiences.

An interesting feature here is the early experience of frustration due to expectations built on prior experience, and the contrasting appreciation of macro-models that emerged. In other words, it was the contrast between what this student was used to and emergent design that allowed her to appreciate the ambiguity inherent in the macro-models.

Br. struggled similarly in the earlier parts of the course (see above) but also later was able to appreciate the value of emergent learning, and was even more precise in describing the benefits that emerged, answering a structured interview question in saying:

> The ambiguous nature of the lessons allowed students to explore and learn more on their own, and also collaborate about their thoughts and ideas. Not having all the answers allows students to continue their learning outside of the classroom which contributes to more diverse and individualized thoughts opinions and ideas. Not knowing exactly what was happening or what exactly we were learning added an element of excitement to the lessons and to the course. I exercised more problem solving skills which allowed for greater learning and thought, and allowed me to think about concepts a bit deeper, than if I was just told the material. Also, not having definitive boundaries made the concept of complexity more realistic because the environment has no absolutes, and the idea of exact boundaries is more of a human construction.

Other participants had less difficulty embracing ambiguity. Interestingly, Ca., though also acknowledging an educational history of being fed pre-determined meanings, had a different initial response to the ambiguity of emergent learning:

> To be honest, I'm so tired of being told what to do in other classes. … Really, this class is a breath of fresh air. We're in our professional year, you know? It's time we started taking responsibility for our own learning and the decisions we make.

Note the acknowledgement of exactly what the instructor had said early in the year, that students were on their way to becoming teachers, positions in which they would no longer be waiting for others to determine meaning, but instead would be expected to take the lead themselves. Aa. wrote that "ambiguity and uncertainty is a favourite aspect of this course. I love the mystery… the journey, mystery, and beauty excite me." The words used here are noteworthy, and call my original theme into question, at least for this particular participant, but also for myself, as the course progressed. Aa. was not really discussing the beneficial outcomes of ambiguity and

emergent learning, but rather was valuing being in the uncertainty itself. A journey into unknown territory, the lack of knowing a requirement in order to be open to what is new, what is to be discovered.

Overall, most participants, even those who were more initially resistant to the ambiguity inherent in the macro-model approach, came to appreciate its importance. Further, many students seemed to understand, or grow to understand, that the experience of uncertainty is a requirement of meaning making and the appreciation of the fully beauty of our existence.

Theme 2: Engagement. As is already obvious, emotions and feelings were stirred in participants for a variety of reasons. As students found their way through the struggle, and began to thrive with ambiguity, they demonstrated fuller engagement. I noted four (4) main subthemes in the overarching theme of engagement, with subthemes embedded within each of these, as follows:

Community. During my master's level training, which included an intensive internship in facilitating group process, the building of community was heavily emphasized. I was taught to focus on initiating processes that would: (a) lead those who did not know each other to make early connections; (b) slowly invite participants to enter into activities that would progressively deepen their engagement and subsequent learning; and, (c) shape but not control the material and experiences of participants to stimulate their thinking and ways of thinking. During the current research study, I observed all of these things and they are described in the following three subthemes. I have already discussed the setting of parameters, but will revisit this in the first

subsection, in which I describe the early building of community and observations about the impact of the processes the instructor employed to do so.

First steps in building community. I have always envisioned ice-breaker-type processes as an invitation to slowly walk down steps, in the sense that when the intention of a process is for participants to have impactful experiences, facilitators cannot simply expect them to immediately jump directly into the depths we wish to get to. Early on, the facilitator plays a central role from this perspective, whereas once participants are more connected and deeper in the process, the facilitator can fade somewhat into the background. The following starts with a brief description of the first day of class, and then continues with a journal entry of what I observed, including terms of the impact of what was done:

The students were delivered a letter in class, the instructor not there, and had to follow a map to where he was. They were suspicious that I was actually the professor and wondered if they really should follow the direction to be in line, smallest feet to largest. Interestingly, as described earlier, one group of students went outside first while others stayed inside for a time trying to fully understand the directions. There was a lot of giggling, but in the end they lined up outside. It was raining when we first went outside, though not hard. As the class progressed it began to really pour, so that you had to nearly yell at times to be heard, though towards the end of the class the rain tapered off again. (The instructor had informed everyone including me that we would be outside for most classes, rain, snow or shine. Most were prepared for the rain, though I was not, really. Later, the instructor smiled when I had said how wet I got under my non-waterproof coat, and suggested that it had all been part of the process.) The students

followed the directive and arrived, after 15 minutes or so at the destination, with me following slightly behind.

They arrived at the bank of the river, the instructor on the other side. A student noticed the next day that he was lower than they were, she liked this as it indicated a refuting of regular hierarchy. The instructor read in the rain as I stood further along the bank. I was again struck by the students' silence, not sure if they were listening or simply quiet because of the strangeness of it, the ritual of it, just plain respect. He invited them across the river, to support each other. The water was much deeper than it had been when we prepared the space because of the rain, and a decent current. They were laughing, some nervously, the first young woman jumping right in. There was something spiritual about it for me, though no one said this when reflecting on it the next day. The instructor greeted each of them with a handshake, gave them their "text-ropes". It appeared to me that the crossing was a ritual, a metaphor for entering a different than normal space, and his handshake a welcoming to that different space. We were put into pairs and small groups and were told to gather information about each other, then introduce our group members to others. Later, the instructor showed us how to tie a number of knots, told us the ropes were ours to keep, spoke about them being the course textbook, without being explicit about the metaphor's meaning. Tying knots was meditative, and created feelings of being capable. These experiences suggested that something was different here with the ropes to keep, the ropes as texts, the crossing of the river and the hanging out in driving rain. It was wet and cold, I was wet and cold, but there was no urgency to finish the class and go.

There are several points regarding the beginning of the process that match well with my earlier training on facilitating good group process. The first is the leading of processes that got participants talking and interacting with each other, such as the introduction exercises and

working with ropes together, but even earlier than that, the implicit invitation to interact by giving instructions without being present as the professor. The second is the ritual nature of the process of inviting participants to take a step towards a deepening of participation and experience. Though showing up and not finding your instructor there as expected is somewhat anxiety-provoking (as evidenced by the nervous giggling), it is not so provoking as to leave participants feeling unsafe (as evidenced by their following the directions) and starts them down the steps. Finally, setting the initial lesson outdoors, the reading that the instructor used, the text-ropes and various other processes were all a part of the setting of parameters for the course to come. The instructor shaped participant experiences through the entire class, but did not specify what was to have been learned. In fact, several of the processes could be seen as markers for participants that this course was not going to be business as usual.

Connections made through interactions. The processes described above led very quickly to a sense of connectedness, which increased over time and was the basis for many of the learning outcomes in an emergent fashion. This phenomenon made me think of the brain developing more and more synapses (the connecting points between neurons) through experience, which leads to the emergence of higher forms of thought. I reflected on the development of more and more connections between participants in two entries a few days and then two weeks into the course:

> Lots of conversation on the way to the staging grounds. The instructor walked very quickly and on his own. Grain, cow, human macro-model, so the students (most of them) do a lot of running. There are a few who don't run as much at first, but the group in general is totally into it, and don't really know much about what this is supposed to be

> about in the beginning, so the rest seem to get pulled into it. The group interaction, for just day two together, is amazing (though I have seen this many times with good group process). They have coalesced to a degree very quickly. Big smiles for many students, but they are also quite serious about the activity. As soon as they know the basics, most groups were devising strategies, team-member roles, and then switching with each other when one would get tired. I heard many of them afterward talking about how out of shape they feel. …. The rituals which I have written about have already led to a profound, and yet unthreatening, sense of community. I see students who had not known each other at all before the course talking quietly with each other. I have had many of these conversations myself, asking questions and getting responses that are well beyond the depth one would expect with less than two weeks exposure to each other. The teamwork and strategizing has, in a way, a competitive edge, but it is not personal at all. Everyone is quite ready to switch teams for the next process and be as committed to the new team as they were to the last. No one is keeping score. That is not the point. We are simply engaged, through the activities, to give our all to those who we belong to in the moment. This is completely transferrable, even to the students who just joined the group this week. I imagine that after our weekend(s) away, this will become even more profound. The little things the instructor says and does contribute to this in such a big way. Constant encouragement to help each other, that this is no race, to be empathetic, to say thank you, and so forth.

Many, if not all of the participants reported that they became much closer to their classmates through the macro-models than they had experienced in any traditional classes, and that this was an important part of the learning experience. This was typified by a comment from Jo: "[in the

macro-models] you are able to form close bonds and friendships through teamwork and proximity." But comments from students went beyond just bonds and friendship. In discussing the importance of the community in terms of the ambiguous nature of the emergent teaching approach Al. said:

> It is not hard to deal with ambiguity when you trust the people. At first the [participant group] was just another class but it became more than that as the months moved forward. I trusted everyone collectively and individually and because of that ambiguity became less and less of an issue.

It was clear that the connections made through a variety of processes led by the instructor allowed participants, then, to cope with any anxiety that they felt about challenging situations. Am. said:

> …as our class became very close, we were able to rely on each other and look to each other for help if we were uncertain. We began to express our feelings about the macro-model during the macro-model to figure out what was going on.

The closeness developed between participants allowed them to explicitly share experiences, which led both to a sense of comfort, but also the ability to process learning experiences at a deeper level.

To summarize, building community was a focus for the instructor early on in the course, and was then developed organically through interactions in the macro-model approach. The community that was built over the course was crucial in terms of trusting each other in dealing with the uncertainty students faced with the emergent approach. This allowed participants to feel a sense of comfort, but more importantly allowed the deeper forms of learning, that are possible with such an approach, to emerge.

Curiosity. Interest, curiosity, and flow experiences were common through much of the time of the study. I observed that lack of curiosity in some participants at some points was correlated with a lack of engagement and learning, though this was relatively rare. For the great majority of time, participants were full of questions and hungry for more in specific ways that sync well with the literature explored earlier. The following subcategories regarding curiosity were identified:

Curiosity caused by process. Jo.'s following comment in answer to a structured interview question is a good example of a common report about participating in macro-models:

> The macro-model experience ignited curiosity amongst the participants. I found myself thoroughly reading the textbook in order to acquire more knowledge about the topic in question. If the macro-model was thoroughly interesting and engaging, I would research the topic further online. For example, the Nurdle exercise let me to Wikipedia and other websites. I was able to obtain visual images online of the topic in question. I also browsed Youtube for videos on plastics manufacturing.

Other participants also spoke about reading up on macro-model topics before and after class to deepen their understanding. The main thing that participants pointed to, in terms of sparking curiosity was that their role was compelling, pulling them into full engagement, which then led to being more interested later in finding out more about a particular topic.

Interestingly, many also said that they were not consciously thinking about the meaning of macro-models while in the process, but instead would later talk about it with peers and/or spend some individual time processing. During macro-model participation, it appeared that

participants' full attention was taken up with playing the role they had been assigned, and very little reflection on that role was occurring. For example Ca. said:

> There was something about having to work so hard just to get the bucket full, getting splashed while I was plugging the holes, that when we were doing it, I wasn't even thinking about what it represented even though he had told us. Then, when we were watching the other team do it, I could see how hard they had to work, and then I started thinking about what the holes represented and how hard conservation of water is, will be. It was the combination of the hard work with my body and being totally absorbed, and then seeing the other team working so hard and having time to think that really made the information sink in. I saw the connection then.

There were some exceptions, one of them being my own process, in which I was participating in macro-models, reflecting on my own experience, considering their ecological meaning, and observing others, sometimes asking questions about their experience, to try and understand the learning process that was occurring in more depth. All of these things were not always happening in each moment, of course, as I was fully engrossed in some of the macro-model roles I played. It is not clear to me whether this sort of reflection-in-the-moment and observation of others potentially took away from my own learning experience. Another possibility is that it enhanced my learning, and that invoking such reflection-in-the-moment in students would be advisable, but even if this were to be the case, it was not my role as participant-researcher to do so. These questions lead into the next subtheme of developing an attitude of curiosity.

So, the order in terms of igniting curiosity seemed to be (a) set up roles that are interesting and compelling to participants, and get them started with these roles, which led to (b) interest in following up on concepts which were the focus of a particular macro-model, and over

time (c) developing a kind of curiosity habit, which will be discussed in the next subtheme section.

Cultivating an attitude of curiosity. Everyone who has experience in lighting fires, especially with less than fully dried wood, knows there is a moment when the base of coals is enough to maintain a fire without further blowing or kindling being needed. Where early, individual macro-models acted as a match to light curiosity about particular concepts for participants, what I observed was that over time the collection of macro-models built a metaphorical base of coals, resulting in a perpetual fire of curiosity about ecological topics.

When asked about whether she thought curiosity was important in terms of ecological literacy, Al. replied:

> Curiosity is what enables us to ask the questions and find the answers that will bring us towards a society of eco literacy. The only problem is when the questions are hidden. When beauty products say organic it really means nothing but how would you even think to question that? I suppose the more curious you are the more curious you become.

Perhaps as Al. suggested, curiosity begets further curiosity, in the sense that curiosity tends to lead to knowledge and understanding, and experiencing that process of learning increases the desire to learn, just as eventually a fire does not need further attention once it gets to a certain stage. However, my observations suggest that there is a skill in devising processes that both spark initial curios responses, and keep building and inspiring curious responses until a perpetual attitude is firmly in place.

Play. A very common component of participant descriptions of macro-models was their experience of play, in terms of both fun and the sense of participation in simulations of ecological concepts. As in other sections, it has been difficult to separate out these subthemes from others in the analysis, particularly the second subtheme of as-iffing discussed below. There is quite clearly a strong connection and/or overlap between play and embodiment in terms of getting into a role for macro-model learning, and so deciding where this data fits has been an ongoing process. For now, it fits best with play as discussed by Piaget and Vygotsky with its role in learning on an embodied level in a space that is safe for practice and mistakes. But first, the subtheme of fun will be explored, and as the data shows, this is a key component of student engagement.

Fun and playfulness. When I was a young boy, my grandfather took me to see a young family of river otters playing in a small waterfall near to his home in Mindemoya, Ontario. We sat for what seemed like hours watching them chase each other up and down the brook, leaping almost clear of the water at times, slipping in and out along the bank easily, pulling up stones from the bottom, chattering at each other in excitement and perhaps irritation at times. I was absolutely entranced, absorbed and could have kept watching but we eventually needed to go. I imagined that they just kept playing after we left, and never forgot the unbridled joy they seemed to take in their play. This is how I still think of the term "fun", not as some trivial and fleeting experience, but rather the sense of pure absorption in an activity, with time passing unnoticed.

Participants commonly and constantly mentioned fun in describing macro-models. In fact, more than one participant said something to the effect that they waited through the whole week for Friday (which was the day of the class) to come because they could count on doing

something fun, something that would make the time pass after a week of often feeling bored in classrooms. I observed several things that seemed to be integral to having fun, including the aspects of community already discussed. Another key element to fun in my experience was water. Water was a central component of several of the macro-models, whether representing itself (in the river) or something else (e.g., grain, sunlight). Here is one example of the fun that ensued through the use of water, as reported in my journal:

> The [WUBS] macro-model involved two teams trying to fill two of the big barrels, with holes drilled into the side, with big holes representing agriculture (65%), medium representing industry (25%) and small representing household use (10%) of world-wide water usage. In teams of 6 we had to decide how to fill the barrel. Our team had a small fire line to the river, with a few members plugging holes near the bottom of the barrel, and the rest of us starting to plug holes as we got it filled. Again, great fun, compassion and empathy mixed in as our team members plugging holes got splashed and totally drenched, but yelling for us to continue. All activity and noise and teamwork.

During and after the Entropy of Food Consumption macro-model, I wrote about the absorption aspect of learning through play, that is, we do not think about what we are learning while it is happening:

> I started asking some of them what they were thinking during the activity, and then what they were feeling after one said "I'm not thinking about anything". There were many answers about strategy like how to best organize the team, how to adapt to some of the containers that were broken, how to deal with breathlessness, wet feet." This matches what was discussed above regarding curiosity, that when absorbed in an activity, there is little to no conscious reflection on what is being learned. Instead, fun led participants to

be absorbed in what was happening in the moment. In terms of learning through the macro-model approach, conscious reflection and seeking out related information occurred before and/or after the experience.

Participants reported that this type of engagement was crucial to their learning, and also to the learning of students during their teaching placements: Al., in answer to a question about her experience about what was beneficial about the macro-models, said, "I learned from the macro-models and my first placement that children/people are willing and in fact want to learn; you just have to give them the opportunity to have fun and play." Note that this data connects with what has been organized into a separate subtheme around learning, that is, how participants took forward learning through the macro-model approach into their own teaching. Many participants discussed the need for fun in their teaching practice after having experienced the macro-model approach, which they reported led to engagement, which meant they learned and retained information. When asked what about macro-models had facilitated her learning, Am. replied that they were "fun and engaging which sparked interest in the subject area and made the experience more memorable. Learning by doing and immersing myself in the learning experience increased my understanding and retention of the material learned to trigger lifelong understanding."

As-iffing. Participants often talked about how being in the macro-models, and playing some part in whatever system a particular activity was modeling, led to the learning being more meaningful than information alone had been in their learning experience. A metaphor here is the method actor, who must embody a character in order to effectively portray them on screen. As discussed earlier, Piaget and Vygotsky both emphasized the importance playing roles in terms of having a safe space and time to develop necessary skills. In the literature review section, I stated

that there are only a few theorists who see this as-iffing as continuing to be an important learning mode after childhood/adolescence, and that this appears to ignore a key aspect of learning at the post-secondary level. The data presented here strongly support the notion that playing roles is a learning mode that leads to the kind of depth of learning towards which educators strive. In discussing as-iffing, Jo. said: "Immersion in the outdoors assisted in the understanding of the macro-models. For example, during the one soil exercise, you felt like a worm since you were rolling around in the dirt." Ka reported a similar experience, saying:

> In the Fuel Cell macro-model, I was able to picture electrons splitting. I felt like I was a tiny particle inside a giant microscope. It was a neat feeling. I loved doing this activity in the winter and jumping into a pile of snow through the hula hoop.

Ju., after the Solar Energy Web macro-model, said:

> This macro-model really opened my eyes to the harsh eat or be eaten mentality of nature. As a carnivore, it was exciting to chase my peers. I can't remember the last time I have run so much, especially through the bush. I felt like the king of the animal world, stalking its prey, crashing through the woods, shouting war cries, and working with my fellow carnivores to hunt prey. However, this mentality came crashing to a halt when the hunter and Mack truck entered the equation. The playing field was simply not fair, then. Then hunter had a throwable bag for longer distances, where I did not. I could only imagine how unfair this would be in real life with a rifle and scope. Me and my fellow carnivores were no longer kings of the forest.

After the Solar Energy Web macro-model, Jo. also reflected: "I think I played the role of carnivore pretty well, to the point where I began to stalk and track my prey. I stayed very low and tried to walk quietly through the bush." I, too, was struck with the impact of playing roles in

the Solar Energy Web macro-model, writing in my journal:

> I noticed and heard several things from them about this macro-model. They were very engaged with their characters. Role-playing was a major piece as the carnivores especially were growling. Many students talked about the fear experience of being stalked and having to be on the lookout all of the time for predators. I could relate with this too because even as the Mack truck, the hunter was after me the whole game. Later, when we were reflecting on the experience, several students wanted to tell stories about particular hunting or being hunted experiences, of predators going by very close and not noticing them. There was a clear sense that they had had visceral experiences of survival, right in their bodies.

This last phrase "right in their bodies" connects back to the theme of embodiment of course, but is also a fundamental quality to the absorption of play being discussed here. It is through becoming the role, through method-acting, that the deeper learning occurs. As Am. reported:

> I have learned the process of photosynthesis and transpiration multiple times in my university studies … but through lectures, textbooks, and diagrams. Until now I have never really understood the inner workings of the tree until this macro-model which allowed me to become part of the internal structure of the tree. I assumed the roles of phloem and xylem and got to transport nutrients down the tree and water up the tree.

Simply calling something a macro-model, having roles to play, and being outside is not enough, however. Students were required to construct and facilitate their own macro-models on an assigned theme as the term progressed. Some of them engaged participants fully in the same manner as the course macro-models did. Others, though, seemed to miss the mark, even though they were conducted outside and were attempts at creating analogues of ecological phenomena.

In a journal entry after participating in several of the student-created/facilitated macro-models, I speculated about what made them work, or not:

> I have really noticed, with the atmosphere, yesterday's model, and a few of the students' models, that having people standing around in the middle of the activity doesn't work (at least for everyone). While some students will take it up, find a role, et cetera almost no matter what (and I put myself in this camp) others will take the opportunity to fade out. They almost seem like they are waiting for these opportunities. I think this happens with small group work in my classes. Some really take it up, but if the activity/topic isn't really engaging, others take the chance to check out. This is certainly not an opportunity for transformative meaning making for many of them. I'm trying to grasp what wasn't as effective with the macro-model yesterday, because I thought the concept was good, the information really interesting, but somehow there was too much lull in the middle of things. It didn't entice engagement. Hmmm… Is movement more important even than I had thought? How about an opportunity to play? In R.'s case, to role play. This latter seems more likely. It doesn't seem like just movement is enough, but rather movement that also has an as-iffing quality. And perhaps this is connected to imagination, making the connections as you are as-iffing.

In the reflection above, I focused on the as-iffing quality of absorptive play, the need to become fully immersed in a role in order for it to engage the learner at the level that leads to the kind of depth of learning educators strive for. Similarly, Am. ended a journal entry after the Big Dentro macro-model by saying:

> Now when I see a tree, I do not just see it as a structure that only moves when the wind blows … but now I visualize the inner workings of the tree and that nutrients and water are constantly being transported up and down the tree.

Her macro-model experience of being different parts/roles of the tree has changed her experience of trees, through the deepening of her understanding of what they actually are.

Another important point included in the last sentence of both my and Am.'s journal entries above is imagination. This is the next subtheme in terms of engagement, and connects to the as-iffing quality of play. Again, it was very difficult (and somewhat unsuccessful) to attempt to separate out data from these subthemes (that is, the distinction between the as-iffing quality of play and imagination). Somewhat uncomfortably, then, I have drawn the line between as-iffing (this subtheme), the construction of images and metaphors, and the aspect of imagination that has to do with planning for future activities (next subtheme).

Imagination. As shown in the last subsection, being able to immerse oneself in a role as an actor in an analogue of an ecological function is vital to engagement and deeper forms of learning, and this could certainly be seen as an aspect of imagination. Being able to imagine oneself within the ecological phenomena being played out is an important aspect in this learning, as well as being able to see the connections between the analogue and real-world phenomenon. This section, though, will focus on two other aspects of imagination, including how participants used visual images and other creative expressions to make sense of their macro-model experiences and deepen their learning, and how participants saw the imagination as important in their own and others' learning about ecological phenomena and societal change.

Creative expression. Several participants regularly used drawings in their journals as a method of visualizing macro-models that they had participated in. Figures 1 and 2 are examples:

Figure 1. Participant drawings after macro-model.

Figure 2. Participant illustrations after a variety of macro-models.

These drawings demonstrate the way that participants used the drawing of images to record what they had learned through macro-models they had participated in. Images like these were always also accompanied by writing about the macro-models that had been experienced. The use of images, several participants told me, was a helpful method for many participants to record their understanding. Participants also said that images were alternative and sometimes more dynamic and all-encompassing of the phenomena of interest than they were able to achieve with written, reflective prose.

Other participants used visual images to record what they had experienced without an obvious or overt purpose, in the sense that they were not illustrations of phenomena per se. Participants that drew these types of images said they were a way to deepen and express visually what had happened in the experience. Figures 3, 4, and 5 are examples of this type of imaging:

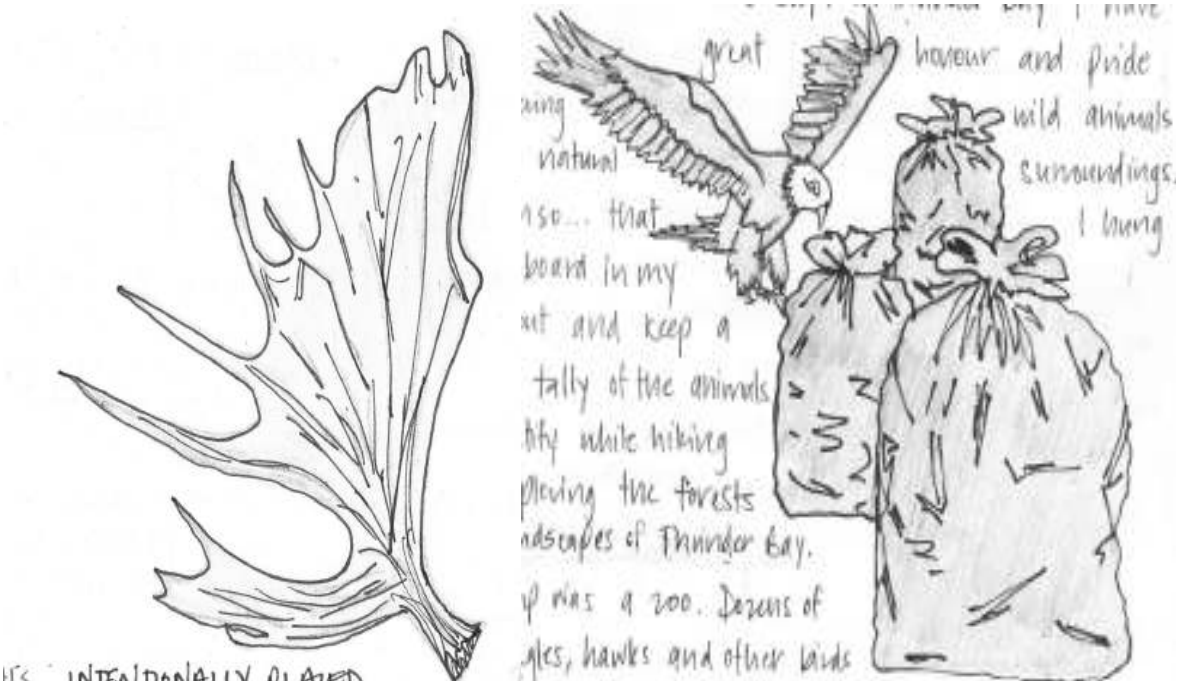

Figure 3. Illustrations after finding antler on outing, trip to the dump.

Figure 4. Participant drawings after reflection on macro-model experiences.

Figure 5. Participant illustration in journal reflecting on class outing.

I was struck by the amount of time several of these images must have taken to create, and that this reflects the depth of engagement of these participants in the ecological concepts they had earlier explored through macro-models. Overall, visual expression appeared to be a way for participants to reflect on macro-model experiences, which in turn contributed to the deepening and solidification of understanding of key ecological concepts.

The other type of creative expression that stood out was the writing and performing of songs related to ecological phenomena. Participants were put into groups of two or three, and each week one small group was responsible for presenting a song based on the macro-model(s) that had occurred the week before. There was a wide variety of approaches to performance, as some participants had well-honed musical skills, instrumental and/or vocal, while others did not. Where some groups presented without any electronic accompaniment, for example, singing and sometimes playing guitar, other groups played well-known songs with the lyrical component removed, singing their lyrics over the track. Many groups had the rest of the class join in for the refrain of the song, posting their created lyrics on PowerPoint slides or overheads. It was fascinating to watch each group move to the front for their performance, often somewhat nervous. Though many groups started tentatively, especially earlier in the year, without fail the entire class would be fully engaged as the song continued, laughing and singing loudly, appreciating the creative meshing together of well-known songs with concepts from macro-models. I have included several of these songs, written form only, in Appendix D.

The fun and playfulness of both visually and musically expressed creativity, but also the expression of the imaginative capacity itself, clearly contributed to the developing of understanding of important concepts, and the embedding of understanding in our memories.

Envisioning, planning, problem-solving. Participants also used imagination in terms of inventive thinking about potential solutions for ecological problems. Many times I heard participants, engaged in reflective discussions about ecological issues, start their sentence with "What if…?" demonstrating the entertaining of an imagined future. Al. said:

> I see imagination as being an integral part of ecological literacy. The very nature of imagination challenges the norms and requires intense discipline and practice. Imagination is what comes up with solutions to problems and other ways of being or existing. We are nothing but decaying society without it.

Similarly, Jo. said:

> Imagination and thinking outside the box will be instrumental for figuring out how to overcome ecological illiteracy amongst the general population. The solutions are complicated and it will take an ecologically literate individual, with a great deal of imagination, in order to successfully educate the public.

Note that both suggest it is only new thinking that will result in solutions to ecological issues, and also that imagination is key in engaging the population with these potential solutions. The ability to look forward and plan, with the important dimension of invention added is being discussed by participants here. In addition, participants are pointing of how crucial these aspects of imagination are in addressing ecological issues.

The kind of creative, forward thinking described by participants was a crucial aspect and emergent outcome as participants made their way through the course. In other words, the very kind of imaginative thinking they described toward the end of the course as crucial in engaging the public in inventive solutions for ecological issues was the kind of thinking that emerged in

them as they progressed through multiple macro-models. Describing this growth, and other kinds of emergent learning observed in the course, is the focus of the next section of this analysis.

Theme 3: Embodiment. The recursive and overlapping nature of reporting on these themes is likely already evident to the reader, and will increase as this analysis continues. For instance, subthemes from the previous sections (e.g., emotional responses, embracing ambiguity, empathic community, play, curiosity, and emotional engagement) are all aspects of an embodied learner, that is, someone who is present in mind and body, and who is doing something meaningful. With that in mind, the focus and rationale for this section is to capture aspects of participant experiences and parameters of emergent design that are specifically about kinesthetic experiences, the natural world, and their integration.

The felt experience. Based on my analysis of the data, a major component of macro-model learning is what I call "the felt experience". In other words, participants gained a great deal, in terms of learning, through physically participating in analogues of ecological phenomena. By the felt experience I am not meaning feelings or emotions, per se, though I will share participant experiences of emotions in this larger section on embodiment. Instead, by the felt experience I mean both the kinesthetic and conceptual impacts of participating in the macro-model analogues.

Kinesthetic impacts. One of the participants used the phrase (see below) "gum on your shoes" in talking about the kinesthetic impact of macro-model learning, and having physical learning experiences in general. I liked the sticky nature of this metaphor; how it raises memories

of sticking to the floor, not being able to ignore what is happening, needing to address the physical reality one is confronted with when gum is on the bottom of our shoe. The way that kinesthetic impacts made learning memories sticky is evident in the examples of participant experiences. Below, I share several examples of participants discussing this stickiness, and how felt symptoms (e.g., soreness in muscles, being wet and cold) deepened their understanding of particular concepts. Am. reflected that "when I think of salmon I know of the struggles a salmon has to endure upstream because I was a salmon in the macro-model and had to literally go upstream. I felt what it was like." In first discussing the Solar Energy Web macro-model, and then the Coke-can macro-model, Jo. said:

> In the animal world accumulating trophic energy is a huge challenge, which becomes wasted through entropy … Through this macro-model I was actually wasting energy at times. I was panting for air, sweating like crazy and radiating heat. … During the Coke can model … it was our duty to transport items across the field, and progress through each of the stations. The snow was deep and the distances great. It was physically exhausting, due to the complexity of the system. By me shedding blood, sweat, and tears I learned much more than I ever would through a textbook, presentation or video.

Ki., in reflecting on her experience of the Entropy of Food Consumption macro-model, said:

> Making us run, creating that embodied learning experience, really does add to that gum on the bottom of your shoe. … Our minds can resist a whole lot. Mind over matter, right? But stick your hand in a fire and you still will burn regardless of your mental state. So I feel more open to the idea of reducing my cow consumption, "cowsumption", because I can think back to how frustrating and tiring it was trying to fill those damn buckets. … Decisions made without whole body assent will not stick.

Am. made a similar point in saying, "while all senses were at work during the macro-models, I felt that by physically doing the activity and feeling or embodying the topic at hand had the greatest influence on my understanding." After the WUBs macro-model, Kat. reflected:

> …when you are constantly reminded of conservation and ecological issues, and you're later faced with choices, the trickling, gushing, sloshing sounds of water leaking from symbolically sized holes from a barrel plays like a siren song, helping guide those choices you're faced with.

Early on, I noticed and appreciated the kinesthetic impact of the macro-models, which is evident from the following entry in my journal:

> During and after the WUBS: All of us plugging the last holes as we could, having to wait five minutes to see how much we could retain. Everything starting to go quiet, tendons and ligaments and muscles starting to ache. I was hunched directly behind a young woman, body draped around her but not touching, to plug holes. Suddenly I wondered if it was okay that I was so close, so beyond regular physical boundaries. Fingers started aching, and we had to make adjustments to fill holes that we couldn't cover anymore. A young woman and then a young man covered a hole with their mouths! I began to feel somewhat overwhelmed with the task of trying to hold this water, trying to stop the leakage, the work of it, and it was only five minutes… A young woman started to sing, I think noticing our flagging morale. All of the basic boundaries of regular education were broken down in this exercise. Emotion had a main role in the experience, connected to physical exertion, connected to the analogue.

The impact of kinesthetic experience in macro-models, as is shown here, was central to participant learning. Experiencing exertion, exhaustion, temperature, and so forth, deepened

learning, making important aspects sticky in memory, to follow the metaphor, demanding our attention because of their physical nature. Though in this last entry from my journal the emotional impact of macro-model learning is also foreshadowed, the next subtheme deals instead with another aspect of the felt experience which is closely related to kinesthetic impacts, which is the power of role playing in analogues of ecological phenomena.

Natural surroundings and learning in place. Nature is the context within which the macro-model approach to emergent design occurs. Of course, all learning could be said to exist within nature as humans and human structures are natural, but the natural world, the human world, and their intersections are intentionally invoked in several ways in emergent design that impact the experience and root memories in particular places.

The following comment by Br. exemplifies the notion of how learning in places that match the natural phenomena being studied leads to the rooting of memory:

> Being outside allowed me to connect to nature more than if we completed the activity in a gym or the classroom. It also allowed me to internalize the experience more because I attributed to macro-models to real places, and that's what the learning is all about!

Similarly, after the Virtual Model macro-model, Aa. made the connection to bodies of fresh water she had visited:

> In coming to Thunder Bay, I have already had a number of experiences that have reinforced my appreciation for our fresh water. The first of these experiences was to set foot in Lake Superior for the first time. It is a beautiful lake that has a brilliant aquamarine shade and startlingly cold touch that is not common to my familiar Lake Erie or Lake Ontario. … My second experience was to view the pictograph of Misshepezhieu

> at Agawa Bay and the native handprints on the cliffs of Quetico Lake. There was a connection and reverence for the natural world in native culture that is terribly lacking in today's society.

The sensory impacts of natural surroundings in the macro-model experience led to felt experiences that the participant distinguishes from typical societal experience and awareness. Her sense of reverence simply would not have been possible learning through traditional modes of learning in classrooms. This leads to the next subtheme, which is strongly related to the notion of learning in place, namely the emotional impacts of learning in natural surroundings.

Emotional impacts of learning in natural surroundings. Mention of the surroundings on a basic level was common in the data, including the aspect of memory being rooted in place as discussed above. Participants also consistently talked about their enjoyment of the natural surroundings, and other emotional impacts at times. Natural phenomena seemed to resonate with the emotional world of participants, often creating a basic sense of wellness. The following is an example from my experience, early in the course:

> My first day of research yesterday. No students yet. Out with the instructor to clear debris from the river for the first macro-model in the first week of classes. Salmon run for the students with predators lying in wait. It was wonderful. Cool river water up to the waist at times, removing sharp rocks, dangerous sticks, one broken beer bottle, three shopping carts (though we couldn't remove one, so only marked it instead). The beavers had built a dam, the first time according to Tom, so the salmon run will be shorter this year. I said "now this is my kind of education".

I have reported on this experience in an earlier section, and hope that in these descriptions the impact of natural surroundings is clear, even including the human contributions (e.g., broken glass, shopping carts). Note that in my own writing I felt the need to put quotation marks around the word research, indicating a significant departure from what is typically thought of as academic activity. With the last sentence I also made it clear that this was a different type of education. Having natural surroundings as the context for macro-models provided a rich, multi-layered sensory experience, and a level of engagement and enjoyment that was beyond what is possible for me in the classroom. I felt that day as if I had made the right choice in terms of my program and research, in that anything more traditional would have paled in comparison.

In a later journal entry I continued to describe the emotional enrichment of the outdoors on learning, including touching on the feeling of being overwhelmed in a macro-model exercise, which was part of what rooted this experience in memory:

> The excitement and bliss of being outdoors, using our bodies, belonging, exertion, smells, touches, sounds, sights (without consciously registering them), and then the strain, the overwhelmed feeling while waiting for our five minutes to be up yesterday. All of these felt experiences so important in inscribing the experiences into memory, making the information remembered.

Jo described another emotional state, not normally considered to be positive, that led to a much deeper learning experience through the macro-model being set in the outdoors:

> I also became paranoid, always looking over my shoulder. I listened attentively to the sounds in the air of footsteps and screams. And I felt I began to become familiar with that area as I knew where I was at all times and where others were.

In earlier sections of this analysis, and in sections to come, many emotional experiences have been and will be related, each of them embedded in the context of natural surroundings. Throughout the data is evidence that learning ecological concepts in outdoor contexts enriches learning through stimulating emotion in learners.

In general, overall, the macro-model approach clearly invokes the felt experience, through role playing, setting, and causing emotion, which in turn roots and deepens learning. The second subtheme regarding embodiment, which follows, examines the data for specific evidence of embodied cognition.

Embodied cognition. On the most basic level, the data shows that the power of macro-models is based in doing something, rather than just hearing about it through book, lecture, video, or other more traditional learning methods. As discussed during the literature review, one theory of embodied cognition employs a complexity model to understand the interwoven nature of individuals, their communities, their natural surroundings, and the process of learning and change. Data shared in the following two subsections are specifically related to this model of understanding the learning and change process. The first subtheme is the common perspective participants reported regarding embodied learning, that they experience it as far superior to traditional modes of learning. The second subtheme is "complexity and emergent learning", which is based on data showing the way in which macro-model, embodied learning leads to emergent outcomes for participants that are shaped by the parameters of the macro-model, but rely on the embodiment of individuals, and their interaction with others and natural surroundings.

Preference for embodied learning. A number of aspects of this have been analyzed already, and others are to come, but in this section I will share the answers given by participants when asked directly about the embodied nature of macro-model learning. In the education system we often neglect to ask for the wisdom and insight of learners themselves when trying to understand how students learn, to our great detriment. First, an excerpt from my journal:

> I asked [a student] what he thought of the macro-models so far, and he said that the information was almost all new to him, but that he felt comfortable now (after having felt concerned that his background wasn't suitable at the beginning of the course). He believed that the macro-models embedded the information much more deeply that the information alone would have, that his entire undergrad experience had been indoors and information-based, and that this just hadn't made him learn in the same way.

Other participants similarly pointed to the deeper learning that comes from embodied approaches. In response to a structured interview question, Am. stated:

> Through embodied experiences, students grow from being passive learners to become active learners and experience themselves through all the body's senses what they are to understand. … Through a lecture-based teaching style the information being learned may be forgot as it has not cognitively resonated with me, whereas, experiences actually doing a macro-model get students to feel the information being learned which not only enhances understanding, but students are more apt to think of the macro-model outside of class because it was fun, challenging, and overall more memorable than sitting in a classroom listening to a lecture.

Similarly, also in response to a structured interview question, Al. said:

> When compared with traditional ways of learning or rote learning embodied experience has an interesting effect. The experience becomes deeply rooted in your memory and the experience becomes something to build knowledge on. Whereas with rote learning you may remember that Columbus sailed the ocean blue in 1492 but the information is meaningless. There is nothing surrounding or embedding it in an empathetic center.

During his structured interview, Jo. reported:

> Embodied experience has a great deal to do with igniting imagination, since you are instructing a student to use their mind, in order to place them into a specific role. Personally, I do not learn by hearing or seeing. I am a kinesthetic learner who learns best by doing. Embodied experience caters to all learning spectrums, since it is a combination of audio, visual and kinesthetic teaching styles…. By seeing, doing, touching and smelling, I was fully enthralled in the activity. My attention was concentrated on the macro-model and not on other areas.

In general, then, participants reported several beneficial aspects of an embodied approach, including discussing the felt experience, memory enhancement, and deep engagement. The first two have been explored already, and engagement is the next main theme in this analysis, so I will leave further analysis of this subtheme until then. One more aspect of embodied cognition needs exploration first, however, namely the emergence of learning through the complexity of the embodied learner.

Complexity and the emergence of understanding. Though there is a full theme regarding learning from the macro-model approach to come later in the analysis, there is an aspect of emergent learning, based in embodiment, which needs to be touched on here. Again, the

impossibility of separating out distinct themes arises, and so some level of overlap and repetition is unavoidable. Emergent understanding is a necessary subtheme here because embodiment, including the immersion and interaction within natural surroundings and other actors, is crucial to such learning, and it is the larger theme of this section. However, I will focus the data included in this section only on the direct connection between embodiment and emergence as much as possible. The idea is that the type of emergent learning that is the aim of the macro-model approach can only occur in the appropriate, embodied, circumstances.

Two participants shared similar experiences of embodied learning leading to an understanding of important ecological concepts that they had not been able to gain through more traditional modes of learning. After the Big Dentro macro-model, in which participants play different roles in tree respiration, Ha. said:

> I have studied vascular plants several times in university. The structure of a tree was of course an important component in these courses. Strangely, I never was able to memorize or visualize the main structure of trees. Now, after learning Big Dentro, I've got it! By golly! If I had only had such an excellent interesting lesson earlier.

After the Salmon Run macro-model, Sh. wrote:

> Participating in the macro-model is the closest experience I have encountered with understand the wild salmon ecosystem. On an undergraduate geology field trip to BC … our class stopped at a Fraser River tributary to witness the salmon swimming upstream to spawn but they did not make an appearance. I was informed of how the bears relied on the salmon in their diet and the importance of the fisheries, but until this [macro-model], I could not remember another instance since that time where the subject was brought to my attention or I had ever given the wild salmon ecosystem any thought. … This is important

> to me as a Canadian and a global citizen. I appreciated the complexity of a system for which I had only understood the mere basics.

One of the things I noticed throughout my participation and observations was that the embodied, macro-model approach naturally created what Vygotsky (1930-1934/1978) called the Zone of Proximal Development. In other words, participants were able to plug in to macro-models at the level that they were ready to, based on their own level of understanding and expertise coming into the process. I wrote in my journal:

> One of the things I am profoundly aware of at this point is that many of the students I have informally interviewed have related different internal experiences of the same external experience. In other words, the very same processes have engaged students, though they have stimulated very different kinds of processing of the experience, of the information offered. Some have fairly good grasps (relatively) of the concepts being explored, and yet the embodied components of the approach are engaging them with the information at a deeper level. In fact, even those with a rudimentary understanding of the concepts are being drawn into engagement with the information at a level which seems to be requiring them to question what they will do with the information, rather than just amassing it. In other words, the engagement seems to be causing a reflection on the information, new or not, that is transformative.

Note the word engagement encroaching into this journal entry that has been marked in this analysis as being about embodiment. Engagement is the next major theme, but in this research study, engagement and embodiment were not truly separate things, as the aspects of embodiment already described required engagement, and at times, caused it, and engagement heightens the experience of embodiment in emergent learning. The two are intertwined, inseparable in reality.

Before moving on to the next section, a moment to summarize what was noted about embodiment: (1) learning in place/natural surroundings, and exerting themselves in these surroundings, led to firmly rooted, and meaningful (connected to emotion) memories of learning experiences; and, (2) participants preferred embodied experiences and these experiences led to a complexity of learning that traditional modes of learning in their educational histories had not. The types of learning that occur through emergent design will be highlighted in the final thematic section of this analysis.

Theme 4: Categories of learning. Though from a complexity point of view examining outcomes may be somewhat problematic, since picking out the beginning and end of any natural process (such as learning) is difficult at best, I did observe much learning that was the result of the emergent approach. Along with more traditional gaining of knowledge from particular lessons, this learning was often the emergent result of many of the macro-models and other associated learning experiences combined, which is the intention of the overall curriculum. When utilizing emergent design, it is not expected that students will learn each chunk of ecological information separately and combine them, machine-like, to create an overall ecological literacy and ability to teach ecological science to students later in their teaching career. Instead, the intention (and this is what I observed) is to set up parameters that create opportunities for students to gain information on several levels, to wrestle with it, and to develop their understanding over the course of time. Below are the subthemes, which represent interrelated types of evidence of the learning that emerged from over the course of the study.

Concepts. As already reported, some students expected information-transmission types of teaching processes, the same types of processes they said were being used in other pre-service teaching courses. One student said that in another course the professor simply handed them lesson plans each week, and went through the plan in a step-by-step fashion in terms of how to present the lesson to future students. Emergent design is not simple or linear in this way, but instead creates spaces for students to grapple with information and dynamic situations that are analogues for ecological phenomena, and challenges them to make meaning of their experiences. Below, I report on the types of knowledge they demonstrated had emerged from macro-model experiences.

Concept growth. Concept growth was evident in terms of developing understanding of ecological concepts in general. Participants demonstrated gains in their basic knowledge of key concepts over the course of the study. In some cases, participants (including myself) were learning about key concepts for the first time. These were the new shoots of knowledge. Several students discussed not knowing anything or much about many of the concepts covered by the macro-models. In reflective journal entries, I observed that all students, at some point, were amazed at the facts that came clear through several of the macro-models. The macro-models (Puk, 2010) that received the most mention from participants in terms of experiencing concept growth were: Entropy of Food Consumption; WUBS (water usage); Nurdles (plastics manufacturing); Coke-can (following the manufacturing of a can of pop); Greenhouse Gases; and Virtual Water (regarding the use of water in food production and manufacturing). Here are some examples of concepts that many participants did not know the meaning of at all at the beginning of the course:

- Virtual water
- Entropy
- Agricultural use of water and aquifer decline
- Trophic levels

Similarly, many students wrote that they had learned about some of the concepts in other contexts, including secondary and post-secondary education, but realized they had actually known fairly little before the macro-model experience. These were the cases of spreading branches, where the area of knowledge was not new, but participant knowledge of a concept became more sophisticated. There have been several of these situations already described in other sections of this analysis, but it is important to note in this section as concept definitions can exist on several levels, as discussed in the Growth Schemes model. Here are two examples of participants reporting concept growth in terms of deepening the sophistication of their conceptualization of key ecological phenomena. First, Aa. reported:

> My initial reaction [after the Greenhouse Gases macro-model] was confusion. Although my prior understanding regarding the mechanism by which greenhouse gases exert their effect on the climate was correct, this macro-model clearly demonstrated my lack of understanding of the relative contribution of each greenhouse has to the anthropogenic effect. Methane has always been engrained in my mind as the gas most detrimental to the environment. While each methane molecule may have a greater relative effect on the atmosphere, the absolute abundance and the long half-life of the carbon-dioxide molecule clearly makes carbon dioxide the greenhouse has that will challenge human life in the foreseeable future.

After the HONCO macro-model, Ju. reported that his family had, for years,

> …sprayed Roundup around the trunks of our trees. This kills the grass and weeds around the trees so you don't have to use the weed-whacker around them. After doing some research, I looked at the chemicals used to make roundup. Glyphosate (a synthetic herbicide) is one of the main chemical ingredients. Although it is rated low in toxicity, it is a chemical that my family and I can live without.

In summary, participants learned both about concepts that were new to them, and grew in terms of the sophistication of their knowledge about concepts that they had already known something about coming into the course. This finding is important in the sense that it demonstrates that emergent design can and does lead to concept growth in participants, which is a common concern about less-directed teaching approaches. The common, and yet unfounded, criticism of approaches that allow and encourage students to make meaning of their experiences (as opposed to telling them the correct answers) is that these types of emergent approaches will lead to students creating incorrect meanings for important concepts. The data shared so far demonstrates that this is not correct, at least in terms of the emergent design presented here, and as the sections below show, emergent design leads to types of learning that are less likely or impossible with traditional information-transmission approaches.

Conceptual understanding. Conceptual understanding was reflected in a more thorough demonstration of understanding the interconnected nature, and therefore the complexity, of ecological concepts. Where concept growth has to do with more knowledge gains about specific concepts/phenomena, conceptual understanding reflects a development in recognition of the ways that all concepts are parts of a nested whole, an ecology. It was obvious that the instructor did not just set up parameters macro-model by macro-model, but also shaped the whole course

around a larger set of parameters through which participants had the opportunity to see connections between concepts and the larger whole overall. During her structured interview, Br. said:

> I really felt that the macro-models were strategically planned, and that helped me understand and connect to the concepts. It was also more exciting, because there was a bit of a progression in my learning experience because I was able to build upon all of the macro-models. It's as though the layers of knowledge were being built upon layer by layer.

Setting up such a progression required an understanding of complexity, in terms of understanding ecological complexity, but also the complexity of the learning situation as a nested ecosystem. The following reflect the conceptual understanding that developed in participants, as well as their more specific reflections of the complexity inherent in ecosystems. After the Entropy of Food Consumption macro-model, S. wrote:

> I was left wondering what my impact of purchasing canned salmon has on the salmon ecosystem discussed in the last lesson. I've decided that finding an alternative to canned fish would be the most ecologically conscious change I could make in my diet.

This is a demonstration of connecting concepts from different macro-models (examining ecological impacts of farming salmon and potential danger to the natural system). After the Strip Ecology macro-model, Aa. reflected that further research on his part led him to information about using hemp for clothing manufacturing, especially as an option in Canada since other textile crops are not viable in Canada. Similarly, Jo said:

> Complexity for me now means that there are much more important links between natural and human systems, than most of the population is aware of. For example, everything in

> the natural world is connected to human systems. We are part of the natural world and have been since the dawn of evolution. When natural systems are degraded or destroyed it affects us as a result.

After the Strip Ecology macro-model, Kat. wrote that it had,

> struck me with its complexity. Where clothes come from is a minefield of issues in Social justice, economics, ecology, and ethics. I really don't think these issues can, or even should, be separated.

On a more poetic note, in answer to a structured interview question, Al. showed the development of her understanding of the interwoven nature of ecology in saying:

> Complexity is as the call and response patterns in Jazz. A bird sings in a tree and I smile. Overwrought with happiness I move to hug a loved one and the bird flies away. There is only one natural system and each movement is followed by another reaction. This continues through the system losing energy and effectiveness until it all energy is lost. Complexity is learning to see the natural system in the human-simulated environment and not allowing oneself to forget or ignore this connection. Complexity is listening to the notes of a symphony and understanding that silence is an equal part of it.

Aa., discussing his response to the Virtual Water macro-model, wrote:

> …astonishment. Water usage is a large concern in the growing of crops and animals, and I have therefore become familiar with the water debt and conservation methods pertaining to agriculture. What I had never considered was the expense of water in my clothing, linens, and other fabric items. With the growing detachment of children from the natural world, I wonder how many children know that cotton is produced by plants. I am also astonished that the most vocal efforts for water conservation are made at the

household level. The macro-model clearly demonstrated that conservation tactics could be most productive if the efforts yielded even moderate success at the largest source of water debt: agriculture.

So, in summary, the ability to understand the interconnected nature of key ecological concepts developed over the course. Participants noticed connections between macro-model topics, saw the intersections of human behavior and the natural world (and indeed the illusion of separating these), and recognized the complexity of the world around them with a much greater depth of understanding and appreciation. This depth of understanding led to a seeing through mistaken understanding of ecology in general, and often to an awareness of the political motivation behind such mistakes, which is demonstrated in the next section.

Participants, to summarize this subtheme, gained in knowledge on several levels. First, they developed the accuracy and depth of key concept definitions, both in cases where they had never heard a term, and in situations where they had thought they knew what something meant but learned much more about particular concepts through macro-models. Second, participants began to see the interconnected and complex nature of ecological concepts and knowledge, especially over time and exposure to multiple macro-models. Finally, participants saw through surface level understanding of concepts and activities, which are sometimes put in place to influence citizens activities, making them feel like they are doing something environmentally responsible when in fact the activity has dubious benefit or is outright harmful. These gains in knowledge were integral to changes toward behaviours with more ecological integrity, which are described in the next section.

Complexity thinking. Perhaps more than any other discipline, when the topic is ecological education, learning requires more than simply the amassing of information. Ecological literacy must include changes in behavior if the major ecological issues of our time are going to be adequately addressed by society. This final subtheme is an examination of the types of changes that occurred for participants through the macro-model experience. There are four subcategories in this section, starting with growing discernment and then changes in participant attitudes toward their own responsibility for societal action or inaction on ecological issues. The third subcategory involves changes participants planned or did make regarding ecological issues that they had learned about. Finally, the impact emergent design on participants' plans for future teaching is explored.

Discernment. Discernment was demonstrated through participants' awareness of how particular terms are used in the larger society politically, or where their meaning has been lost because of misapplication/misuse. Similarly, discernment was evident where participants realized that they had unconsciously carried a societal perspective, value, or belief system, which they were then able to critically analyze. Where a lens is a metaphor for how we look at the world, our perspective, cleaning the lens can be seen as a metaphor for clarifying that perspective, for wiping off any residue that was blurring what we see, whether that residue was put there purposely or by accident. After the Big Dentro macro-model, La. said:

> I am surprised that some of the largest trees can pump more than 100 gallons daily. That is amazing! I think we are trained to look at organisms in the environment in terms of what their personal or commercial value is, rather than their inherent value. In looking at these systems deeper we could learn a lot.

The Big Dentro macro-model, then, helped La. to look beyond, or through, a more typical perspective on trees (as a commercial resource) in order to appreciate complexity and importance of the roles of trees in our ecosystem. This was a typical response of participants to macro-model experiences, in that they often spoke of discovering a world beyond what is typically seen in the ecological phenomena they were studying.

Another typical experience of discernment was demonstrated by Aa.'s reflection after the Strip Ecology macro-model. He wrote that earlier in his life he had sought out Canadian-made clothing after several clothing manufacturers in his geographic location were lost to globalization. "…the label "Made in Canada" usually does not tell the whole story, because only a portion of the final processing is required to have occurred in Canada." This is a good example of what might be termed "Green-washing", defined by Greenpeace (2013) as the bombardment of consumers by corporations with false or misleading claims about the ecological impact of their products. The Strip Ecology macro-model led Aa. to investigate and learn more about corporate use of such terms to sway consumer activities. In other words, the macro-model promoted discernment about something that had seemed obvious to Aa., that is, that "Made in Canada" would mean all of the product was made in Canada. Again, this was a typical, often disturbing, experience for participants, most of whom came into the course with a history of trying to do things with an environmental conscience. Recognizing that some of the things they had believed were environmentally responsible actions (e.g., buying "Made in Canada" merchandise, recycling which can paper over the problems of over-consumption, etc.) were in fact questionable was difficult, but led to a greater understanding of the nature of ecosystems.

Sense of ecological responsibility. Citizenship in nature, and a responsibility for the impact of behaviours was a common outcome that emerged in students after particular macro-model experiences. A typical response was to ask "What can we do?" when new knowledge, understanding, or discernment emerged after a particular macro-model. For example, after the WUBs macro-model, I listened to and then became involved in a discussion about the Ogallala aquifer about how to raise awareness about its overuse and dwindling water levels. Participants felt quite strongly that if people only knew more about this issue, there would be more political will, because of pressure from citizens, to address the over-usage of water from the aquifer by agriculture industries. Another example arose after the Bee Boogie macro-model which explores the world of bees, their importance in food production, and the issue of die-off. Participants felt very keenly after the macro-model that society needs to step forward to push for change around pesticide use as a civic issue. Several participants also discussed their attempts, when having returned home at Thanksgiving or the Christmas/New-Years holidays, to promote such ecological citizenship with their families.

As discussed above, increases in a sense of civic responsibility occurred through individual macro-model experiences, but as an overall attitude, this occurred more as a whole as an emergent property of the course. When the course ended, participants typically had developed very strong views that ecological literacy should be a requirement of citizenship, and that an important part of what they would take from the course was this perspective. What follows are responses from participants in two post-course interviews regarding ecological citizenship. In response to a structured interview question, Br. said:

> My philosophy is that with greater knowledge comes greater responsibility. After learning the inherent beauty of nature, and how nature operates and works as a

> community, and also how humans negatively affected these systems I felt a responsibility.

Similarly, Al. reported:

> This learning experience allowed me to think more critically and also to be more creative. I think this is important, because an important part of teaching is helping in the development of students to become responsible contributing citizens.

A sense of ecological responsibility in citizens, then, was an important and emergent outcome of the macro-model approach. Participants were moved to consider what changes they could make, what societal responsibility would look like with particular issues, and how they could/can be an influence that promotes a sense of civic, ecological responsibility. This sense of responsibility was a key aspect of the changes that they planned and made, as described in the following sections.

Making plans and changes. In the past, pages of books were referred to as "leaves", and so the saying "turn over a new leaf" meant to start something fresh, to turn to a new page. All of what has been described and explored in the above sections led participants, including myself, to consider what might be written on such new pages, and many participants engaged in changes in their lives towards a more ecologically conscious lifestyle. Below are several examples of specific and concrete changes participants planned and made in response to a macro-model experience. First, Sh. wrote, after the Strip Ecology macro-model:

> This issue really made me examine ecological health and its intrinsic relation to human social health. To me it ties strongly to self-sufficient communities and individuals. I'm going to take this opportunity to get going on making an article of clothing.

After the Entropy of Food Consumption macro-model, Ju. said that:

> As a meat eater I never looked at the agricultural industry through a different perspective. The macro-model and our discussion helped me see it differently…. During this activity I learned about the transfer of energy through the production of grain and meat…. The hardest thing for me to do will be excluding red meat from my main course. There are substitutes for a main course, but I just need to find them.

The Entropy of Food Consumption macro-model also caused Am. to write:

> I am surprised at how inefficient meat production is, and how damaging it is to the environment. I don't consume a lot of red meat … for health reasons, but this gives me a stronger excuse to eliminate it from my diet. It just doesn't seem responsible.

Similarly, Li. reported:

> As a result of the Greenhouse Gas macro-model I have learned a considerable amount about the specific gases and their sources. The word Greenhouse gets thrown around a lot, but very few people (including myself) have a very good handle on the specifics of the gases and the background information about them. The first result of this macro-model was that it significantly increased my knowledge of the subject. This wider knowledge has left me with the urge to further read and learn about greenhouse gases, where they come from, and what I can do to reduce my contribution to their emission.

Later in the course, in answer to a structured interview question about impactful macro-models, Jo. said:

> One model that stood out was the virtual water exercise. It made me realize just how much fresh water went into the production of consumer goods. It made me seriously consider the quantity of meat that I purchased. I found myself shopping differently and

> taking virtual water into consideration. The macro-model helped me realize what the term virtual water was and the serious ecological conditions associated with consumer goods that contain high amounts of virtual water.

After the Solar Energy Web macro-model, Ju. stated:

> The macro-model really showed me how much energy the upper levels of the food chain used. It seemed that plants were the most efficient organisms in the chain, since they get most of their energy from the sun and energy is not lost through consumption. I have already been practicing meatless Mondays and have reduced my meat consumption. More vegetables and fruits are needed though, which I will add to my diet.

After the Greenhouse Gases macro-model, Li. acknowledged that though she had thought she knew a lot about greenhouse gases, she realized that she had known very little. This led her to setting three intentions, with specific actions attached to them, including: reducing what she intended to throw out, supporting businesses that offset emissions, and taking the bus or riding her bike to school more often. In fact, several students stated that they felt overwhelmed with the Greenhouses Gases macro-model, in terms of the amount of information and the implications in terms of behavior changes that are needed to address this issue. However, most students came up with at least one intended change, many matching the intention Li. set to drive less, and several others planning to turn the thermostat down a degree during the day, or significantly at night.

Finally, in terms of behavior changes, several participants discussed changes in the larger sense, over time, and the sustainability of making change in one's life. Br.'s comment typifies this approach and awareness of the need to be thoughtful so that changes could be maintained:

> As my knowledge developed layer upon layer as the macro-models progressed, I felt uncomfortable, and not at ease by the way I was living my life. I slowly started changing my behaviours bit by bit so it could be a lifestyle change rather than a trendy phase.

In summary, participants were moved to make changes in their lives, in response to macro-model experiences, both individual experiences and the cumulative effect of many macro-models over the academic year. Rather than simply adding information about ecological phenomena, macro-model learning affected participants at a depth that caused them to plan and make changes in their behavior, developing an ecologically conscious attitude and approach overall. The final subcategory to be discussed is perhaps the most important, considering that participants were in a pre-service teacher education program. What follows is a discussion of the impact of the emergent design approach on participants' plans for their own teaching approach.

Application to teaching practice. The experience of participating in macro-models led to emergent teaching intentions in participants. The course instructor at no time told participants how they should teach, but their experiences certainly led to them to plan on employing an emergent approach in their own future teaching careers.

First, participants often discussed how they would apply a particular macro-model in future teaching situations, and had conversations amongst themselves about different tools and techniques they might use in particular situations. After the Solar Energy Web macro-model, Da. reported that she,

> …would love to use this either as the introduction or the conclusion to lessons or a unit on foodchains and ecosystem habitats. I think that it is easy enough to understand for grades 7 & 8 and engaging enough to get even the too cool for school 12th graders. … as

> a teacher I feel more comfortable delivering this type of information. Great gateway into lessons, units.

Similarly, Kat. said, after the Trophic Levels macro-model:

> Throughout the model and afterwards I thought of the particular ways I would use this model in an environmental science classroom. … Perhaps I would introduce the activity with an introduction to deer ecology. I will most likely be teaching in Northern Ontario so I may change the deer to moose.

Participants also noted the differences in the instructor for the course versus more traditional instruction models they had encountered, and talked about what this would mean in terms of their future teaching if they decided to teach in a more emergent way. One example is Jo's answer to a structured interview question:

> The instructor was there to introduce and guide the macro-model experience. He was a facilitator who would relinquish control over the group as the models progressed. Many of the macro-models took on a life of their own, once the instructor had introduced them, and the group had become familiarized with their inner workings.

Br. also noticed that

> …the instructor left as much of his personal life and role as an instructor out of the learning experiences. I thought that he ensured that the learning wasn't about us learning from him and all of his experiences, but rather learning from the environment itself. He acted a tool that guided us to the places that would be most engaging.

Participants did not simplify the challenges of such an approach, however. When asked about what applying an emergent approach would mean in her future teaching practice, Al. answered that it "… means letting go of control and allowing learners to experience and come to

their own conclusions within the parameters you have created.", but also pointed out that ambiguity can be a challenge "…because students want to know what they are doing and why. I spoke to my mother about this and she said that perhaps it was the responsibility of everyone in the community to pull those people back in." Am. said:

> I believe that there is a happy medium to using ambiguity in teaching and learning in that too much ambiguity can be confusing and frustrating which could destroy the interest in the activity and the learning experience. However, having a certain level of ambiguity is important in that we want to challenge students to draw their own conclusions and construct knowledge on their own, and not spoon-feed the students the information.

In her structured interview, when asked what the experience of the emergent design course meant to her future teaching practice, Am. said:

> Having students construct their own knowledge from the macro-models is such an important tool in teaching and such experiential techniques I will strive to use with my students. It is my desire to move completely away from teacher-oriented direction to cooperative and constructive strategies that are student-oriented and derive meanings for themselves. I sometimes found it difficult on my last placement to take a step back and let students learn for themselves without stepping in and helping them. When students figure things out on their own it's such a rewarding experience for not only the students but the teacher as well!

Similarly, Jo. said:

> Experiential education is the way of the future. I believe that we need to get away from the traditional role of the classroom and integrate it into the outdoors. By getting students

> psychologically and physically engaged in a macro-model, they retain much higher percentage of information.

Essentially, participants agreed that their experiences of being a student in an emergent design-based course had convinced them that their own teaching practice would have to be based in such an approach if they were going to be effective teachers. As Am. said during her structured interview:

> Overall, learning through embodied experiences that encompass all senses provides students with the opportunity to use 5 different modes of understanding the information presented to them, which enhances their learning experience and comprehension and retention of the course material.

Sometimes, it took more than just the experience of being a student for such awareness to emerge, however. I talked with several participants about how the awareness of the effectiveness of an emergent design approach did not really dawn for them until they led their own macro-model, and/or moved into their placement teaching experiences. Being in the facilitator role themselves made it clear to them that they needed to use an emergent approach, and seemed to lift a final veil that had not quite been lifted through their student experiences. Br.'s description typifies this phenomenon:

> My second placement nicely tied everything together, and made the entire experience amazing. It was like most of my questions were answered, or some of the mysteries of the lessons revealed themselves to me as the roles were reversed and I was teaching the grade 12s using macro-models. I noticed how engaged they were in the lessons and felt a sense of accomplishment that the students could engage and gain meaning from the concepts they were learning, while having fun!

So, in summary, participants thought about and discussed how they would apply particular macro-models in future teaching experiences, considered the difficulties in such an approach, agreed that it was necessary due to the depth of learning of participants, and were greatly affected by opportunities to facilitate emergent approaches.

Summary of Analysis I - Parts. As suggested in the introduction to this first level of analysis, the theoretical framework with which I started the research process influenced both the data recording and thematic analysis processes, and this is reflected in the themes and subthemes just discussed. However, the process of separating out themes from the data has been a recursive rather than repetitive process, in terms of revisiting themes evident in the theoretical framework for the study. As a result, though there are similarities between the theoretical framework and the framework of themes just identified, there are also surprises, and more depth and nuance in terms of understanding some of the themes already discussed in Chapter Two. This recursive process continues in the next section of this chapter. First, though, a re-visitation to the overarching theme of wholes being more than the sum of the parts of a system.

Finishing with the last point in the analysis section above, that students need to be in the teacher role to fully appreciate emergent design, represents coming full circle with the analysis of the data. This section started by discussing the difficulty of separating out themes, since the whole experience of being in an emergent design course can be thought of as being immersed in an ecosystem, where different parts are interwoven and inter-influential over time, leading to emergent phenomena. Br.'s revelation through teaching in a placement situation was one of these emergent phenomena, an emergence that was reliant on all of the history, actors, and interactions involved in the ecosystem of the course. There are many, many aspects of such an ecosystem,

including natural surroundings, parameters set up by the instructor, the participants and the aspects of their experiences, and interactions between all of these things over a substantial period of time. I have shone a light on different aspects of this system with the hope that such a focus would allow for a deepened understanding of how such an approach works in terms of learning, and to learn more about participant experiences. In the second analysis section to follow, I will progress from examining different parts in isolation to viewing wholes as dynamic processes. In other words, I will be describing a complex ecosystem.

Analysis II – Wholes

The traditional process of separating out themes, as I have done in the last section, has been a valuable activity in the research and writing processes in that it focused, like a beam of light, on particular aspects of dynamics and experiences of emergent learning. As stated before, it was awkward to do so in the sense that separating out parts of the whole experience tends to leave each of these parts feeling incomplete and somewhat lifeless, inert. Like the examination of neural connections under electron microscopes, valuable detail can be gleaned, but seeing the parts unmoving and separated from the system leaves us far from understanding the mind. Like a neuroscientist trying to isolate the foundations of memory in particular, isolated components of the brain, the movement, dynamism, and interactive nature of learning through emergent design were missed when looking at the parts isolated as they were in the last section. The following section is intended to remedy this issue, at least somewhat, through the description of whole experiences. It is meant to be a type of meta-analysis of the data gathered, which includes the aspects of experiences described so far, but also illustrates the intersecting, interacting nature of emergent learning experiences. Intersections and interactions occur within each individual, and

between members of the group. To be clear, what follows is not separate from, or distinct from the first analysis section, but rather is meant to build on the first section and represent a more whole and dynamic representation of the data I gathered. At times, the following representation will include descriptions of my own experience, but as Tedlock (2000) suggests, this is not meant to represent a distinction between my experience and that of other participants, but rather a richer and unified narrative, an "observation of participation".

This section includes the following four interwoven meta-themes: *Water Bending Light, Living and Learning on the Edge, The Ground of Learning,* and *Facets of a Crystal.* I have used metaphor here as an alternative form of description, which can serve as a useful interpretive tool in qualitative analysis (Suter, 2012). One noticeable feature is that in describing these four meta-themes, there is the potential continuation of a false separation of the whole experience. At some point, however, the researcher must accept that there are limitations in terms of representing a phenomenon. The descriptions that follow are meant to be fuller and more dynamic representations than the earlier analysis section. In a related vein and as already suggested, there is overlap between the subsections. For example, the meta-themes of *Water Bending Light* and *The Ground of Learning* both involve discomfort, but the former uses more of a psychological, and the latter more of a physiological perspective or focus. This phenomenon, of similarity emerging in a recurrent fashion, will also be discussed in more depth as the dissertation progresses. It is of course impossible to perfectly represent a whole, lived experience in the written, linear form of a dissertation. The attempt here is to begin to put together the more traditionally sectioned themes of the first analysis section into more whole descriptions of experience, and then in the final chapter to give an overview of the whole phenomenon. I imagine a lens focused close-up and narrowly in the first analysis, then widening the focus to

allow for a larger, living view in the analysis section to come, and then at its widest angle in the discussion chapter.

In terms of structure, Analysis II meta-themes will be presented with a description of illustrative experiences, followed by a brief analysis of the influences on participants that emerge from such experiences.

Water bending light. One of the most common things I heard from participants early in the study was that the class was very different than any of the other pre-service teaching courses they were concurrently taking. For some of the participants it was very different than anything they had ever experienced in their educational history, though several had graduated from an outdoor education undergraduate degree, so were used to being outside, and had played typical outdoor education games. As I have written elsewhere, disequilibrium was intentionally caused on the very first day of class when the professor was not in the classroom. He left somewhat cryptic instructions about how to seek and find him, outside of the building, and indeed off of the campus grounds. This was a marker that things were going to be different from what they had known, and I watched excitedly to see how they would react. Some students were clearly ready to go with a different approach, perhaps bored with the status quo or more used to leaving the classroom if they came from an outdoor recreation undergraduate degree. Many students were somewhat wary and seemed out of their comfort zone. They went along with the first group nervously and tentatively, while a few were more resistant, and sat in the classroom for some time after the others had left, though they eventually followed. I felt the disequilibrium myself, as I was supposed to be around to make sure everyone came, but be unobtrusive and let the students make their own choices. I wondered whether it was okay that the group had split into

two already, that some of them were anxious, that they might not listen to each other since they had not formed as a unit yet. And right on the edge of my discomfort, or even fear, was excitement and attentiveness to what was different and new. As I have already written, it started to rain as we got closer to where the note directed us, and I had a non-weather proof running jacket on, but have never been shy of getting wet. When we arrived at the location the note had specified, the professor stood at the other side of the stream we had been clearing the day before, when it was sunny and warm. The rainfall had swelled the stream into a small river, and then it really began to pour rain. I will never forget the experience of listening to his words cross the stream to our group, standing silent in the crashing rain, those of us without proper gear getting soaked to the skin. After the reading the professor invited us across the river, and one brave participant started to cross, sinking in the water up to her waist. Some participants were quiet, others yelping and laughing with the coldness of the plunge, all helping each other as we overcame the intentionally invoked disequilibrium to cross over to the professor's side. I saw it as a metaphor of crossing from something known and normal to something distinctly different. We needed each other to cross over, getting dunked and drenched from below and above. This was the first of many such crossings, such changes in perspective, all caused purposely by disrupting expectations, by experiences of things outside of what we had come to know. Later I came to think of this disruption of old expectations as causing the dispersal of old structures of understanding in favour of making room for newer, and more adaptive structures. As time went on I began to realize that the process of dispersal of old understandings was constantly occurring, and then reoccurring, as ever newer and more complex structures of understanding coalesced in participants, including myself.

I experienced disequilibrium in an early macro-model called Deer Ecology (Puk, 2010), staged at night in the same roped-off area of about 5 acres described earlier. I played the role of a wolf, along with the professor, while the other participants played deer. On either side of the staging area, there were cans of corn kernels, representing food, tied to a tree. The deer were split into two groups, half starting on each side of the staging ground, and on signal were to cross the staging ground, retrieve metaphorical food and then return to the starting side. We, as the wolves, were to hunt the deer, and if we caught them, take some of their food. It was night, and I was experiencing a wonderful feeling of excitement and trepidation, as I left my half of the deer at the border to get a short lead into the woods before they entered. This was different than any learning experience I had been a part of and so I was not in a comfort zone, and a voice inside me (fairly quiet) was wondering whether this was even okay to be doing. We had head lamps, but I left mine off as I wanted my eyes to get used to the dark. Suddenly, sounds were much louder, even my breathing sounded like a beacon, and so I slowed my pace to catch my breath and kept half of my vision downward to attempt to step on fewer dry leaves and sticks and so go more quietly. As the game progressed I found myself wanting to run less and use my sense of hearing to find the deer, sneak up on them, and take their food with a minimum of energy wasted. In the middle of the game, though, I ran into the other wolf and after a short, quiet discussion, it became clear that he had been the more successful hunter, and so my competitive juices began to run and I chased more deer until the end of the game. Once the whistle sounded to signal the end of the time, we all left the staging area and headed back to the meeting space to debrief. I talked to the professor and offered to retrieve the cans of food that we had left in the staging area. As I re-entered the area, this time alone, I felt more anxiety than excitement, more trepidation about being in the woods by myself in the dark. I switched on my headlamp trying to

make sure I could see the small paths, but this backfired as everything started to look different and I became disoriented. I started to move more quickly, not worried any longer about retrieving the cans of corn kernels, but instead just wanting to be able to find my way to the edge of the staging ground. Coincidentally, I ended up finding all of the cans before finding the way out of the woods. After thrashing around for several minutes in a mild panic, I calmed myself, partly by reminding myself that there was a rope around the perimeter, so that if I just walked in one direction, I would eventually come to an edge. I turned off my headlamp, waited for my eyes to adjust, and much more calmly started to walk the way I believed was toward the side. Soon I recognized the terrain again and was able to leave the staging area and get back to the meeting room without anyone realizing I had been lost for a time. It was an experience of disequilibrium I will never forget. An experience that led me to learn a lot about myself in terms of what results can occur depending on my different reactions to the anxiety that arises in the face of the unknown. An old structure of understanding dispersed and a newer, more useful one began to coalesce. However, this was only one manifestation of this process.

On a hike one day fairly early on in the course, our group stopped for a break beside a small lake that had tamarack trees growing on one side but not the other. The facilitator asked us to speculate about why the trees would grow on just that side, and participants began to speculate out loud. At some point one of the participants asked the facilitator whether anyone had come up with the right answer yet, and to everyone's surprise (including mine) the facilitator answered that he did not know the absolute answer, and in fact did not believe there was a knowable explanation, just that some answers were more probable than others. When I talked with him about the experience later, he said that he had made the statement knowing that it would cause disequilibrium, indeed that this was part of the point of raising the question, as disequilibrium is

a key ingredient for emergent learning. I could see that several participants were disturbed and that others did not believe that he did not know the "right" answer. I personally had not even considered that he did not know the answer, but after he denied knowing so that I finally believed it, I began to think about what I could find out about the phenomena once I got home, and later spent a considerable amount of time on the internet researching the tamarack and its preferred environments.

Another experience that upset participant equilibrium was our visit to the municipal dump. Most participants identified at least somewhat with the need for more ecological responsibility in our society, and so the group appeared duly impressed with the efforts taken by management to carefully divert leachate to a pond and away from groundwater, and to collect methane from the garbage which was used to create electricity. The manager that gave us our tour made it quite clear that there had been millions of dollars spent on development and equipment to divert and otherwise minimize the amount of garbage coming to the dump, to crush garbage to extend the life of that particular site, and to minimize the impact of leachate and gas emissions from the decomposition process. Instead, it was the presence of animals that disturbed participants. There were hundreds of geese in the leachate pond, swimming with their goslings, dunking their heads beneath the surface, eating and drinking in a toxic pool. Perhaps even more traumatic were the perhaps hundreds, at least dozens, of eagles roosting in trees along one side of the enormous garbage pile. It was unclear whether they were in the trees because they were waiting for us to pass, for a new load of garbage to appear, or for some other reason. I think it was the contrast between how participants usually perceive eagles - often alone, majestic and proud, and in unsullied environments. Here they were as numerous as a flock of gulls, waiting unashamed for literal table scraps, and surrounded by plastic bags fluttering in the scraggly trees.

The experience raised an existential "No!" in several participants that I talked to. They did not want their sense of an eagle's majesty marred by this picture.

Influences. The disequilibrium inherent in the emergent design approach, and ecological phenomena generally, sparked interest - often intense interest. As demonstrated in the data shared in the first analysis section regarding experiences of ambiguity and curiosity, and the descriptions of my and other participant experiences described above, patterns began to emerge as a response to disequilibrium. First, participants started taking a different approach to learning processes, and second, understanding became more complex. The disruption of expectations led to a dispersal of old understandings, whether about oneself, educational processes, or course-specific concepts. A vacuum was caused by this dispersal, which caused curiosity, that is, the desire to understand things in ways that the old understanding had not provided. Different ways of understanding coalesced out of these types of experiences.

As in the example of the dump visit, disequilibrium forced participants to recognize other realities. The most obvious reality was that our garbage does not disappear when the truck leaves the front of our house, and that the amount of garbage we send to landfill is deeply problematic for a number of reasons. But it also challenged participants to consider the concept of waste itself, and caused some to recognize that "waste" is really a human construction rather than anything real in the natural world. The eagles recognized food opportunities at the dump - food that humans had cast away as waste. In other words, such experiences caused participants to realize that there are other perspectives, other ways of looking at things than the ways they had grown unconsciously comfortable with. Experiences in the program pushed participants out of

their psychological comfort-zones, to think less simply. Old understandings dispersed to be replaced by newly coalesced and more sophisticated, useful understandings.

Students were also pushed out of their comfort zones, and into experiences that connected them with natural systems, in more physiologically-based ways, which is the focus of the next section. It is worth foreshadowing that in the emergent design approach though challenges may start on intellectual or physiological levels, influences on participants do not end there.

Living and learning on the edge. A key aspect of emergent learning is discomfort, which draws our attention on a basic and fundamental level so that we become focused on the reduction of that discomfort. This attentiveness heightens our memory of experiences and information related to the discomfort (Ackerman, 2004; Damasio, 2003). In this sense, discomfort is an excellent tool for focusing the attention of learners. In the current study, participants (including myself) were often uncomfortable, something I came to think of as being on the edge. The metaphor of being on the edge is fitting because though there was discomfort, it was generally not so great that it distracted from the learning, but at the same time got participants on our toes and alert to what was available in terms of learning. In the following paragraphs, as an example of the meta-theme "living and learning on the edge" a description of the experience of participating in the Solar-Energy-Web macro-model is offered, through reflections of other participants and my own, as well as through the observations of other participants made in my field notes. Some of the data from interviews and reflections regarding this macro-model have been shared in the Analysis I – Parts section above, but it is presented here as more of a whole in an attempt to represent the dynamic nature of the experience.

In the Solar-Energy-Web macro-model (Puk, 2010), participants were assigned a role (e.g., plant, herbivore, omnivore, carnivore, disease, Sun, Mack truck, hunter) and within the staging ground (approximately 5 acres of roped off, somewhat hilly, wooded area) had to acquire water tokens, sun tokens (if applicable), and hunted, and/or were hunted by, other participants. We played for over an hour, and by the end were exhausted on all levels. It has been an experience I have never forgotten, with lessons about the Sun's energy inscribed in memory through the many and moving aspects of my experience.

The roles we were assigned put us on the edge right from the beginning. As each participant was assigned a role, their reactions quickly followed - the carnivores whooped and pointed at the others at first, threatening to hunt them down when the game began. Those being threatened smiled as if uncaring, as if thinking "This is only a game, what do I care?" But you could see the nervousness in their eyes, but also the steeling of nerves in some, the beginnings of defiance. I was assigned the Mack truck role, meaning only the hunter or disease could kill me, and that I could hunt everyone else. The professor was to be the hunter, and suddenly with this announcement the carnivores quieted some, recognizing that they would need to look over their shoulders, too. At first, I decided that it would only be fair to try to play the role earnestly, and so though I would move quickly, I would not veer or turn on a dime to hunt others, but instead would try to behave as an impassive truck. This attitude lasted until I was shot the first time by the hunter, and had to give him some of my food and water. I needed to replace it then, and the only way to do so was for me to be ruthless, too; to take my place in the food chain, take my place in the competition for the Sun's energy. All of these preparatory steps and reactions I consider a part of the play inherent in emergent design. We were as-iffing in the assigned roles, and though some participants (including myself) were initially resistant to feeling ourselves into

the roles fully at the beginning, the game quickly drew everyone in until what occurred over the 90 minutes we were in the play area. Initial nervousness moved quickly into a melee of sprinting, chasing, evading, starving for oxygen, sweat, running through mud and water, and later soreness to remind us of the experience. If, as I have suggested, it was play that took us to the edge of learning, emotions and embodied cognition (including the natural environment) kept us there.

I entered the game area second to last (the hunter after me), and the first thing that struck me was the silence of the other participants. A few birds were calling in the distance, and a slight breeze rippled through dry poplar leaves that had not yet fallen. It was difficult to keep my steps quiet as the forest floor was carpeted with leaves that had fallen, though they were somewhat damp from a recent rain, and it was possible at times to skirt around big piles. But I wanted to move quickly, too, wanted to stay in front of the hunter, and also not give others time to get out of the truck's way. I was on the edge of fear and excitement, and stayed there much of the game, even though I well knew that we were in a simulation and there was little or no real danger. The smell of the damp leaves is interwoven with these emotion-laden memories for me, that and the sound of my own breathing, which I was constantly trying to quiet in favour of listening for the movements of others, both those that I was hunting, and the disease and hunter that were stalking me at times. Once, at the bottom of a small ravine in the centre of the game area, where there was some watery, marshy area, I found a bit of an overhanging bank, and so I tucked into it, and sat as still and quietly as I could. I wanted to run over the hunter, who had already shot me (he had a pair of mittens rolled into each other for weight that he could throw as a simulation of shooting, where I had to get close enough to touch in order to kill). I sat under the embankment for at least five minutes before I heard the sound of movement, and it was quiet and surefooted enough to make me believe it was the hunter. I began to rise, slowly, barely allowing myself to

breathe, watching to try and avoid crunching any leaves, and was able to see through the V of two trunks of a tree. The hunter appeared, creeping down into the ravine, looking the opposite way, arm cocked and ready with the gloves. I crept slowly forward, getting to behind the tree and waiting for him to move just a little closer so I could jump out and touch him. But just as I leapt out he heard me move and turned, leaned back and threw at the same time. I believed I touched him before the bullet got me, but he did not agree, and so eventually we agreed to go our separate ways without exchanging tokens. As I walked away, though, he started to follow me, and I realized he was going to try and get me again. I began to sprint, and he to chase, I went up the embankment on the far side, looking for one of the minimal paths that cut through new poplar growth, and found a small one, with the hunter right behind me. I knew, as a predator myself by that point, that once the chase is started, a hunter wants to finish it because it takes a lot of energy each time. Equally, though, I had seen in other participants that I had chased, and could feel that moment in myself, an incredible desire to get away, perhaps even more intense than the desire to catch. The path I had entered came to a dead-end but I continued, putting my arms up to try and guard my face from the young, whip-like, and sharp branches. The hunter was deterred from continuing his chase, and after being sure of that, I stopped and hunched down, starving for breath, with stinging sensations all over my body, trying to recover while also listening in case he had not really given up. Earlier in the game, I had easily caught a few omnivores that had evaded the carnivores only to run straight into my path. They had simply given me their tokens, too tired to run anymore, and I had felt somewhat sheepish about taking them. As I sat, recovering from my escape through the trees, I thought about what it must be like for an animal to experience that, and then the need to get back out, foraging for food and water, as soon as possible, to survive. Each animal needing to seek out the forms of the sun's energy

that they can consume, with more and more of that energy being required the larger the organism, and the more it needs to consume other animals in order to survive.

Influences. In our sharing and reflection on the macro-model it was clear, through the group's discussion, that the exertion of the experience had a great impact. But it was not only the physical exertion - it was equally the psychological and emotional exertion of having to risk the seeking of energy to survive while avoiding being eaten. The carnivores told me about their enjoyment of exertion and howling at the top of their voices early in the game, before they realized that these noises attracted me (the truck) and the hunter to their position. Then they spoke of being silent, stealthy, and all of the others agreed that this became one of their main tools of avoiding detection in general. It was clear in that time of immediate reflection that this was an experience not to be soon forgotten, and this was born out when I was conducting interviews later in the course and this experience was spoken of often.

Later when I was reflecting on the experience and reading other participants' reflections, one of the strongest impacts was a recognition of how separated humans are from a sense of being a part of a greater, natural system. We seldom see the connection between the energy exerted in work and the shelter and food it brings. I also realized that we never have to live with a sense of danger that something powerful might view me as sustenance, or that we might need to hunt down something simply trying to live to find sustenance. The macro-model experience caused a recognition that we are often divorced from a sense of being a part of a greater whole. It was only the emotional intensity intertwined with the physical exertion of running to survive, the experience of being on the physical, emotional edge, which re-connected us to a greater whole. Natural surroundings were vital to this too. In a sterile environment, we often cannot imagine

feeling like a part of a greater web. In the forest, the smells of damp leaves, the mud pulling at our shoes, the branches scratching at our faces - each of these physical interactions, and many others, were vital parts of our experiences of interconnection, though this latter piece really foreshadows the next section. It is important to note here that the dispersal of our old ways of thinking in favour of a rich understanding of being part of a much larger web of energy exchange, relied on physiological, emotional, and psychological aspects of the learning experience. The conceptual understanding that coalesced was not intellectual only, and could not have been, as the understanding itself emerged out of these other aspects of the learning process.

The embedding of information because of the richness of experience of being on the edge was also clear. After the macro-model, even before reflecting, we were asked to show our tokens. One of the main insights that came through this macro-model was that the majority of the sun's energy tokens ended up with those further up on the food chain. In other words, those that were consumed had a harder time amassing and keeping the sun's energy, which became concentrated as time went on with the consumers. At first those at the top of the chain hooted and hollered, feeling that they had won where others had lost, but then we began to discuss the use of energy in ecosystems, and the implications of such a top-heavy system. Human activities, including the consumption of meat were again discussed, and a deeper sense of the interconnection of all living things was re-visited. Questions were raised: What happens if those at the top of a system keep winning? What happens if those at the top of the system find a way to not really experience the outpouring of energy it takes to find sustenance, if their meat comes packaged and processed, the energy required to get it to the store in the form of the burning of fossil fuels? Our experiences on the edge, of risk-taking and success or failure, were a major factor in the coalescence of these questions and lessons into our awareness.

The ground of learning. As has been stated, the main classroom used by the facilitator in this study was the outdoors, and specific settings were selected with specific intention. Being outdoors was crucial because of the physically grounded experiences we, as embodied participants in the natural surroundings, had within it. The sights, smells, sounds, tastes and tactile experiences of being outside were, on a very basic level, a joy to participants throughout the course, but also in both literal and figurative senses, were the ground of our experiences that embedded learning into our bodies. It is hard to overstate the importance of the enjoyment witnessed in participants, simply being out in the natural world. The joys of sun on your face, a cool fall breeze through sweaty hair, the smell of fallen leaves and moss, the thrill of feeling one's body in full flight. At times physical experiences were not joyous, but were equally impactful. The wet, cold, heat, and level of exertion required caused discomfort at times, but these physical experiences, too, played a central role in learning being embedded in memory. In the first class of the term, for example, though the facilitator had sent everyone a letter letting them know that we would be outside the majority of time (sun, rain, or snow), there was an obvious excitement in the group about leaving the bricks and mortar classroom for the out of doors. There were multiple effects of using the outdoors as a classroom, and of us being embodied beings in the outdoors. Many examples of participant discussion through interviews and reflection on this theme have already been offered in the first section of this Analysis chapter. I have termed these effects "embodied transformation" which will be discussed in greater detail shortly. First, though, a description of one such experience is offered here, not as a separate and new theme, but as a dynamic and more whole representation of this pattern which was encountered again and again with all participants throughout the study.

During the first macro-model, the Salmon Run which has been described in earlier sections, there were many physical aspects that continue to root the learning of that model in my memory. To start, I will never forget my excitement on the day the facilitator and I set up the course by removing glass and sharp sticks from the river to make the space as safe as we could. Just going outside to set up, for what I considered to be my first real day of the doctoral program, was a revelation. I wondered to myself how I would ever go back to the classroom again to teach as I felt the warm sun on my face, and the cool breeze. I was in school, but able to move around, walked down through a forest trail to get to the start, waded with sandals into the shallow river to look for danger. I remember reaching down again and again in the water, meditatively and quietly as we moved up the stream clearing debris, thinking about the salmon run, the factors of the macro-model that the facilitator had described to me. Even now as I write about it I can go back to those moments, to some degree, because of these physical experiences, and thoughts about ecosystems, salmon, and predators are intermingled with the feel and smell of water, the joy of being outside to learn, and the curious anticipation about meeting the class and seeing how things would go.

The next day, as I have already described, the first day of class, was completely different than the set-up day because of the natural surroundings changing so radically. It poured rain all day long, the river was swollen, and I had neglected to get a good, waterproof coat as our introductory letter had instructed us to do. All of these physical factors play a major role in my memories of the event, and the subsequent learning I have kept about salmon ecology. The experience of being cold and sodden as we got acquainted and then organized for the macro-model will stay with me always, and I remember thinking about animals living in the wild and what it was like to be a fish in the river during a torrential downpour. Loud? Invigorating?

Negligible? Later, as the macro-model proceeded, I played a predator/fisherman role, and prepared upstream to catch as many salmon as I could. As they roared through the stream toward me, there suddenly was a different sense of their agenda than I have experienced in fishing in the past. Though I had learned before that to set my fishing activities based on ideas about what fish are doing during certain times of the year and day, I had never really thought about their agenda until seeing them represented in that macro-model. There was some remorse for catching the salmon that I did, and suddenly, an awareness of their need and effort to move upstream. Some participants were in full joy to be running like that, fully exerting themselves and loving the sense of their own power. Others were slower, appeared more afraid or had given up trying not to get caught. The water was much deeper and colder that day, and on the shore I could only guess how difficult it was to try to trudge through.

Influences. When I remember the sunlight on skin, wind through hair, burning of muscles through exertion on land and in water, I think about chasing salmon and their need to go up river for spawning, the way they bring life inland for many predators, and the way their nutrients are spread through the forest through their defecation. My learning, and the learning of all of the other participants, was rooted, through the outdoor macro-model learning approach, right in our bodies. Perhaps it would be even more accurate to say that the learning is grounded in the physical experience of interaction in natural surroundings. Old understandings, based usually only on intellectual aspects of these phenomena, dispersed, and new, rich, embodied understanding emerged and coalesced. The nature of these memories, embedded in the sensory realm, also means that they do not disappear with lack of use as much intellectually acquired knowledge seems to do (Nyberg et al., 2002). We were transformed in an embodied way, and

therefore the learning became part of us, rather than being disparate knowledge easily lost. In short, the interaction we have as embodied individuals with natural surroundings leads to the rooting of learning in our very bodies; this type of learning lasts, and coalescence of new understanding goes far beyond the intellectual (although it includes it). The term that has emerged for this type of learning, through the course of research and analysis, is embodied transformation, which reflects the coalescence of my own understanding of the phenomena I witnessed and experienced.

Embodied transformation will be discussed further in the final chapter of the dissertation, especially when introducing and describing the main model that emerged from this research. Next is the final subtheme to the Analysis II – Wholes section of this chapter, which explores key features in the process of embodied transformation which have been alluded to but now become the focus.

Facets of a crystal. Participant understanding of key ecological concepts emerged over time, over successive experiences of many macro-models and other course activities throughout the study. It was apparent that some concepts simply could not be understood right away, on first encounter. Instead, the understanding of complex ecological concepts required time and multiple exposures, through different but complimentary learning experiences. In other words, the dispersal of old, and coalescence of new, understandings of key concepts did not occur all at once, but rather should be seen as a longer, less exclusively linear process. Learning of these concepts instead occurred through the recursive process of complex systems, where self-same patterns occur again and again while at the same time the system gets more complex (Davis et al., 2008). I will describe several examples of this recursive process that led to a complex or

mature understanding of threshold concepts, and then will finish with a short description of influences, including my own learning through recursion in the dissertation process.

Early in the course, when riding bikes, we stopped briefly by a storm-sewer out-flow grate that emptied into a small river. The facilitator asked everyone what they saw. The obvious was named, and then a few students tentatively suggested that this grate might be related to the neighbourhood we had just ridden through. The facilitator encouraged people to say more about that, and a few participants discussed the potential for pesticides and herbicides to be washing into the river from the neighbourhood or that the outflow with rainfall would be greatly increased because of the pavement blocking more widespread absorption of rainfall into the ground. I thought these answers were excellent, as I had felt fairly blank after the question was raised. It was not until much later in the course that, after being exposed many times to these sorts of intersections between the natural world and human development, participants (including myself) started to think more consciously about human-nature intersections, and our overuse of resources in general. This early experience was deepened retro-actively, by later experiences, such as the one described next.

We were challenged to examine the effects of our massive use of plastic, and how this intersects with nature during the Nurdles: Plastic Poisoning (Puk, 2010) macro-model, which was one of the macro-models that participants reported impacted them the most. Nurdles, or micro-beads, are tiny (5mm long or less) plastic pellets that are used in manufacturing (melted down and formed into products) and as exfoliants in bodywash, shampoo, toothpaste and other like products. Because they are so small, they are not picked up by collecting screens in sewage treatment plants, and so collect in rivers, lakes, and the world's oceans. The pellets attract toxins such as PCBs and DDT, which adhere to them and then are ingested by birds and animals

(Tanaka et al., 2013). In the Nurdles (Puk, 2010) macro-model, the playing area represents the Pacific Ocean. Participants played humans, albatrosses, an otter, fish, and zooplankton. There were two food containers on either shore (side of the playing area) which contained symbols of healthy food and nurdles. Zooplankton ran from side to side, gathering food/nurdles from the containers, keeping their food if they could remain untouched. When a fish touched the zooplankton, they got two pieces of food from them. When the otter and albatrosses tagged the fish, they got two pieces of food from them. The humans threw sponge balls from the shore and if they hit a fish, otter or albatross, they would receive three pieces of food. At the end of the game, the participants tallied up how many pieces of healthy food and how many nurdles they had collected. It became clear that it did not take long to amass a large number of nurdles, because they are being ingested alongside food. Once ingested, nurdles can cause choking or digestion problems, but also help to concentrate the hitchhiking toxins as they move up the food chain when larger animals (including humans) ingest smaller ones (Tanaka et al., 2013). The manufacture and use of these tiny plastic pellets has a serious impact on ecological systems, and humans as a part of these systems. After the session, I heard a number of participants says things like "I'll never drink from a plastic bottle again," and "we really need to stop companies from using so much plastic packaging," and "why are cosmetics companies still allowed to use this stuff?" An abstract idea became a concrete reality as participants looked at the collection of nurdles in their hands following the macro-model. Their bodies spoke of the effort of participating in the food chain, only to come to the end of what should have been a successful hunt full of plastic and toxins. The manufacture, use, and recycling of plastic, which had seemed rather simple (you buy products packaged in plastic, discard the plastic in recycling containers, the plastic is re-used) was revealed as far-reaching and devastating through the mirroring process

of the Nurdles macro-model. A similar awakening regarding the intersection of human activities, the use of energy, and the natural world, occurred through the Pop-Can macro-model, which is described next.

The Pop-Can (Puk, 2010) macro-model seemed to help participants put together the experiences that had been going on through the course around human-nature intersections and overuse of resources, gathering a deeper and more complex understanding of the concepts. Briefly, the macro-model has teams of four participants starting with a route that represents the manufacturing process of a can of pop, from scratch to market. At each of 21 stages, the group must record the ecological costs of that stage, but a member must also return to the start to retrieve a ball that represents these ecological costs. Each time the team changes countries they must carry an additional weight to represent additional ecological cost, so that they feel very physically tired by the end of the route, which is a representation of the energy required in this process. After they had participated in this macro-model, participants seemed to suddenly grasp that our whole model of globalized trade creates a hidden ecological debt (Puk, 2010).

Afterward, we spoke as a group after about the connections between this macro-model and the visits to the dump, the recycling plant, and several other macro-models including Nurdles. It was as if this macro-model galvanized an understanding of how recycling and reuse, though perhaps noble in intent, are a part of globalization processes, and therefore are processes that contribute to the overall ecological debt we are incurring on a daily basis. We sat, sobered, and spoke about how we would not forget the energy use, the exhaustion. This threshold concept, though, required time, required nurturance with a variety of experiences that pointed to the same complex truth. It took several experiences to disrupt and then disperse our simpler, less connected understandings of these different phenomena. Re-visiting the concept of ecological

debt again and again, through different yet related experiences, led to the coalescence of a whole new understanding of the concept, and the ways that seemingly disparate activities are actually deeply interconnected.

Another example of recursive reflections leading to emergent learning was in the use of macro-models/emergent design itself. Though the participants in the study were in their professional year, and many had been exposed to a variety of modes of experiential education in their past degrees, it took a significant amount of time before many of them began to consider how the very experiences they were having in our class offered lessons about how to approach emergent facilitation, and by extension, ecological education in their future teaching practices. In fact, early on some participants complained that they were not learning about teaching at all. On one walk back from a macro-model experience early in the term, I overheard one participant saying to the other "The macro-models are really fun, but I wish he [the professor] would start telling us how to teach environmental science. Our geography prof just gives us the lesson plans." At the time, because I had already done a lot of teaching, I smiled to myself, thinking about the fragility of the illusion that lesson plans will make everything okay as a teacher. It was like they were missing what was right in front of their faces, but I also knew it would not help for me to point it out. They needed a new consciousness about teaching to emerge before they were going to be able to really see what the professor in our class was doing, and learn from it in terms of their own teaching practice.

As the course progressed, and the disequilibrium of the approach consistently disrupted their expectations, I started to notice some participants consciously observing more about what the professor was doing. They began asking each other, and me, why he was doing what he was doing in particular moments, why he sometimes participated in macro-models and at other times

faded into the background more, why he sometimes initiated some reflection and at other times stayed quiet. There old conceptions of education were beginning to disperse, and new connections being made, though it was tentative at first. I avoided saying anything out loud to the participants about why the professor did or did not do things, and instead asked to hear their ideas, and was keen to observe this process of growing conscious attention to his practice, with their emerging thoughts about how it might (or might not) apply to their own. An acceleration of this process occurred when it was time for the participants to design and led their own macro-models in pairs. Suddenly all of them were quite actively and overtly discussing what had worked for them in past macro-models, what they wanted to incorporate in their own and why. Their understanding of how to use an emergent approach to teaching was beginning to more consciously coalesce. It was fascinating to listen to their differing thoughts about what makes a macro-model work or fall somewhat flat, with some focusing on equipment, others on informational content, and others still on their own role versus participant roles and how explicit instructions should be at the beginning of the macro-model. Even more fascinating was observing the macro-models they had designed and participating in some of them. The principles that have been extensively described regarding the emergent design process at the center of my study were fully present in the student macro-models that worked, that is, they were embodied and in nature, were engaging and caused us to have physical and emotional experiences, allowed us to interact with objects and each other and for learning to emerge, and involved human and the natural world interactions. The student macro-models that did not work as well tended to include more rigidity in rules, too much information being pushed onto participants especially early in the process, and had a lack of activity and interaction with each other and the natural

world and objects. Old understandings in these latter students had resisted dispersal and so an understanding of how to implement an emergent approach did not coalesce.

Influences. In terms of this discussion of recursion, then, there were at least two influences that occurred because of the revisiting, sometimes intentional, sometimes spontaneous, of key course concepts and themes. The first was the deepening of the understanding of key ecological concepts. Multiple and varied exposures to experiences caused participants to revisit and deepen their understanding of phenomena through a process of dispersal of old and coalescence of new and more complex understanding. We needed to look at many facets of the crystal, and see the same truth reflected back, deepening our awareness and understanding of it each time.

The second layer of influence caused by recursion (though not totally distinct from the first) was the change in participant approaches to teaching and facilitation. It was only later in the course that I had many interactions with participants who were talking about how and what they would be taking from the course into their future teaching activities. A number of the participants started to discuss how they could use macro-models in subjects other than ecological education, brainstorming with each other about lessons for teaching English, other hard Sciences, and History. Though participants discussed parts that they felt might or might not fit other subjects or their own teaching style, all of them had moved into a mode of reflecting on the experiences they were having in the macro-models in our course, and considering what they wanted to take with them. No longer were they wishing for lessons to be handed over, and no longer did they subscribe to a prescriptive approach to their own teaching intentions. Instead the emergent concept of experiential reflection and integration about teaching practice had coalesced

for them, and the old prescriptive approach had dispersed. The emergent design approach first held up a mirror to nature through macro-models and other processes, and then participant experiences of nature and their thinking about how to teach ecological concepts reflected back the emergent design experiences they had been having, and then they held up an emergent design mirror in creating their own macro-models, and so on. Facets of a crystal.

Finally, there is one more layer of recursion observed. The concepts of complexity and emergence have been revisited in my own doctoral process again and again, through reading, discussion, experiences, and writing. Each time I revisit them, during and after each recursive reflection, I find my understanding of the concepts changed and more complex. Old, less useful, narrower views on the concepts have dispersed over time. Newer, more adaptive, more interconnected understandings have coalesced. I now think of the two sections of analysis that are almost complete as a method of looking at different facets of the same crystal, each a slight turn, to see the concept of emergent design from a different angle. As I have already written, my sense of how I could study emergent design has changed substantially from when the study began. And because of this process of recursive reflection leading to change and increasing complexity each time I revisit the concepts, I now know that my understanding of these concepts will continue to change and grow as I re-visit them going forward. This dissertation itself is an artifact that represents what I have been researching, that is, a complex process of emergence occurring again and again. I had not realized, initially, that my doctoral process was a facet of the study when setting out to understand emergence in complex systems, which was likely quite naïve. But this reflects the recursive principle, as complex systems have patterns of self-same emergence in their layers and across time.

Summary. The analysis of the qualitative data collected in this study, including observations of participants, field notes (including descriptions of my own experiences), artifacts (including the dissertation itself), and interview responses, has been an extensive undertaking and has yielded clear, if complex, findings. Several key aspects and dynamics of emergent design, and participant experiences evoked by this approach, have been identified and extensively explored. A brief summary of findings is warranted here.

The emergent design approach that I have studied is purposeful, in that it sets parameters through processes designed to have participants encounter specific concepts and themes from multiple perspectives, many times, and over a period of time, and that these encounters involve a great deal of movement and interaction with others, and occur generally in natural surroundings. The facilitator intentionally causes disequilibrium, challenging participants to live on the edge and get involved in the process of understanding the complexity of the world. Embodied transformation in participants included changes in perspective and action through physiologically, cognitively, and emotionally stressful encounters with the world. Embodied transformation involves the ongoing deepening of engagement with, and understanding of, the complexity of the natural world, human activities, and the intersections between the two.

In the final chapter of this dissertation, I further and more fully amalgamate what has been described and analyzed, offering a model for embodied transformation.

Chapter 5: Discussion

Overview

In the following chapter, major findings of the study are shared under the three headings of "Engagement", "Embodiment", and "Complexity". As these major findings are discussed, they are also situated in relevant bodies of literature. Briefly, the aspects of engagement evident in participants were; disequilibrium, discomfort, challenge, curiosity, and play. The discussion regarding embodiment includes physiological, emotional, and psychological domains of learning experience, and the nature of concept development that occurs when these domains are invoked. Finally, findings connected to complexity theory and thinking will be summarized, including discussion of the interaction of agents, emergent change and increasing complexity, and the recursive, spiraling nature of learning and change in a complex system. A visual model, representing the overall phenomenon of embodied transformation, will then be presented (page 214). The model, which itself has emerged through the multi-level analysis of data presented so far, is a visual representation of the dynamic, complex process of growth in conceptual understanding through embodied transformation. As has been demonstrated and will be highlighted in this chapter, growth in conceptual understanding should be understood to include physiological, emotional, and psychological, as well as intellectual, domains. My hope in this final chapter is to paint an overall picture, but not a static one, though this is challenging in a written work, and it will of course fall short of the actual experience. This will be followed by my recommendations for educators, future research in this area, and the administration of education. Overall conclusions about embodied transformation and emergent learning and research will close the dissertation.

Engagement

Puk's (2010) emergent design starts with the unexpected, intentionally, to cause a sense of disequilibrium. Participants in the study, including myself, were often surprised by the next requirement, were pushed out of our comfort-zone, and frequently (especially early on) felt psychologically uncomfortable. This is quite different than traditional approaches where classrooms have reliable 90-degree corners, classes occur in the same place each session, and students are often required to do nothing but sit still and pay attention. Bjork (2013) demonstrates that "desirable difficulties" led to deeper forms of learning. Running into the unexpected leads students to process the situation more deeply, which leads to better recall later because of this level of processing. This finding suggests that students do not do their best learning when they feel totally at ease, but rather when interest is peaked because something new is being presented and expectations or beliefs based on past experiences are challenged. This was clearly demonstrated through my research where disequilibrium led to the dispersal of existing understanding, which is a necessary state if there is going to be room for changes in structure, but also sparked intense curiosity to more deeply understand things. As Maturana and Varela (1987) suggest, on the neurobiological level this dispersal of old understandings likely has to do with the connections and activity between neurons. The function of disequilibrium, then, is to challenge and disrupt existing structures, which leads to their dispersal, which then allows for new understanding to be developed, often at a level of greater complexity.

In emergent design, after disequilibrium has disrupted existing understanding and sparked curiosity, Puk's (2010) emergent design parameters allow for discovery through interaction and connections with past and future activities, but these parameters do not prescribe outcomes and therefore allow for learning to spontaneously emerge. The parameters often

include roles in macro-models that participants play, but also might include trips, discussion topics, or even open space around a campfire or bus rides where spontaneous reflection on experiences often occurred. The emergent design facilitator, then, plays the part of setting the size of the gap and holding the knowledge/perspectives that the learner does not yet have (Vygotsky, 1930-1934/1978), but trusts that the unknown, the gaps, will spark curiosity in the learner, which in turn will pull them into the experience. This is quite different than traditional classrooms in which sign posts are set up along a linear path and students are metaphorically guided by the hand each step of the way. In this sense, the emergent design facilitator must take what may seem like an enormous risk that students will get curious, get engaged, and will learn at least some of what was hoped for from the experience. Jörg (2004) suggests this is simply the facing of educational reality in the sense that productive learning experiences always involve unpredictable inter-influential interaction. We know, from the literature, that curiosity is sparked when there is a dissonance between what is known and what is being encountered (Berlyne, 1960; Kashdan & Silvia, 2009; Litman, 2005; Loewenstein, 1994; Piaget, 1969). We are intrigued by what we do not know, as long as the gap is not too large (Csikszentmahalyi, 1990) and/or there is someone there on the other side of the gap who does have a grasp on the possible understandings that are available in a given learning situation (Vygotsky, 1930-1934/1978). Therefore my findings show that the emergent design process is tapping into natural processes regarding the sparking of interest. Trusting that this is a natural learning process may make the risk seem much less great for facilitators.

And what is the learning process that follows disequilibrium, the dispersal of old understandings, and the sparking of curiosity? In emergent design, the data shows that a great deal of learning occurs through play, which as I suggested in discussing the theoretical

framework for this study can be seen as a central and natural form of learning in animals, including humans (Bjorklund, 2006; Pellegrini et al., 2007; Spinka et al., 2001). Emergent design sets up repeated experiences which are both fun and allow participants to go through the process of as-iffing in situations and roles that are often unfamiliar. Though more will be said about this in the next section on embodiment, for the moment it is enough to say that fun, of course, is engaging, and we know that engagement is a good thing for learning (Kinzie, 2010). One sign of this is that I do not remember any students that were repeatedly absent from the class, which is something I have not witnessed before in a university or college setting. Many participants told me that they looked forward to that class all week, that it was a huge and welcome departure from the norm. I felt the same. But we know that play goes further than the crucial effect of causing fun. As-iffing has been shown to be the central learning tool of children (Dansky & Silverman 1973; Piaget, 1951; Vygotsky, 1967) and animals (Burghardt, 2005; Pellegrini et al., 2007). The opportunity, in non-life threatening circumstances, to try out and practice roles is what allows animals (including humans) to develop skills that we need in the real world, and perhaps is the process that underlies ways that we continue to learn more advanced skills, like language and reasoning (Reynolds & Jones, 1997). In other words, when we are thinking about novel situations, about challenges and problems in the world, about how we will function in certain situations and relationships, about how to reply to a line of questioning, we are as-iffing in our minds. We are playing out the possibilities before acting, before responding. We are imagining future scenarios depending on possible actions. And so the use of playing roles as a central activity in emergent design taps directly into this fundamental and natural process.

As-iffing also causes us to see things from different perspectives, because we are playing out what it is like to be something else than ourselves and considering the effects our actions

might have on the other. And through presenting the unexpected and playing, rather than instructing, participants are challenged over time to recognize that things are not always predictable. Instead of simply trying to intellectually understand (or often just memorize for tests) a concept, for example, emergent design pushes learners to start asking questions like "but what does it sound like, smell like, feel like?", or "how would some other part of the system experience this same thing?" As Gordon (2006) points out, the world does not present things in pre-packaged, expected ways. Students must get ready for uncertainty, change, and complexity. This requires that they learn more than cookie-cutter definitions of concepts, but rather that their conceptual understanding takes many perspectives and contexts into account, and that this understanding is connected to other related concepts that are likely to be in play in real-world situations (Åkerlind, 2008; Gabora et al., 2008). I was most struck by the value of this aspect of emergent design when participants, as discussed in the analysis section, were required to design and facilitate their own macro-models. Watching them shift from initial discomfort in not knowing how to apply what they were learning in the course (because it was not laid out for them in easy lesson plans as was occurring in other courses) to full and creative application of their own take on the macro-model approach was very telling. Having come through the discomfort, having stayed with the process, led many to find novel and inventive ways to engage their peers. I imagine that this ability to hang in through discomfort has continued into their teaching careers. The experience of setting up the proper parameters to disrupt initial expectations, the sense of fun, and playing multiple roles, was revisited again and again through the research process. These aspects of engagement contributed profoundly to the dispersal of old, and the coalescing of new, understandings. And these new understandings were not limited only to the concepts being studied at a particular time; the process also developed an ability to

experiment and be creative in novel situations because it was not prescriptive (Gordon, 2006). Similarly, engagement was not a one-moment, or one-class phenomenon, but instead was inspired by the first experience of disequilibrium in the course, and continued through an ongoing process of dispersal of old understanding, the stimulation of curiosity and invitation to play within set parameters, and the coalescing of new understandings with ever-increasing complexity.

It is clear from the research literature, and a long history of educational philosophy, that engaging students increases the positive impacts of learning (Christensen Hughes & Mighty, 2010; Boyer Commission, 1998; Dewey, 1938; Kinzie, 2010; Knowles, 1980; Kolb, 2015; NSSE 2010). We also know that less lecture and more activity is good for engagement in the classroom (Christensen Hughes & Mighty, 2010). My research as a participant-observer in Puk's (2010) emergent design model gave me the opportunity to see and experience what is going on from the inside in terms of learning through engagement, and it was profound. The stimulation of the natural learning processes of curiosity and play, through causing disequilibrium and setting up appropriate learning parameters, drew participants into deep engagement. This level of engagement led to intense and influential experiences that dispersed old understandings and coalesced more complex and useful understandings of key concepts. Next is a discussion of embodiment which provides another perspective on the nature of the transformation that occurred in participants while fully engaged in the emergent design approach.

Embodiment

Embodiment is at the center of the emergent design approach, as a crucial component in the transformative types of learning to which the program aspires, including the development of

conceptual understanding, discernment, complexity thinking, and positive changes in behaviour within our ecosystems. The transformative learning and growth that occurred in participants relied not just on their physical presence and activity, but also on the context of natural surroundings and interaction with peers. In other words, it was not just that we moved around a lot and had intense physical experiences, though this aspect was integral to our learning, as has been described in the analysis chapter. Rather, natural surroundings and interactions with each other were vital aspects of embodiment, too.

The combination of these features of the emergent design approach (outdoors in natural surroundings including sensory inputs, physical exertion, emotion, and contextually congruent settings) led to embodied transformation. As has been thoroughly demonstrated, the emergent design approach is highly stimulating of physiological, psychological, and emotional, as well as intellectual, aspects of experience and growth. The sensory stimulation of movement and interaction with other participants and the surrounding environment played an especially significant role in the macro-model components of the emergent design process. Touch, exertion, exhaustion, non-verbal interaction–participants named all of these physiological experiences repeatedly when asked about their learning experiences, and they were central in my experience of the program as well. Emotions and feelings were also integral components of an embodied experience for participants, with excitement, fear, confusion, elation, frustration, and serenity and other feelings variously experienced and named during the study. As Damasio (2003) suggests, emotions are first a physiological experience which are apprehended by the brain and then an associated feeling consciously experienced, which is the bedrock for all of our thoughts. Thoughts with higher intensity of feeling at the base are more likely to be remembered and be

meaningful, and therefore a learning process that can stimulate this type of intensity is more likely to lead to these types of desirable outcomes (Coello & Fischer, 2015).

When discussing Mezirow's (2000) transformative learning in the early parts of this dissertation, I suggested that it was fundamentally intellectual, and therefore not fully aligned with embodied cognition theory research. What I observed in the emergent design approach has led me to combine the terms into the concept of embodied transformation. Embodied transformation goes beyond the learning of information or even the development of a reflective, critical approach to learning. While including these aspects of learning, embodied transformation also includes physiological, emotional, and psychological aspects of experience and knowing of material. It involves the whole being, and more than that, the history of that being within their surroundings, and therefore impacts how they will interact within their surroundings going forward, with more and more complexity and sophistication being the hallmark of having tapped these natural, autopoietic processes. Though the details are still areas of contention in terms of the embodied cognition literature, Calvo and Gomilla (2008) are clear that we can no longer justify the reduction of cognition to simple rational, intellectual processes. Instead, research shows that the sensory apparatus of the body, and the emotion/feeling and motor aspects of cognitive processing, are just as important as factors in cognition as the rational, executive functions of the pre-frontal cortex (Coello & Fischer, 2015; Shapiro, 2014). Maturana and Varela (1987) suggest that the body and all parts of the brain (not just the parts responsible for conscious reasoning) are integral aspects of the autopoietic processes that allow an organism to maintain a coherent structure. In other words, cognition is a dynamic, multi-layered but cohesive process, which includes physiological, psychological, emotional, and rational processes. My research supports these findings and extends them into the realm of learning in higher education.

The simple and yet profound effects of the smells, sounds, sights, and tactile experiences of being outside in natural surroundings cannot be over-stated. Though already included in the above paragraphs somewhat, it is important to emphasize how central the natural world was in terms of the transformative processes described in this study. As extensively discussed in both sections of analysis, being outdoors and interacting as a part of natural systems was highlighted again and again in participant interviews and reflections. The positive impacts of spending time in the natural world is an area of great growth in terms of research, with an abundance of recent studies showing a wide variety of positive effects from simply spending time in nature (Dadvand et al., 2015; Nowak, Hirabayashi, Bodine, & Greenfield, 2014). More specifically, early evidence suggests that cognitive development in children is enhanced simply by being in natural surroundings (Bratman et al., 2015). Ballantyne and Packer (2009) go so far as to say that all ecological education should be partially evaluated on whether the natural world is a significant part of the teaching and learning environment. Their research demonstrated that teaching and learning time in the outdoors is a crucial dimension for the development of ecological literacy. Maturana and Varela's (1987) concept of structural coupling is useful here in understanding why the impact of being in natural surroundings is so great, and by extension, why learning in these settings had such profound effects for participants in this study. As humans, our biological systems have developed over thousands of years within what we, in the modern world, call nature. Until relatively recently in human history almost all learning would have occurred and been applied in a dynamic process in these types of natural surroundings, and so it follows that our biological structures are designed to be congruent with natural surroundings. This structural coupling developed through thousands of years of dynamic interaction between organism and environment. Structural adaptation to new, modern environments has without doubt changed us,

as is natural through adaptation over time. But in terms of biological change due to ecological pressures, there has not been sufficient time to change much more than a tiny amount, and therefore in Maturana and Varela's (1987) conceptualization, natural surroundings would still provide much more congruency that human-made ones. Since we are adapted to survive in natural surroundings, that is, we are structurally coupled, we are much more likely to be fully engaged there, and more likely to be able to absorb and be positively changed by experiences in these environments. Our systems are adapted to the sights, smells, sounds, and feeling of natural surroundings, making us much more likely to be ready for the challenge and adaptation that leads to higher levels of complexity.

The idea that cognition (and therefore learning) is context-dependent is also supported by Wilson (2002) who shows that knowledge is only meaningful as an embodied being in particular situations, whereas abstract bits of information without a home are essentially meaningless. Puk's (2010) emergent design approach puts participants in situations that simulate real-world concepts and situations, and the data I collected showed clearly that these participants derived meaningful learning because of this context. That the classroom was also almost always outdoors more deeply layered the experience of context. Learning about ecological concepts and issues in natural surroundings means that participants were being provoked to shift their understanding in the actual ecosystems being explored. Participant autopoietic processes were not only full and rich in terms of detail, but the understanding that emerged was based on being in the surroundings it was about, and so was congruent.

The research findings, then, clearly indicate the vital importance of embodiment in transformative meaning-making. Features of embodied transformation will be re-stated in the recommendations section at the end of this chapter. The discussion turns now to complexity.

There have already been complexity terms and language employed in the first two subsections above, which is unavoidable as both engagement and embodiment are features in complex systems involving learning. This type of recursion, of course, is itself a feature of complex processes (Davis et al., 2008; Jörg, 2004), and so it is time to return and focus again, one last time, on complexity as it existed in this study.

Complexity

It is clear that the emergent design model I have studied is a complexity approach to teaching and learning (Cochran-Smith et al., 2014; Davis & Sumara, 2007; Kauffman, 1995; Mason, 2008, 2009). The way that macro-models (intermingled with other processes) are set up meet all of the criteria for a complex system. Participants, materials used in particular activities (e.g., rope, energy tokens, barrels, pails, t-shirts), and the natural surroundings themselves can all be seen as actors in the system, and emergent design is set up to promote interaction between actors. The parameters that are set at the beginning of each macro-model, for example, roles the actors will play or constraints they play under, can be considered history, which the actors also bring to the system, in that these roles and constraints are based on natural phenomena and so are intended to resemble some of the character that the corresponding parts of natural systems bring to natural phenomena. Interactions between macro-models cause actors to be changed, and for participants, this is most often a change that includes learning about a particular phenomenon from a number of perspectives and in an embodied fashion. Through this process, participants become more complex, and the class as a whole system becomes more complex. Actors and the class as a system take this learning, this history, into the next macro-model or other emergent design activity, and become more complex, and so on, and so on. Such increase in complexity is

unpredictable in specific outcomes but is shaped by the actors themselves and the parameters within which they interact (Jörg, 2004). As Åkerlind (2008) and Gabora et al. (2008) contend, conceptual understanding is best understood as a correspondence between an individual and the context they are in, a relationship that includes their history, the history of all other actors in the situation, and the history of the situation itself. Maturana and Varela (1987) assert that we arrive to any situation of interaction with others and our environments with our histories informing our approach. All actors in the situation, including organisms and environment come adapted, in terms of the autopoietic processes, based on their history. In other words, we have been shaped by past experiences, in terms of how we self-organize, and our future autopoietic strategies will be based both on that history, and by what happens in the present. This is crucial to understand in any learning situation, as change is therefore both unpredictable and dependent on the histories students (and facilitators, and environments) bring with them (Jörg, 2004). Growth occurs through provocation of each other that is within the boundaries of what we can adapt to, and the whole system becomes more and more complex the more there is this kind of provocation and change. All members of the system carry the history of these complexifying experiences forward with them into new situations, as well. This was a main pattern in my research of the emergent design approach, that is, that members and the system as a whole became more complex in an ongoing way through ongoing inter-influential activities.

Another related central pattern of the emergent design approach, in terms of complexity, was the recursive nature of learning that I witnessed and experienced. As represented in the model of embodied transformation to be described shortly, participants circled back to old understandings of concepts and updated them based on new and related experiences of interaction with each other and their environments. Through the constant interaction with others

in simulations of natural systems (conducted within the context of natural systems as classroom) individuals, but also the group as a whole, self-organized again and again into continually more complex entities. The increasing complexity reflected a progressively more sophisticated understanding and symbiosis with each other and the surroundings, so that conceptual understanding became more and more adapted to the environments participants found themselves in, and more and more flexible in availability to apply in related settings and situations.

My research demonstrates two things that underpin and are related to this phenomenon. First, participants did not even seem to recognize the existence of some concepts until encountering them in the real world. This was true for the experiences described in the recursive reflection meta-theme in the analysis section. The simple naming, defining, and memorization process which typifies traditional prescriptive educational processes, that is, just talking about concepts in an abstract manner, does not seem to allow us to recognize them in the real world. Participants did not see intersections when we looked at the grate. They did not see greenwashing when at the recycling plant. Learning about a complex phenomenon appears to require encountering it, seeing it, hearing, smelling, touching, tasting it, and being affected by it over time and through many varying, yet related, encounters. Second, once such conceptual understanding does start to coalesce, other thoughts, questions, and connections to related concepts seem to emerge at the same time. For example, when participants started to grasp the concept of human/nature intersections they began to see them everywhere (which, of course, they are), but they also started to notice other complex phenomena too. After the Pop-can macro-model, students began to think about other products and their manufacturing and shipping costs, and connect their understanding from that particular macro-model to other experiences in the

course, such as the Nurdles macro-model and the trip to the recycling plant. It is as if the understanding of one complex phenomenon coalesces the ability to recognize and understand complexity in other places, or perhaps begins to push learners to think in complex terms about other phenomena more generally.

One of the key findings of my research is that as conceptual understanding grows, dispersal indicates a lessening of simplistic understanding of concepts in general. Rather than understanding concepts as individual, stand-alone entities, part of the coalescence of complex conceptual understanding is the emergence of an awareness of the interconnected nature of concepts in general (Åkerlind, 2008). Participants began to look for connections, for other places that threshold concepts might also apply, for other situations in which their understanding could help them adapt and thrive (Myers, 2010). This occurred for me through the dissertation process as well as through participation in the emergent design program. My own understanding of complexity and emergence dispersed and coalesced again and again in a more and more complex fashion. Crucially, then, the emergent design process leads to a complex level of understanding of complex concepts, and influences behaviour in a manner that abstract, information-transmission of concept definitions does not. The emergent design approach leads to complexity thinking as a result of engaging in the processes which typify complex systems.

Finally, another main finding is that emergent design itself reflects the naturalness of the systems it simulates, in that through the use of macro-models and other processes that are conducive to emergent learning, a natural learning process is being tapped into. The fact that complexity theory, with its description of emergent processes, emerged itself from biological sciences supports this perspective, as does Maturana and Varela's (1987) theory about the biological roots of change and growth. In other words, the reason that emergent design and

natural phenomena hold up mirrors for each other is that emergent design is a natural phenomenon, as the type of interaction it promotes with and within natural settings quite naturally produces emergence. So emergent design requires us to tap into, or re-discover, what is already there, rather than create something brand new. This is clear from the discussions on engagement and embodiment above, but also rests on my observations of how the emergent design process matches the features of complex systems (Davis & Sumara, 2007; Kauffman, 1995; Morin, 2008). However, one cannot just say these words to another and be understood. Instead, it must be discovered by each learner, in their own time, through recursive, reflective, emergent, and fully embodied experiences of their own.

Kolb (2015), after decades of examining experiential learning, suggests the symbol of a spiral shell to represent this process of change and growth, which has similarities to my model of embodied transformation. Kolb's (2015) spiral shell represents a recursive circling back over and through similar contexts and interactions, and so each turn of the shell is patterned in shape, but not quite the same and not in the same space. Spirals further along the shell are built on the history of older ones, and an experience of the whole shell is required to understand the way the organism has organized itself in its environment, and so the shape represents the history of the organisms experience within its environments. Similarly, the embodied transformation model shows growth in conceptual understanding over time, through re-visitation of key concepts many times, and the ongoing dispersal and coalescence of understandings. Our first encounter with a complex concept does not lead to full, rich, and complex understanding, but at the same time such understanding does rest partially and originally on that first encounter. In this sense, it is important that I have left artifacts of the original research proposal in this dissertation as the later sections were built on that original shell. Experiences that have occurred since originally writing

the research proposal have formed new spirals that resemble the old shape, and yet they represent a more complex and useful conceptualization of the phenomenon I studied.

What follows is a visual model of embodied transformation and written description of what the model is meant to represent. After the model is presented, the dissertation comes to a close with recommendations for educators and researchers, and a conclusion.

Model

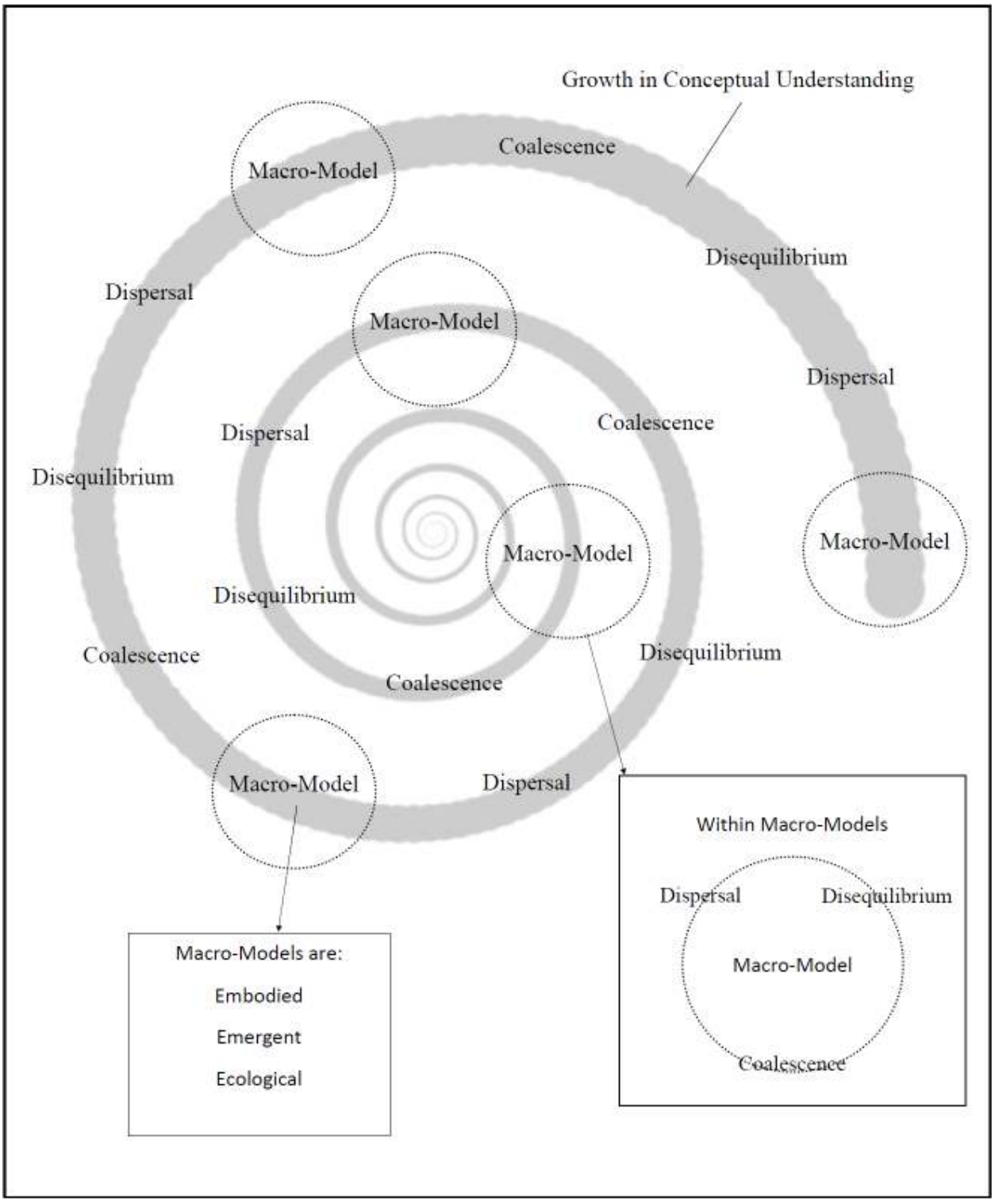

Figure 6. Embodied transformation through emergent design.

This model of embodied transformation through emergent design is a synthesis of the findings of the research project, the culmination of my doctoral study. It is intended to be a visual, coherent overview of the longer-term embodied transformation process that occurs for participants in Puk's (2010) emergent design approach to education. What follows is a summary of the aspects of the model, with the intention of clearly outlining what the model is intended to depict.

The center of the spiral represents the history that an individual brings to the process, including their level of development of understanding of key ecological concepts. As the individual starts into, and continues through the process, they encounter macro-models. There are two immediately apparent levels to the model: within and outside of the macro-models. Within macro-models (right inset in Figure 6), individuals encounter disequilibrium, dispersal of old understandings of key concepts, and the coalescing of new, more complex and adaptive understandings of these concepts. The dispersal of old, and coalescing of new, understandings of concepts refers to the reorganization in networks of connections between related thoughts, concepts, and ideas. Dispersal occurs through the disruption of less complex and adaptive networks when encountering the world in new ways through each macro-model, where coalescence equals the growth in the adaptivity and complexity of networks of connected concepts. It is important to emphasize that conceptual understanding in this model means much more than just intellectual growth, as emotional, intellectual, physiological, and psychological dimensions are all integral aspects of such understanding.

Outside of macro-models, the process of growth in conceptual understanding continues. The thickening of the spiral represents the ongoing growth in conceptual understanding over time through the program, as central concepts are revisited and understandings are reconceived

again and again through the recursive, emergent process. Though there is a sequence of events presented for the larger process of emergent design, (macro-model, coalescence, disequilibrium, and dispersal), this is certainly not always the order in which these aspects of the process occur, though it is a regular pattern and so is represented and described here. Participants leave macro-model experiences with newly coalesced understanding of key concepts. Through reflective processes, discussions with others, readings, and other activities, disequilibrium occurs, which leads to the dispersal of old structures of understanding. In my research study, this dispersal has to do with ecological concepts, but also concepts about what education is in itself, and how learning takes place. The process continues through many iterations of new structures of understanding emerging, with understanding becoming more complex with each recursion and connection to other intersecting concepts. As described in the analysis section, coalescence often has a non-linear quality, and so perhaps the model should in fact include some non-linear arrows of affect between macro-models across the limits of regular linear time. These were left out as the visual value of the model was disrupted when their inclusion was attempted. It is vital to note that the disequilibrium, dispersal, and coalescence of understanding that occur within and between macro-model experiences does not occur only on the rational level. Instead, the process of increasing conceptual understanding for participants was rooted in physiological, emotional, psychological, and intellectual stimulation. These aspects of embodied transformation are not separable, but instead contribute in an interwoven, complex fashion to the phenomenon of growth in conceptual understanding at this level of depth.

Finally, the coalescence of new understandings, since it is embodied, leads to transformation not just of conceptualization, but of emotion, psychology, and action. And though the spiral ends in this model, embodied transformation includes a shifting to complexity

thinking, and therefore taps into a natural desire for the lifelong pursuit of new knowing and connection. Growth does not end with the end of the program.

Recommendations

The following are my recommendations for educators, future research, and the administration of education. These recommendations have emerged from my doctoral research and are intended to be part of a dialogue rather than being prescriptive. My experience with the emergence of a deeper understanding of complexity through this process contributes to a sense of certainty that my own development and growth will not end with the doctoral program, and that the future is generally unpredictable. I am also sure that dialogue and interaction about these findings and recommendations will be part of the process of my development and any educational or research activities that I conduct based on these findings, and so what follows is highly likely to evolve and change over time.

Educators. Recommendations for educators are based on the assumption that those reading this work are interested in deeper forms of learning.

- Embodied Transformation is:
    - Engaging – creating challenge to old understandings, and a sense of (reasonable) risk sparks curiosity. Creating fun situations where students try out new roles and interact with each other taps into natural learning processes based in play.
    - Embodied – the sensory and motor systems, as well as emotions and feeling, are crucial components in transformative learning. Conducting

learning processes in natural surroundings as much as possible allows for natural structural congruence to deepen experiences.

- Emergent – setting parameters, but avoiding prescriptive outcomes, allows the student to discover and make their own meaning, relative to the history they begin each process with. Setting up opportunities for the re-visitation of key concepts, and embedding chances to see connections between them, taps into the recursive, non-linear nature of emergent learning.

Research. Recommendations for research relate to my overall finding that the emergent design approach led to embodied transformation, which is a highly desirable educational outcome. Therefore, emergent design should be better understood generally, and researchers should be looking for ways to further study and develop this type of approach. Suggested areas are:

- Further and more specific understanding of the nature of the relationship between disequilibrium, the dispersal of old understandings, the sparking of curiosity, play, and coalescence of new and more complex levels of understanding, that is, embodied transformation.
- Further research into disequilibrium in terms of intensity, timing, and potential other factors that may play a role in its efficacy in dispersing old understanding and sparking curiosity.
- Closer examination of the role of recursion in the coalescing of more and more complex understanding of threshold concepts. Some questions may be (a) Are there patterns in the number of times key concepts must be revisited? and, (b) Are

their individual differences in the influence of recursion on coalescence of complex levels of understanding?

- Continued and further examination of the role of embodiment in understanding, through neuroscientific and other inquiry into the development of conceptual understanding of threshold concepts.
- Development and examination of macro-models in other fields of education, and study regarding similarities and differences based on discipline. I am particularly interested in researching the use of emergent design in teaching clinical counselling skills, especially with threshold concepts such as inferred empathy, as this is my main area of teaching and content expertise and interest.
- Explore the use of natural systems as learning setting for other disciplines.
- Research on dispersal and coalescence in neural networks, and their functioning as a complex system.
- Ongoing literature review, and further study regarding the use of emergent design approaches in other areas of higher education, and/or other facilitators delivering them, to assess larger patterns, and to appreciate unique phenomena.

Educational Administration. Recommendations for educational administrators are based on my research findings that the emergent design approach leads to embodied transformation, which includes highly desired aspects of learning, including engagement, growth in conceptual understanding, the ability to apply learning adaptively to novel situations, and complexity thinking generally.

- Opportunities, encouragement, and reward for educators to experiment with emergent design approaches. Educators need opportunities to experience emergent design themselves in order to understand how to use this approach–they need an embodied experience of it. They also need assurance and support as they take risks in applying this innovative approach. Success with this approach should also be highlighted and rewarded to increase the profile of emergent design.
- Discussion of complexity in teacher education programs to develop awareness of the self-organizing properties of natural systems. Educators should have the opportunity to (a) understand individual learners, classrooms, schools, and so on, as complex systems that have a natural ability to adapt to contexts, and (b) to learn to develop discipline-appropriate parameters that simulate these systems.
- Further development of macro-models (and overall emergent design in courses/programs) in other disciplines, and promotion of more emergent design courses in ecological education specifically, including teacher education programs. Prescriptive approaches to teaching led to passivity in learners who do not understand threshold concepts or how their knowledge is connected to other concepts or can be applied in novel situations. For pre-service teacher candidates especially, if the prescriptive approach is all they encounter, it is repeated in their teaching practice, and therefore the cycle continues. Therefore, pre-service teacher candidates should encounter emergent approaches in every discipline so that they are more likely to apply it when they become teachers.

Conclusion

The emergent design approach that was the focus of this study taps into the natural dynamics of complex systems to deeply engage participants in the learning process, leading to embodied transformation. Embodied transformation involves a process of growth in conceptual understanding that includes intellectual, but also physiological, emotional, and psychological dimensions. Growth in conceptual understanding occurs through recursive linear and non-linear patterns of disequilibrium, dispersal of old understandings, and coalescence of new, more complex and adaptive understandings of key concepts. Participants are initially challenged to let go of pre-conceived notions of what learning, and even classrooms, look like. At the same time, there are welcoming processes including early interaction with fellow participants to create a sense of a safe community in which to take risks. Parameters for activities are set by the facilitator, so that particular information is encountered, but within these parameters, participants may play many roles and outcomes in terms of understanding are not circumscribed. Participants reflect in writing on experiences, and time is set aside periodically for reflective conversations on activities. Classes are almost exclusively held outdoors, and so natural surroundings are an important part of the learning dynamic, including the sensory experiences available to participants. Sometimes you get soaked, at other times it is warm and breezy. You may be tunneling through snow, or navigating a forest in the dark. Physical engagement and exertion play a significant role in participant experiences, as do other dimensions of experience, including emotions evoked by physical or psychological circumstances.

The emergent design approach taps into the dynamics of complexity, natural systems and processes in the constant activity and interaction between participants, natural surroundings, and learning materials. All of these system actors come with histories and are changed through their

interaction. One of the patterns that emerges from complex systems is that the self-organization of the system and the actors within it resembles a spiral pattern of change, where concepts and connections are re-visited and understanding and relationships become more complex and adaptive with each recursion (Kolb, 2015). Participants in this study not only developed a deeper and more complex understanding of core course concepts and theories through this recursive process of dispersal and coalescence of conceptual understanding, but also began to think in more complex ways in general. They began to wonder how seemingly unconnected situations and concepts might be connected, and also to consider what actions they could take to make a positive impact on key ecological and educational issues. The term that emerged through my doctoral research, analysis, and writing processes to describe what was witnessed and experienced is embodied transformation, meaning that this type of learning is not simply intellectual or abstract, but instead is engaged, related, and felt. Embodied transformation leads to real and positive changes in behaviour because we have a felt understanding that we are a part of larger wholes, and a relationship of caring with the other members of our ecosystems.

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Appendix A: Research Design from Research Proposal

Research Design

My research will follow an emergent, sequential qualitative → quantitative mixed methods design, aimed finally at developing a quantitative instrument (Nagy Hesse-Biber & Leavy, 2008; Plano Clark, Creswell, O'Neil Green, & Shope, 2008). This research is emergent in the sense that the initial stages will be exploratory, with results contributing to the development of the next stage. It is important here to distinguish between emergent design as the instructional process examined in this study, and emergent design as a research approach. In order to reduce the potential for confusion, I will refer to the latter as emergent methods (Nagy Hesse-Biber & Leavy, 2008). I am somewhat uncomfortable with the adjective of 'sequential', though this is the existing mixed-methods model that best fits my plan of research. Though there is a sequential aspect to the design, I also plan on analyzing all collected data (qualitative and quantitative) together at the end of the project using crossover analysis (Onwuegbuzie et al., 2010). My dissertation will contain data drawn from three phases:

- Pre-dissertation phase - presently in progress (Fall 2010).
- Dissertation Research Phase 1 – results from the pre-dissertation phase will be utilized to create focused interview questions for Phase 1 (Winter 2010).
- Dissertation Research Phase 2 - results from the pre-dissertation phase and Phase 1 will be utilized to develop a quantitative instrument to measure participant experiences. I will conduct a pilot study of the instrument in Phase 2.

Plano Clark et al. (2008) suggest that a sequential qualitative → quantitative mixed methods approach is appropriate when researchers need an instrument that will measure specific variables of interest (or even when the variables are not/only vaguely known) and such an instrument is not available, or the instruments that are available are not adequate in representing the experiences and perceptions of the participants in the phenomena of interest. Qualitative methods can offer rich data, which, when analyzed for themes and compared with pre-existing theory and evidence, can form the basis for developing a quantitative instrument (Onwuegbuzie et al., 2010). Researchers utilizing this approach pilot-test the instrument with the participant group from which the qualitative data was gathered, in order to determine whether the data gathered by the new instrument is congruent with the qualitative data it was based upon. This process of comparison offers a form of triangulation for the researcher's initial thematic interpretations. Marton & Saljo's (1976) and Trigwell and Prosser's (2004) research approaches are excellent examples of this use of mixed methods research. As was discussed earlier in this proposal, these researchers used phenomenological analysis of participant experiences shared through interviews to develop instruments that measure depth of student approaches to learning, and attitudes towards teaching.

Appendix B: Structured Interview Questions

Macro-models during the year:

Fall

Salmon Energy

Entropy of Food Consumption (Grain vs. Beef)

Virtual water

Water Usage Barrels

Greenhouse Gases

Sun's energy (herbivores, carnivores, etc)

HONCO

Transpiration (tree)

Bee boogie

Winter

Soil/Carbon Energy

Coke can

Hydrogen Fuel Cell

Quest for fire

Nurdles

Journey of water molecule

Timelines

Story of beaver

From the list above, tell me your 5 favorites.

1.

2.

3.

4.

5.

For each category a-d below, name the macro-model that was:

a/ most engaging and/or you had the most fun

b/ that you learned the most from

c/ helped you understand complex topics the best

d/ challenged you the most.

Envision these macro-models when you respond to the questions below.

1. As you know, one of the characteristics of macro-models is embodied experience:

a/ what does embodied experience now mean to you in terms of teaching and learning?

b/ describe how embodied experience facilitated your learning experience in a macro-model.

c/ how did all of your senses working together assist in understanding the macro-model?

2. As you know, one of the purposes of macro-models is to facilitate the understanding of complexity:

a/ what does complexity now mean to you in terms of the reciprocal relationships between natural systems and human systems?

b/ describe how a macro-model helped to facilitate your understanding of complexity

c/ how did the ambiguity of the parameters (boundaries, rules, and/or guidelines) of the macro-model facilitate the understanding of complexity?

d/ how did your experience of ambiguity change over the course?

e/ how did successive macro-model experiences assist in expanding your understanding of the complexity involved in natural and human systems?

3. As you know, one of the characteristics of macro-models is that they are conducted in natural settings:

a/ how did the natural setting facilitate your learning experience in the macro-models in regard to

i/ embodied experience

ii/ complexity ?

4. a/ How did the macro-model experience affect your ecological beliefs and/or behaviors?

b/ How does the macro-model experience have a transformative affect on beliefs and behaviors in comparison to lecture-based, transmission-oriented teaching and learning?

c/ Were there times when you experienced conflict between your own behaviors/values and what you were learning through the macro-models? If so, describe this dynamic.

d/ Did this dynamic/conflict shift over the length of the course?

5. a/ What contribution do you see the macro-models making towards the development of imagination, i.e., being able to visualize and conceptualize in your mind?

b/ What contribution do you see imagination having in becoming more ecologically literate and ecologically conscious?

6. a/What contribution do you see the macro-model experience making towards the development of curiosity, i.e., the desire to explore and learn more?

b/ What contribution do you see curiosity having in becoming more ecologically literate and ecologically conscious?

c/ How did play and having fun contribute to your learning during the macro-models?

7. What did you learn about the role of the instructor/teacher during the macro-model experience?

8. How has the experience with macro-models changed your view of:

a/ teaching

b/ learning

c/ your level of ecological literacy

d/ university education

e/ yourself

9. Do you have anything else you would like to add?

Appendix C: Lakehead University Research Ethics Board Submission

Emergent Outcomes in Higher Education: An Active Inquiry Approach

Summary of purpose of research

Many researchers have contributed to a large body of evidence that demonstrates that student-centered approaches led to deeper forms of learning than teacher-centered approaches (Christensen Hughes & Mighty, 2010). Deeper forms of learning, based on active inquiry rather than on the amassing of knowledge only (Christensen Hughes & Mighty, 2010), include the development of critical thinking skills (Entwistle, 2010), the ability to innovate in the face of novel challenges (Gordon, 2006), and increases in confidence to meet challenges (Bandura, 2006),

Society faces serious and complex ecological challenges that are not amenable to easy answers. Courses that invoke deep learning in preservice teacher candidates regarding ecological dynamics and issues are crucial so that the teachers of tomorrow are able to help elementary and secondary students become ecologically literate citizens (Puk & Stibbards, 2011). The ecological macro-model approach is an innovative teaching style utilized in ecological education for several classes of preservice teacher candidates and graduate students at Lakehead University's Thunder Bay campus. Ecological macro-models involve students in outdoor, cooperative activities that are analogues of ecological phenomena (Puk, 2009). It has been demonstrated that this approach leads to emergent outcomes such as increased self-efficacy in understanding central ecological concepts, intention to use student-centered learning approaches in students' own teaching

practices, and deepening of knowledge regarding the functioning of complex ecological systems and our place as humans in that system (Stibbards & Puk, 2011).

The purpose of the proposed research is to deepen the understanding of the processes and dynamics of the macro-model approach to learning, and the emergent learning outcomes described above. Though there is ample evidence that student-centered and active learning approaches do lead to deeper learning, the dynamics by which such deeper learning occurs are not well understood. Complexity theory, an interdisciplinary paradigm used to describe biological systems which are self-organizing (Davis & Sumara, 2005, 2007), will be used as a lens to examine the 'agents' (including students, teacher, materials, and natural surroundings) and dynamics (mutually influential interactions between agents) of the macro-model learning approach.

Research Methodology

A mixed-methods design will be utilized, as a combination of quantitative and qualitative methods offers the benefits of both research approaches including: utilization of measures that have been examined for reliability and validity; generation of hypotheses that are testable using statistical analysis; detail, depth of information through interviewing, field notes, artifacts and content analysis; ability to observe emergent phenomena which are often unpredictable, both in essence and in timing (Leech & Onwuegbuzie, 2009).

Participants will be approximately twenty-five (25) students enrolled in EDUC 4284YA and twenty-five (25) students enrolled in EDUC 3282FA at Lakehead University in Thunder Bay, Ontario, during the fall/winter semesters in 2010/11. These courses are for preservice teacher candidates who wish to teach Environmental Science/Ecological Literacy. See

‘Recruitment procedures’ and ‘Informed consent’ sections below for descriptions of the steps that will be taken to ensure that students in these courses are treated in an ethical manner regarding this research.

The qualitative component of this research project will be ethnographic, in the sense that: two particular cases (4284YA and 3282FA) will be explored in detail; data collection tools will be unstructured; the focus will be to explore and describe a social phenomenon in as much depth and detail as possible; and this description will be primarily verbal (rather than statistical) with the intention of deriving meaning from the collected data (Atkinson & Hammersley, 1994). Though the intention is to not enter into this process with pre-conceived notions of what will be found, all researchers are informed by paradigms, which allow for a more structured approach. Complexity theory offers a perspective on social phenomena in which all members are seen as inter-influential agents which bring their own history to a particular system (Davis & Sumara, 2007).

Field notes will be derived from informal interviews with participants and participant observation. Informal interviewing allows the ethnographer to avoid limiting the field of inquiry (Fontana & Frey, 2005). The main intention of ethnography is to enter, as fully as possible, into a particular culture, while at the same time maintaining a certain level of objectivity (Atkinson & Hammersley, 1994). Artifacts will also be collected during this qualitative portion of the study, and may include educational materials, photographs and other creative forms of expression. Students who have not consented to participate in the study will not be interviewed, and no data will be collected that includes their personal information.

The intention of the qualitative aspect of this research is to gather data in rich detail in order to describe, as holistically as possible, the components, dynamics, and outcomes of this unique approach in ecological education.

The quantitative component of this research will involve participants filling out a survey instrument (see Appendix A) both pre and post-course. The instrument is designed to collect data on several subscales, including: attitudes and beliefs about conceptual play and learning (Stibbards, 2010); items related to experiences of teaching approaches; and written definitions for course related concepts (Puk & Stibbards, 2011). The intention is to analyze whether and how scores on these scales have changed using paired-sample t-tests, and to examine whether changes in conceptual play and/or experiences of teaching approaches can predict improvements in the sophistication of definitions, using a multiple regression analysis.

The intention of the quantitative aspect of this study is to gather measurable data regarding some of the vital components of deeper forms of learning in terms of the importance of how students approach learning and how teaching approaches affect student approaches.

Recruitment Processes

A Graduate Assistant, without the course professor present, will meet with all students in the courses and give an overview of the research study, reading the covering letter and answering any questions. Students will be given covering letters and informed consent forms to read, and the students will be invited to sign if they consent to be participants in the research study, without coercion. No advertisements will be used.

Harm and/or Potential Risks to Participants

There are no known physical or psychological risks for participants in this study. Please see informed consent and anonymity and confidentiality sections below in regard to privacy concerns.

Deception

There is no deception planned in this research.

Benefits to participants and/or society

As stated above, it is generally accepted by researchers of higher education that student-centered learning approaches led to deeper types of learning than teacher-centered approaches, and that these deeper forms of learning are what employers are looking for in University graduates (Christensen Hughes & Mighty, 2010). This research is an attempt to at least partially fill a gap in our understanding of how student-centered learning leads to such emergent outcomes. Understanding student-centered dynamics is potentially of highly significant value to higher education, and therefore to society, because if we understand these dynamics, it will help instructors integrate this approach further into their own teaching practices, which in turn will lead to the desired learning outcomes discussed above. In addition, such understanding could be very valuable for pre-service teachers as they are training to enter professional teaching positions in elementary and secondary schools.

In addition, participants will reflect on their own learning experiences in the course (through the informal interviewing that is part of the ethnographic approach planned in this research) which may provoke meta-cognition, i.e., participants will be thinking about their own

thinking/learning process. Consciously reflecting on their own learning has the potential to more deeply embed the learning experience, and also to encourage connections with other learning experiences and important concepts.

Informed Consent

Please see covering letter and informed consent form (Appendix B). Potential participants will be informed of all of their rights including; the right to participate or not participate without coercion, the right to withdraw from participation at any point in the study, the right to refuse to answer any question, information regarding confidentiality (see also Anonymity and Confidentiality section below), how their data will be stored, how the data will be used, and how to find out more about the study and/or outcomes of the study.

Anonymity and Confidentiality

Potential participants will be informed that the instructor will in no way know whether they have consented to participate or not. A Graduate Assistant will introduce the study and invite, without coercion, students to participate in the study, giving each of them covering letters and consent forms, and will collect all informed consent forms. These forms will be kept in a locked cabinet, along with all data, at Lakehead University. Participants who consent to participate will need to provide names on pre and post-course surveys for comparison analysis purposes, but the course instructor will not see these names. None of the qualitative data will contain participant names. These measures are clearly indicated in the covering letter and informed consent forms.

Storage of Data

The data will be stored in a locked cabinet at Lakehead University for a period of five (5) years.

Peer Review

Not applicable

Research partners and graduate students

Not applicable

Conflict of Interest

A potential conflict of interest is that one of the co-researchers is the instructor of the courses, and therefore students could feel coerced to participate. All efforts to deal with this potential conflict of interest have been described above, and are clearly stated for potential participants in the covering letter and informed consent form. The course instructor will never know which students did or did not participate in this study, and potential participants will be clearly informed of this, and of the measures in place to assure their confidentiality and anonymity regarding their instructor.

Dissemination of research results

The research results may be included in papers submitted for publication, conference presentations, included in Adam Stibbards' dissertation, and utilized for instructional purposes.

The informed consent form invites participants to get more information and/or study results by contacting co-researcher Adam Stibbards, and both the covering letter and informed consent form provide an email address.

References

Atkinson, P. & Hammersley, M. (1994). Ethnography and participant observation. In N.K. Denzin and Y.S. Lincoln (Eds.) *Handbook of Qualitative Research* (pp. 248-261). Thousand Oaks: Sage Publications.

Bandura, A. (2006). Guide for constructing self-efficacy scales. In *Self-efficacy beliefs of adolescents,* Information Age Publishing: New York, 307-337.

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Leech, L.L., & Onwuegbuzie, A.J. (2009). A typology of mixed method research designs. *Quality and Quantity, 43*, 265-275.

Puk, T. & Stibbards, A. (in press). Ecological concept development of preservice teacher-candidates: Opaque empty shells. *International Journal of Environmental and Science Education*.

Puk, T.G. (2009). *Transforming the Ecological Self: Stop Peeing in the Drinking Water*. Thunder Bay: Lakehead University.

Stibbards, A. & Puk, T. (2010). The efficacy of ecological macro-models in preservice teacher education: Transforming states of mind. Manuscript submitted for publication.

Stibbards, A. (2010, May). Play and learning in higher education. Round Table presentation at CSSE conference, Concordia University, Montreal.

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Letter of Introduction

The purpose of the proposed research, 'Emergent Outcomes in Higher Education: An Active Inquiry Approach' is to deepen the understanding of student-centered, emergent learning processes. There is ample evidence that student-centered and active learning approaches led to emergent learning (e.g. Christensen Hughes & Mighty, 2010). However, the dynamics that lead to emergent learning outcomes are not well understood. This study will utilize a mixed-methods research design. Participants will complete pre and post-course surveys, be asked to give insight during the course regarding their learning experiences through informal interviews, and observational field notes will be collected regarding the learning processes utilized in the course.

We wish to invite you to participate in this research, as it has great potential to deepen our understanding of the dynamics of active inquiry learning approaches, which in turn has the potential to positively impact learning approaches in post-secondary, secondary and elementary education. You have several rights as a potential participant in this research, including; the right to participate or not participate without coercion, the right to withdraw from participation at any time, the right to refuse to answer any question, the right to anonymity and confidentiality, the right to know about any potential risks or benefits associated with participating in the study, and the right to know how the data from this study may be used. Attached to this covering letter is an informed consent form, which details all of these rights as they pertain to this study. Please read it carefully, and if you choose to participate, sign and date the form and return it to the graduate assistant. Below is contact information for the researchers in this study, as well as contact

information for the Research Ethics Board at Lakehead University, which has examined and given ethical approval for this study.

Researchers

Adam Stibbards, Doctoral Student, Lakehead University, astibbar@lakeheadu.ca

** Contact for further information about the study

Tom Puk, Professor, Lakehead University, tpuk@lakeheadu.ca

Research Ethics Board

Office of Research

Lakehead University

1294 Balmoral Street

Lower Level 0001

Thunder Bay, Ontario

Contact: Susan Wright, ext. 8283, susan.wright@lakeheadu.ca

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Informed Consent – 'Emergent Outcomes in Higher Education: An Active Inquiry Approach'

Thank you for considering taking part in this study. In general, we are interested in more fully understanding how the active, inquiry methods utilized in this course led to emergent learning outcomes. Please carefully read the following rights that you have as a potential participant. If you understand these rights, and agree to participate in the study, please indicate this below by printing and signing your name, and indicate the date of signing.

1) The right to participate, or not, in the study, without coercion. You have the right to refuse to participate in any part of the study, and to withdraw your participation and/or consent to use your data, at any time during the duration of the study. You may decline to answer any question at any point during the study.
2) The right to confidentiality. Your participation, or decision to not participate, will not be known by the instructor of this course, and therefore whether you have consented to participate or not will not affect your course grade in any way. All informed consent forms and data will be kept in a locked cabinet at Lakehead University for a period of 5 years, at which time it will be destroyed. Your name will be needed on pre and post-course surveys, so that any change from pre to post-course can be noted in the analyses portion of this study. Your name will never appear in any research paper, presentation, et cetera.

3) The right to know of any potential risks and/or benefits associated with participating in this research, physiological or psychological. There are no known risks for participants in this study. It is anticipated that through the process of answering survey and informal questions during the course of the study, students will potentially benefit due to meta-cognitive (self-reflective) processes being initiated.
4) The right to know how the data from this study will be used. The data from this study will potentially be used for submission for publication(s), presentation at conference(s), dissertation research, and/or instructional purposes. Participant identities will never be revealed. Please contact the co-researcher (astibbar@lakeheadu.ca) if you would like further information about the study, and/or would like to find out about results.

_____ _____

(print name here) (date)

_____

(signature)

Appendix D: Macro-model Songs

Living Easy
Living Free
I'm a hunter and I eat everything I see

Herbivores
Omnivores,
Everything just taste so good in my belly

Don't need reason,
To eat that carnivore
There's nothing I would rather do

I don't care,
About the entropy,
I'm on the top of trophic pyramid...

I'm on a
Highway to solar energy
Highway to solar energy
Highway to solar energy

First it starts
With the plants,
Who take the sunlight and produce their own energy

Then comes along,
A herbivore
To eat that plant, and steal the energy

Omnivores
Carnivores,
Eat those herbivores to stay alive

But here I come,
With my Gun,
Gonna shoot them so I don't have to eat vegetables

I'm on a
Highway to solar energy
Highway to solar energy
Highway to solar energy

THE SALMON SONG

Oh, when I'm swimming,
Yeah, I know I'm gonna be

I'm gonna be the fish who makes it up the stream.
In the current, yeah I know I cannot be
I cannot be the fish whose eaten by you!

But if I get caught, yes I know I'm gonna be
I'm gonna feed the mouths and forests of BC.
And if you eat me, yes if you swallow me up,
My nitrogen will replenish Mother Earth.

Refrain:

But I would swim 500 miles
And I would swim 500 more!

Just to be the fish who swam 1000 miles
to spawn my eggs at my hoooooome.

Nananana.... etc!

EVERYBODY!

THE BEATLES lyrics - Come Together
(Lennon/McCartney)

Here come old Queen Bee, she come Boogin' up slowly
She got two-male dronies, she one sexy doller
She lay eggs down for us bees
Got to bee a playa she just do what she please

Hive care about nursebees, they make royal jelly goodness
Hive got honey combs, equal energy-storage
They say.... "I know you, you know me"
One thing I can tell you is you got to be free
Dance together right now, time to eat

They do a shake dance, they got 10 sec waggle
They got Pollen sources, they fly too collect it
They got 6 feet and no knees
Cross their air space and you can feel their unease
Dance together right now, time to swarm

(Ouch!
Fly, oh, fly, fly, fly.

The honey-cluster, it got virtual water
Rupe got scrumptious water, he one foraging flyer
Queen say "Water, nectar and pollen is free"
Got to be a bee-hive cos they got community
Dance together right now, time to see

Oh
Dance together
Yeah dance together
Yeah dance together
Yeah dance together
Yeah dance together
Yeah dance together
Yeah dance together
Yeah oh
Dance together
Yeah dance together

G D C G
Greenhouse gasses support our life,
Em Am C D
But too much of them is causing strife.
G D C G
Heat from the sun is trapped up high,
Em Am C D
It's gonna heat us up until we die!
G D C G
Many sour-ces come from the way,
Em Am C
We have cho-sen to live each day.
G D C G
So it's up to you and I,
Em Am C D
To learn about them or say GOODBYE!

CHORUS:
G D
Carbon dioxide and some C – H – 4,
D G
Is heating up the atmosphere, more and more and more.
G D
Ha-locarbons and some N – 2 – O,
D G
These are 2 more gasses that you and I should know.

G D C G
Dirty land-fills cause methane gas,
Em Am C D
Even more than a bovine's ass.
G D C G
Mass production of chemicals,
Em Am C D
And aerosols make N – 2 – O.
G D C G
Halocarbons are a small percent,
Em Am C D
They come from pesticides and solvents.
G D C G
But the biggest one is C – O – 2,
Em Am C D
From forest fires and fossil fuel.

CHORUS X2

Curriculum Vitae

ADAM STIBBARDS

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Lakefield, Ontario K0L 2HO
705 652-7649 astibbar@lakeheadu.ca

EDUCATION

PhD Candidate, Educational Studies
LAKEHEAD UNIVERSITY, THUNDER BAY, ON
CONCENTRATION: Concept Development, Emergent Learning, Transformative Learning, Complexity Theory, Thinking, & Methodology

M.A., Psychotherapeutic Studies, 2004, LESLEY UNIVERSITY, CAMBRIDGE, MA, USA
Concentration: Group Facilitation, Behaviour Change, Empathy

Diploma in Education, 1994, UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER, B.C.

B.A., Psychology, 1992, TRENT UNIVERSITY, PETERBOROUGH, ON

PUBLICATIONS

Puk, T. & Stibbards, A. (2012). Systemic ecological illiteracy? Shedding light on meaning as an act of thought in higher learning. *Environmental Education Research, 18,* 353-373.

Puk, T. & Stibbards, A. (2011). Growth in ecological concept development through embodied experience in teacher education: The discerning teacher. *International Journal of Environmental and Science Education*, *6*(3), 191-211.

Stibbards, A. & Puk, T. (2011). The efficacy of ecological macro-models in preservice teacher education: Transforming states of mind. *Applied Environmental Education and Communication, 10,* 20-30.

Puk, T. & Stibbards, A. (2010). Ecological concept development in preservice teacher-candidates: Opaque empty shells. *International Journal of Environmental and Science Education*, *5*(4), 461 – 476.

PRESENTATIONS

Stibbards, A. (2011, February). Emergent design in higher education. Paper accepted for poster presentation at Conference on Higher Education Pedagogy (CIDER), Virginia Tech, VA.

Stibbards, A. (2010, May). Play and learning in higher education. Round Table presentation at CSSE conference, Concordia University, Montreal.

Stibbards, A., Rodenburg, L., Irwin, D., den Otter, A., Kurrisery, S. & Stubbs, T. (2010, June). Inquiring Minds Want to Know: Impacts of an intensive interdisciplinary inquiry program. Paper presentation at CSSE conference, Concordia University, Montreal.

den Otter, A. & Stibbards, A. (2009, November). *Impacts of an intensive interdisciplinary inquiry program.* Poster session at McGraw Hill Ryerson conference: 'What Really Works: Strategies to Improve Teaching and Learning?', UOIT.

OTHER SCHOLARLY ACTIVITIES

Research Ethics Board Member, Lakehead University Orillia Campus (2008 – 2010)

Reviewer, Canadian Journal of Environmental Education (2009)

Chair, Paper presentations at CSSE conference, May/June 2010, Concordia, Mon., QC

PROFESSIONAL HISTORY

Professor & Coordinator, December 2010 – present
GEORGIAN COLLEGE, SCHOOL OF COMMUNITY STUDIES, ORILLIA, ON

Online Course Developer and Facilitator, Summer 2010
LAKEHEAD UNIVERSITY, FACULTY OF EDUCATION, ABORIGINAL STREAM, THUNDER BAY, ON

Online Course Developer and Facilitator, Summer 2009 – present
ONTARIOLEARN.COM, DURHAM COLLEGE, OSHAWA, ON

Faculty, Fall 2008 – Summer 2010
LAKEHEAD UNIVERSITY, DEPARTMENT OF PSYCHOLOGY, THUNDER BAY, ON
DEPARTMENT OF INTERDISCIPLINARY STUDIES, ORILLIA, ON

Faculty, Summer 2005 – Summer 2010
TRENT UNIVERSITY, PSYCHOLOGY DEPARTMENT, PETERBOROUGH, ON

Faculty, Fall 2007 – Fall 2009
FLEMING COLLEGE, INTERDISCIPLINARY STUDIES, PETERBOROUGH, ON

Teaching Assistant, Fall 2006 – Spring 2008
TRENT UNIVERSITY, PSYCHOLOGY DEPARTMENT, PETERBOROUGH, ON

Psychotherapist, 1998 – 2005
PRIVATE PRACTICE (INDIVIDUAL AND GROUP FACILITATION), TORONTO AND LAKEFIELD, ON

Counselor – Supervisor, 1994 – 1996, 1998 – 2000
FULL CIRCLE FOSTER CARE AGENCY, GREATER TORONTO AREA

Educational Assistant, 1994 - 1996
PEEL BOARD OF EDUCATION, BRAMPTON, ONTARIO

Child and Youth Counselor, 1992 – 1993
SCHOOL DISTRICT #46, GIBSONS, BC

ADDITIONAL SKILLS

Quantitative and Qualitative Research Design

Use of SPSS, Powerpoint, Excel, Word, WebCT, Moodle

Supervision of Honours Student Research

AWARDS, SCHOLARSHIPS AND GRANTS

Faculty Research Scholarship, Lakehead University, 2010

Award for Teaching Excellence, Trent University, 2007-2008

Learning Innovations Grant, Trent University, 2008

PROFESSIONAL DEVELOPMENT

Winter 2011 – Academic Development Program, Georgian College, Barrie

Summer 2010 – Pre-conference for ‘Taking Stock’, STLHE, Ryerson, Toronto

Fall 2007 - Present – Member, Society for Teaching and Learning in Higher Education

Fall 2009 – Present – Member, Canadian Society for Studies in Education

Fall 2007 – Active and Engaged Learning, Faculty Cyber Connections, ERCC